EXPLORATION OF THE SIMULTANEITY OF SAFETY, AFFORDABILITY, UNIVERSALITY AND EQUITABILITY IN DRINKING WATER SERVICES IN MANGOCHI DISTRICT IN MALAWI

PhD THESIS IN TRANSFORMATIVE COMMUNITY DEVELOPMENT

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MZUZU UNIVERSITY

DECEMBER, 2025

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A THESIS SUBMITTED TO THE FACULTY OF ENVIRONMENTAL SCIENCES, DEPARTMENT OF AGRISCIENCES, IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY IN TRANSFORMATIVE COMMUNITY DEVELOPMENT

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DECLARATION

I hereby declare that this thesis titled "Exploration of the Simultaneity of Safety, Affordability, Universality and Equitability in Drinking Water Services in Mangochi District in Malawi*",* has been written by me and is a record of my research work. All citations, references and borrowed ideas have been duly acknowledged. It is being submitted in fulfilment of the requirements for the award of the degree of Doctor of Philosophy (Transformative Community Development) of the Mzuzu University. None of the present work has been submitted previously for any degree or examination in any other University.

________________________________	________________________
Candidate's Name	Date

CERTIFICATE OF APPROVAL

I, the undersigned, certify that this thesis is a result of the author's own work, and that to the best of my knowledge, it has not been submitted for any other academic qualification within the Mzuzu University of elsewhere. The thesis is acceptable in form and content, and that satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate through an oral examination held on 22nd October, 2025.

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DEDICATION

This work is dedicated to my wife Catherine, and my two sons Tayamika and Tamandani.

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PUBLICATIONS DECLARATION

Parts of the materials presented in this thesis have been published in journals and appear as:

a. Community awareness of dental fluorosis as a health risk associated with fluoride in improved groundwater sources in Mangochi District, Malawi (https://doi.org/10.2166/wh.2023.210).

b. Tariff setting for the sustainability of communal water points in Mangochi District, Malawi (https://doi.org/10.2166/washdev.2023.183).

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a. Inequalities in access to improved water sources in rural areas of Mangochi District in Malawi: the exposure of weak governance systems.

LIST OF ABBREVIATIONS AND ACRONYMS

ADC	-	Area Development Committee
AR	-	Affordability Ratio
As	-	Arsenic
CBM	-	Community Based Management
CFU	-	Colony-Forming Unit
CI	-	Confidence Interval
CRC	-	Colorectal Cancer
DHO	-	District Health Office
DP	-	Development Partner
DPD	-	Director of Planning and Development
DVD	-	Digital Video Disc
DWA	-	District-wide Approach
DWDO	-	District Water Development Office (r)
EC	-	Electrical Conductivity
ETDP	-	Economic Theory of Demand and Pricing
FC	-	Faecal Coliform
FGD	-	Focus Group Discussion
FS	-	Faecal Streptococci
GFS	-	Gravity Fed System
GoM	-	Government of Malawi
HH	-	Household
HR	-	Hazard Ratio
HRBA	-	Human Rights Based Approach
HWT	-	Household Water Treatment
ICEIDA	-	Icelandic International Development Agency

IWRM	-	Integrated Water Resources Management
JMP	-	Joint Monitoring Programme
KFS	-	Kener Faecal Streptococcus
KII	-	Key Informant Interview
KIIADC	-	Key Informant Interview with Area Development Committee
KIICG	-	Key Informant Interview with Central Government
KIIGVH	-	Key Informant Interview with Group Village Headman
KIILA	-	Key Informant Interview with Local Authority
KIITA	-	Key Informant Interview with Traditional Authority
KIIVDC	-	Key Informant Interview with Village Development Committee
KML	-	Keyhole Markup Language
LA	-	Local Authority
m	-	metre (s)
MDG	-	Millennium Development Goal
mFC	-	Membrane Faecal Coliform
MICS	-	Multiple Indicator Cluster Survey
MoWS	-	Ministry of Water and Sanitation
MP	-	Member of Parliament
MS	-	Malawi Standard
MSCE	-	Malawi School Certificate of Education
MSP	-	Multi-Stakeholder Partnership
NGO	-	Non-governmental Organisation
NRWB	-	Northern Region Water Board
NSO	-	National Statistical Organisation
NTU	-	Nephelometric Turbidity Unit
O&M	-	Operation and Maintenance

ODA	-	Official Development Assistance
ODF	-	Open Defaecation Free
ODNF	-	Open Defaecation Not Free
OR	-	Odds Ratio
pH	-	Power of Hydrogen
PI	-	Principal Investigator
PSW	-	Protected Shallow Well
ROM	-	Read-only Memory
RTD	-	Real Time Data
SD	-	Standard Deviation
SDG	-	Sustainable Development Goal
SPSS	-	Statistical Package for the Social Sciences
SRWB	-	Southern Region Water Board
TA	-	Traditional Authority
TDS	-	Total Dissolved Solids
UN	-	United Nations
UNDP	-	United Nations Development Programme
UNECE	-	United Nations Economic Commission for Europe
UNESCO	-	United Nations Educational, Scientific and Cultural Organisation
UNGA	-	United Nations General Assembly
UNHRC	-	United Nations Human Rights Council
UNICEF	-	United Nations Children's Fund
US	-	United States
USD	-	United States Dollar
VDC	-	Village Development Committee
WASH	-	Water, Sanitation and Hygiene

WHO	-	World Health Organisation
WMA	-	Water Monitoring Assistant
WP	-	Water Point
WPC	-	Water Point Committee
WTP	-	Willingness to Pay

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ABSTRACT

Safety, affordability, universality and equitability are key elements of the Sustainable Development Goal target on drinking water (Target 6.1). The achievement of this target would depend on the simultaneous attainment of these four elements. This simultaneity was explored in a cross-sectional mixed methods study conducted in Mangochi District. A household survey, key informant interviews, focus group discussions, observations, water quality testing and market prices survey were the data collection methods. A mixed sampling design involving purposive, stratified, cluster and random sampling techniques was employed. Descriptive statistics, non-parametric tests, correlation tests, logistic regression, Gini index and thematic analysis were applied as data analysis methods. SPSS v20 and ATLAS.ti 9 were the main data analysis software for quantitative and qualitative data respectively. The study findings show that, despite access to improved water sources being as high as 92% in the study area, there was high-level inequality in the distribution of water sources among the four TAs, and the water services were unaffordable to 21% of the households according to affordability ratio calculations. In addition, the water sources had poor quality, with only 48% and 12% complying with Malawian standard MS733:2005 and WHO guidelines respectively. The study concludes that the elements of safety, affordability, universality and equitability of access to drinking water services cannot be achieved simultaneously. The study recommends that Mangochi District Council should consider a district-wide approach in the implementation of water supply investments, whereby funds from all partners can be pooled together towards some strategic investments. Future study should carry out an economic analysis on what it would take to achieve the universal and equitable access to safe and affordable drinking water services in the district.

Key words: Affordability; Equitable access; Sustainable development goals; Universal access; Water quality; Water safety.

CHAPTER ONE: INTRODUCTION

1.1 Background

1.1.1 Definitions of Terms

For the sake of this Thesis, the definitions provided in Boxes 1-1 and 1-2 shall apply.

Box 1-1: Definition on Water Source Type and Drinking Water Service Level

TERM	DEFINITION
Improved water source	A water source with potential to deliver safe water by nature of their design and construction, which include taps, boreholes, protected wells and springs, rainwater and packaged or delivered water.
Safely managed service	Drinking water from an improved water source that is located on premises, available when needed and free from faecal and priority chemical contamination
Basic service	Drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip, including queuing
Limited service	Drinking water from an improved source for which collection time exceeds 30 minutes for a round trip, including queuing
Unimproved water source	Includes unprotected dug well or unprotected spring
Unimproved service	Drinking water from an unimproved water source
No service	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal

Source: Adapted from WHO and UNICEF (2017)

Box 1-2: Definition of terms used in SDG target 6.1

TERM	DEFINITION
Universal	Implies all exposures and settings, including households, schools, health facilities, workplaces and public spaces
Equitable	Implies progressive reduction and elimination of inequalities of population subgroups
Access	Implies sufficient water to meet domestic needs is reliably available close to home
Safe	Free from pathogens and elevated levels of toxic substances at all times
Affordable	Payment of services does not present a barrier to access or prevent people from meeting other basic human needs
Drinking water	Water used for drinking, cooking, food preparation and personal hygiene
For all	Suitable for use by men, women, girls and boys of all ages, including people with disabilities

Source: Adapted from WHO and UNICEF (2017)

1.1.2 Sustainable Development Goals

As the implementation of the Millennium Development Goals (MDGs) came to an end in 2015, significant achievements had been recorded on many of the MDG targets worldwide. Some targets, for example 1A "Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day" (UN, 2015, p. 14) and 7C "Halve, by 2015, the proportion of the population without sustainable access to safe drinking water" (UN, 2015, p. 58), were fully met on a global scale; while some targets, for example 1C "Halve, between 1990 and 2015, the proportion of people who suffer from hunger" (UN, 2015, p. 20) and 2A "Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling" (UN, 2015, p. 24) registered remarkable progress although not fully met. However, it was noted that there were still gaps as a result of uneven progress across regions and countries such that millions of people were left behind, especially the poorest and those disadvantaged because of their sex, age, disability, ethnicity or geographic location (UN, 2015).

In September 2015, all 193 Member States of the United Nations General Assembly (UNGA) adopted Sustainable Development Goals (SDGs), also referred to as “The 2030 Agenda”, to run from 2015 to 2030 (UN Water, 2018). The SDGs build on the MDGs. as a framework for achieving sustainable global progress, with a focus on poverty eradication and integrating environmental, social, and economic aspects (Bolatova et al., 2025). The SDGs bring on board “the most universal, ambitious and comprehensive agenda ever seen” (UNESCO, 2017, p. 1) to address the unfinished business of the MDGs and ensure that no one is left behind (UN, 2015). This ambitious agenda led to the increase in both goals, targets and indicators: from 8 goals, 21 targets and 60 indicators of the MDGs to 17 goals 169 targets and 230 indicators of the SDGs (Khan et al., 2017; Ortigara et al., 2018). SDG 6 which states “Ensure availability and sustainable management of water and sanitation for all” forms part and parcel of this global agenda (United Nations, 2018, p. 7).

1.1.3 Drinking Water Services: Transitioning from MDGs to SDGs

Access to clean and safe drinking water is considered as a fundamental human right (Becker et al., 2021; UNECE and WHO-Europe, 2019). As such, it has been part of the global aspirations both in the MDGs and the SDGs. During the MDGs, the progress of the drinking water target (7c) was monitored using “proportion of population using improved water sources” as an indicator, where improved water sources by definition, meant sources that were potentially capable of delivering safe water by nature of their design and construction, and these included piped water, boreholes or tube wells, protected dug wells and protected springs (WHO and UNICEF, 2017b). However, during its implementation, researchers observed some gaps in the concept of “improved water sources” during the implementation of the MDG drinking water target. One of the gaps was that water sources would be classified as improved yet with no guarantee for safety as the water quality was not part of the monitoring criteria (Bain et al., 2018, 2014). Another observation was that cost, distance to the facility, and waiting time, which were disregarded in the monitoring of MDG target 7c, affected access to adequate and safe water (Manda, 2009).

At the end of the MDGs' implementation period in 2015, the new SDG drinking water target 6.1, which reads "By 2030, achieve universal and equitable access to safe and affordable drinking water for all" (WHO and UNICEF, 2017b, p. 7)*,* was introduced to improve the quality of drinking water services and to ensure that no one is left behind (UNESCO, 2019; United Nations, 2024). This shows that the SDG target for drinking water seeks to ensure that drinking water is safe for consumption and that access to it is universal, equitable and affordable. In other words, everyone everywhere should have equal chance to access drinking water of acceptable quality while paying a tariff that is non-limiting to meeting the daily safe water requirements as well as other basic human needs (WHO and UNICEF, 2017a).

Additionally, the SDG target 6.1 was accompanied by a new service ladder for monitoring drinking water services at the household level during its implementation. The service ladder builds on the MDGs' source type classification for the sake of continuity, but introduces additional criteria based on the accessibility, availability and quality of drinking water services (WHO and UNICEF, 2017b, 2017c). Arranged in order of hierarchy, and starting with the least, the following are the five levels on this new ladder: ***surface water*/*no service, unimproved, limited, basic*** and ***safely managed*** (WHO and UNICEF, 2017a, 2017b, 2017c). At the bottom of the ladder is **surface water** usage, which is regarded as **no service** according to WHO/UNICEF (2017b). Improved sources have been categorised into three levels, namely: **limited**, **basic,** and **safely managed.** The difference between limited and basic services lies in the amount of time it takes for a round trip to collect water, including queuing, whereby those taking more than 30 minutes are categorised as limited and those taking less than 30 minutes as basic. As depicted by Figure 1-1, safely managed service is a basic service that fulfils three additional criteria of being accessible on premises, free from microbial and high-priority chemical (arsenic and fluoride) contamination, and available when needed. (WHO and UNICEF, 2017a, 2017b, 2017c).

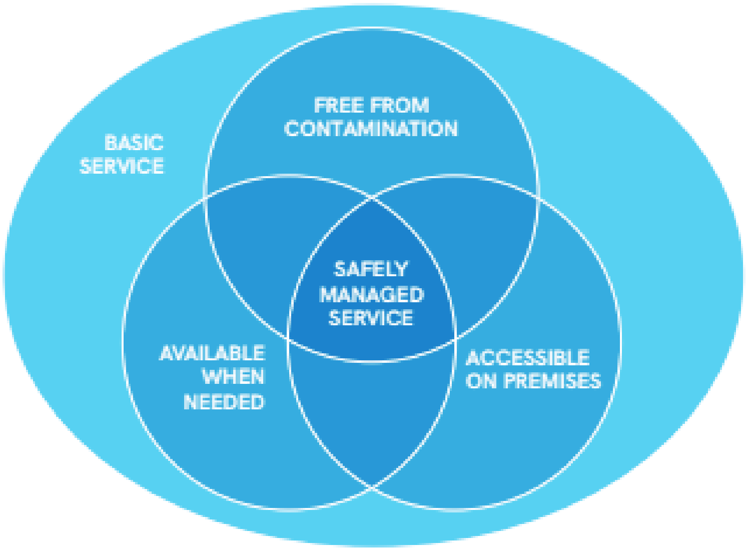


Figure 1-1: Elements of safely managed service

Source: WHO and UNICEF (2017b, p. 8)

1.1.4 Water Supply Technologies and their Sustainability in Malawi

Malawi is endowed with many improved water supply technologies namely: piped water in form of indwelling connection, yard connection, public stand pipe taps and water kiosks; groundwater systems in form of boreholes, protected shallow wells and protected springs; and bottled water. The urban population mostly uses piped water sources (up to 80%), with only 11% having in dwelling connections, 28 % using in yard connection, 27% using public taps, 9 % using the neighbours' taps and 5 % using kiosks. On the contrary, the majority of the rural population (78 %) uses groundwater sources with 73 % using boreholes and 5% using protected shallow wells and springs. (National Statistical Office, 2021). Malawi's bid for universal and equitable access to safe and affordable drinking water, therefore, hinges on the equitable and effective provision, and sustainability of these systems. As such, rural water supply facilities require well-established operation and maintenance (O&M) system for their sustainability because they are not based on *fit-and-forget technology* (Baumann, 2006).

Government of Malawi adopted community based management approach in the early 1990s, having realised that communities feel no sense of ownership if they do not play important roles during implementation of community projects thereby affecting sustainability (Matamula, 2008). The CBM approach aims at fully empowering communities to take the leading role in the project planning, implementation, operation and maintenance (O&M) of the water supply systems (DeGabriele, 2002; Matamula, 2008). Since then, the approach still remains part of policy direction as stipulated in the Malawi's National Water Policy's goal for rural water services, which states *"to achieve provision of community owned and managed water supply and sanitation services"* (Government of Malawi, 2005).

The CBM model is based on an assumption that users will cover costs related to O&M through regular contributions into the O&M fund (Chowns, 2015; Government of Malawi, 2015; Mbewe, 2018). This means that users are expected to contribute enough to cover the costs. However, it sometimes becomes an unbearable burden for decentralised community structures to sustainably keep maintaining infrastructural assets that are inherently unsustainable due to substandard quality. (Truslove et al., 2019). In addition, with Malawi having over 70% of its population living below the international poverty line of $2.15/day (World Bank, 2024), coupled with the rising cost of spare parts due to high inflation rates (29.11 as of October 2025) (Reserve Bank of Malawi, n.d.), payment for O&M may also prove unaffordable by the water users. This presents an interlinkage between SDG 6, that seeks to ensure availability and sustainability of water and sanitation for all, and SDG 1, that is aimed at ending poverty in all its forms everywhere (United Nations, 2018).

1.1.5 Progress on Access to Drinking Water Services

Out of the estimated global population of 8 billion people, the Joint Monitoring Programme (JMP) reports that 5% still lacks access to at least an improved water source, with 4% (296 million) using unimproved sources while 1% (115 million) use surface water. This presents an improvement from 2015 service level, where 8% lacked access to at least an improved water source. Out of the 95 % with access to at least an improved water source, 73% are in the safely managed services category while 18% are accessing basic services and 4% on limited services. Regionally, the JMP further reports a 79% access to at least an improved water source, comprising 31% of safely managed, 34% of basic water services and 14% of limited water services in sub-Saharan Africa (SSA). As for Malawi, the JMP presents an access rate of 93%, comprising of 18% of safely managed, 54% of basic water services and 21% of limited water services (WHO and UNICEF, 2023). This demonstrates that Malawi's reported coverage of access to improved sources falls short of the global access by only 2% points on the one hand, while on the other, it exceeds the regional (SSA) coverage by 14% points. However, on the safely managed services level, Malawi's coverage falls short of the global coverage by 65% points, and 13% that of the SSA.

1.1.6 Safety of Drinking Water Services

Drinking water is said to be safe when it is free from pathogens and elevated levels of toxic substances at all times (WHO and UNICEF (2017a). Water quality is therefore a measure of water safety and forms part of the monitoring of progress of the SDG drinking water target (WHO and UNICEF, 2017b). Reflecting on the coverage of safely managed drinking water services, as monitored by the JMP, it is evident that water quality is the main cause of its slow progress, globally, for being the slowest (73%) in progress as compared to the other two elements of safely managed services namely *accessible on premises* (79%) and *available when needed* (81%) (WHO and UNICEF, 2023).

Different studies have found evidence of either microbial or chemical contamination in drinking water, which exposes consumers to health hazards, thus bringing about health concerns to the water users (Balasooriya et al., 2023; Dzimbiri et al., 2021; Luvhimbi et al., 2022; Masindi and Foteinis, 2021; Onyango et al., 2018). Further to this, the Multiple Indicator Cluster Survey (MICS) of 2019-2020 conducted by the National Statistical Office (NSO) in Malawi, found that 45.5% of 3,121 improved water sources did not have E. coli (National

Statistical Office, 2021), implying that 55.5% of the water sources had compromised drinking water safety. Disaggregated by wealth index quintiles, the MICS found that 54% of the improved water sources used by the richest as compared to only 38% used by the poorest, were free from E. coli contamination. It is therefore not surprising to learn that there was anecdotal evidence that contaminated water played a major role in the spread of Malawi's prolonged cholera epidemic that lasted from 2022 to 2023 (Freeman et al., 2024).

1.1.7 Affordability of Drinking Water Services

Affordability of drinking water services implies that payment for water should not present a barrier to access or prevent people from meeting other basic human water needs (WHO and UNICEF, 2017b). Affordability guarantees citizens access an adequate amount of safe water while paying a fair and reasonable price (Narzetti et al., 2023). Apart from the equity concerns discussed above, the presented progress is flawed because there is no categorisation in the data to depict the affordability of the services counted for in the progress. The monitoring does not even account for the challenges of different vulnerable subgroups, such as the poor, who may not be able to afford available services (Akpabio et al., 2022) and may only prioritise household monthly payments of not more one dollar (Hope and Ballon, 2021). In principle, the payment of water supply services is not supposed to deter people from accessing the service or meeting other human basic needs (WHO and UNICEF, 2017a, p. 11). So far, during the implementation of SDG 6.1, affordability concerns have been raised in various parts of the world, particularly in informal settlements where most households operate on low to average incomes (Beard and Mitlin, 2021; Rahaman and Ahmed, 2016).

1.1.8 Universality of Access to Drinking Water Services

Universality of access to drinking water services implies that everyone, be it at a household or institution, has access to safe drinking water (WHO and UNICEF, 2017a). This entails that, with universal access, no one is to be left behind. Scholars observed that this ambitious target would require significant financial resources to hugely invest in new infrastructure as well as increasing functionality of the existing infrastructure (Holm et al., 2016b; Hutton and Varughese, 2016; Machete and Marques, 2021), targeting the inequality between and within local and regional territories, with the most vulnerable population in mind (Cetrulo et al., 2020). Current practice shows that these required financial resources are mainly supported by donors and have hugely contributed to the current progress (Akpabio et al., 2022). However, effectiveness and efficiency, these investments require good coordination and collaboration among stakeholders at all levels (Huber et al., 2024; Kolker et al., 2016), engaging all actors from local communities to the highest decision-making level alike (Tang et al., 2022). Studies have also shown that there are factors that require serious consideration if the battle for universal access is to be won. Some of these factors include but are not limited to: geographical location, geology, climate, relief, environmental degradation, population pressure, urbanization, community participation, politics and political will, vandalism, poor maintenance culture, tradition and functionality of infrastructure (Obeta and Nwankwo, 2015; Phiri et al., 2023).

1.1.9 Equitability of Drinking Water Services

Although there appears to be progress in universal access to drinking water services globally, significant equity gaps remain in access to drinking water. In this context, equitability is defined as the progressive reduction and elimination of inequalities between population subgroups (WHO and UNICEF, 2017a p. 11). There are serious disparities in access to clean drinking water between and within counties and regions. There are also disparities between the urban and rural settings. For instance, much as the global progress for coverage of safely managed services is reportedly at 73% (with urban at 81% and rural at 62%), Europe and North America sit at 94% (with urban at 97% and rural at 85%). In comparison, SSA sits at only 31% (with urban at 53% and rural at 15%) (WHO and UNICEF, 2023). This shows that Europe and North America exceed the global figure by 21 % points, while SSA is 42 % points under, resulting in a 63%-point gap between Europe/North America and SSA. Similarly, this presents a global gap of 19% points between urban and rural coverage, versus 12% points for Europe and North America and 38% points for SSA.

There has also been evidence that equity concerns linked to low income areas and some ethnic groups (Allaire and Acquah, 2022; Frone et al., 2013). Another evidence of inequalities related to income grouping is presented in Figure 1-2, which shows increasing trends of coverage, from low income to high income. For instance, coverage of improved water sources varies from 79% for the low-income group to 100% for the high-income group. Similarly, coverage of safely managed services varies from 29% (low income) to 94% (high income) while that of basic services varies from 60% (low-income) to 99% (high-income). Other scholars have also established disparities in the access to drinking water services between the rich and the poor; and the urban and the rural populations; with the rich households and urban population having an advantage over the poor households and rural population respectively (Cassivi et al., 2020; Chitonge et al., 2020; Hernández-Vasquéz et al., 2021; Oskam et al., 2021). Beard and Mitlin (2021) point at peri-urban and informal settlements being excluded from public policies as one of the factors leading to such inequalities. In addition, sidelining of rural areas from water supply infrastructure investment and limited awareness of water supply inequalities in the political and social arena are other factors leading to persistent inequalities in water supply (Huber et al., 2024).

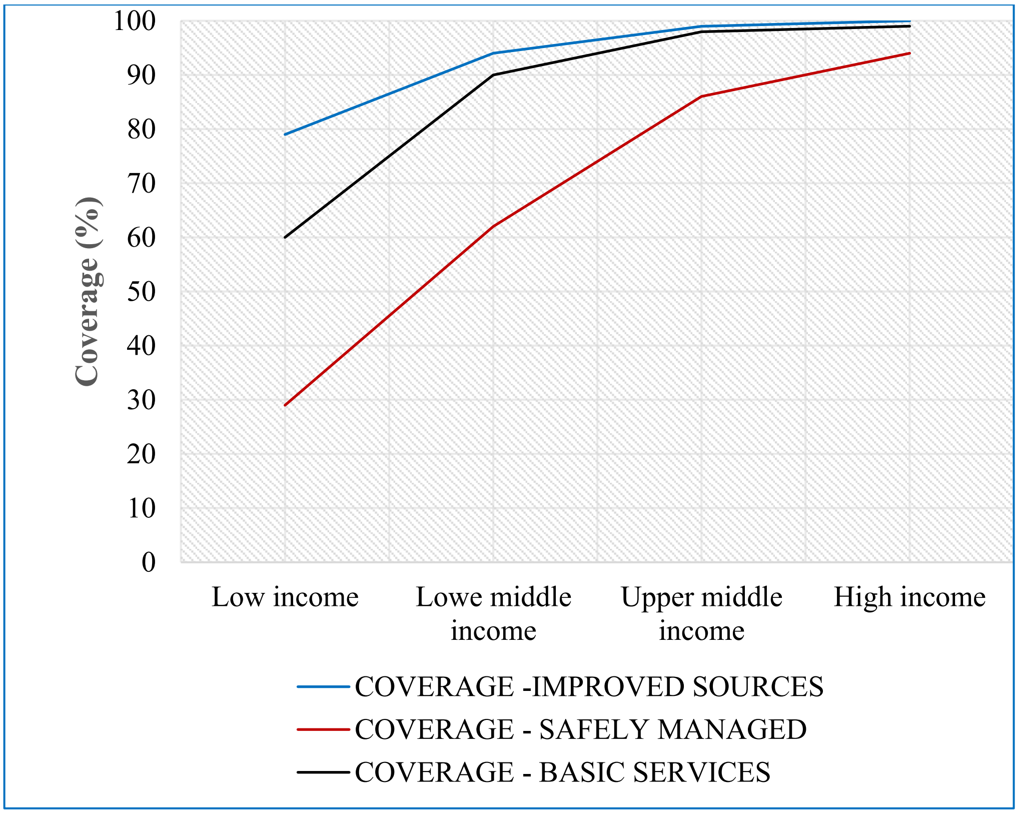


Figure 1-2: Trends of water coverage based on income

Data Source: WHO and UNICEF (2023)

1.2 Problem Statement

The inclusion of the four key elements in the SDG drinking water target, namely ***universal, equitable**, **safe** and **affordable*** (WHO and UNICEF, 2017a)*,* implied that the achievement of this target would be dependent on the simultaneous attainment of all these four elements. This would lead to every citizen having access to sufficient, safe, acceptable, physically accessible, and affordable water, thus ensuring that the human right to water is effectively implemented (Huber et al., 2024). Although access to improved water sources is reported to be increasing every year as monitored by the JMP, other studies have reported of persistent water quality challenges, (Dzimbiri et al., 2021; Holm et al., 2016b; Mercy et al., 2021; National Statistical Office, 2021). This is a serious concern to the development of the country, and requires further exploration, aimed at establishing district based empirical water quality data for the improvement of service delivery.

Literature has also demonstrated that there are limited studies conducted on the affordability of water sources, more especially in Malawi. The available literature shows that past studies have focussed much on piped water systems because of the ease to access water expense data which is mostly based on water bills. The studies that have been conducted in Malawi are area specific, like the case of Mzuzu city. No studies have been conducted to assess the affordability by households that use unmetered water sources like boreholes, whose water expense are merely a contribution towards O&M fund.

Studies on water access disparities and inequalities, both globally and locally, have focussed on a larger scale like global, regional and national, and less done to explore more on the dynamics around the inequitable access to water at micro scale by narrowing down to the lowest community level (Beard and Mitlin, 2021; Cassivi et al., 2020; Chitonge et al., 2020; Hernández-Vasquéz et al., 2021; Mulenga et al., 2017; Oskam et al., 2021). However, UNECE (2013) argued that specific approaches that are adaptive to the needs of people living i rural communities, the homeless, and other vulnerable groups, are needed if disparities in access to safe water are to be eliminated. Such specific approaches would rely on specific narrowed down data, generated by research.

Although there is literature that has independently looked at safety, affordability, equitability and universality of drinking water services (Brown and Heller, 2017; Cook and Whittington, 2020; Dzimbiri et al., 2021; Narzetti et al., 2023; Smiley, 2017), any research had not explored the simultaneity of these four aspects according to the results of literature search. There was, therefore, need to conduct a study that could explore the simultaneity of safety, affordability, universality and equitability in respect of drinking water access, in the absence of which inadequacy of knowledge on the topic would be sustained and could lead to the development of water sector policies and practices based on incomplete or inaccurate information.

1.3 Research Objectives

1.3.1 Main Objective

The main objective of the study was to explore the simultaneity of safety, affordability, universality and equitability in drinking water services in Mangochi District in Malawi.

1.3.2 Specific Objectives

The specific objectives of the study were:

i. To assess the safety of drinking water services in Mangochi District

ii. To evaluate affordability of drinking water services in Mangochi District

iii. To investigate factors that influence universality of access to drinking water services in Mangochi District

iv. To analyse dynamics in equitability of access to drinking water services in Mangochi District

1.3.3 Research Questions

The study's research questions were:

i. How safe is the drinking water in Mangochi District?

ii. To what extent are drinking water services affordable in Mangochi District?

iii. What are the key factors influencing universality of access to drinking water services in Mangochi District

iv. What are the dynamics around equitable access to drinking water services in Mangochi District?

1.4 Significance of the Study

Safe drinking water is fundamental to public health. Assessment of safety of drinking water services is therefore essential as it will generate critical data that is required to identify potential health risks, inform policy decisions, and prioritize interventions to improve the safety of water in Mangochi District.

Affordability is a key component in access to safe drinking water. The water pricing determines who accesses the commodity. If the water services are too costly, some population groups may not be able to pay, as such, they may resort to unsafe water sources as alternatives, thereby increasing health risks. The findings from the evaluation of affordability will help identify economic barriers to access of safe drinking water. The findings will also inform the policymakers in the aspect of designing equitable pricing models and other relevant policies.

An investigation into the factors influencing universal access to safe drinking water helps to understand critical barriers that need to be addressed if everyone is to have access to safe water. The study's fundings will provide a basis for adopting certain technologies, strategies and approaches aimed at extending service delivery in all directions. On the other hand, the analysis of dynamics of equitability in drinking water services will generate data that is crucial for addressing disparities in all forms, and ensure that social inclusion and overall well-being of the communities in Mangochi District are fostered. The generated data will also inform strategies aimed at reducing the disparities and ensure sustainable and equitable drinking water services.

This study on simultaneity of safety, affordability, universality and equitability, as elements of the SDG drinking water target 6.1, touches on the real essence of the target; dissects into the hidden reality of the four elements; and uncovers critical areas that other researchers had not explored. As such, the study contributes to the body of knowledge, specifically in the area of water supply in relation to the Sustainable Development Goals. The application of this newly generated knowledge will contribute towards ensuring the availability and sustainable management of water and sanitation for all (SDG 6). The study also provides data which other researchers can reference in a similar field. The limitation of this study also creates a gap that other researchers can explore further. Finally, the study sparks further debate regarding global, regional, and national policies and strategies aimed at improving access to safe water.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical Framework

The main objective of the study was to explore the simultaneity of safety, affordability, universality and equitability in drinking water services in Mangochi District in Malawi. The theoretical framework as presented in Table 2-1 guided the study.

Table 2-1: Theoretical Framework

No	Specific Objective	Theory Application
1	To assess the safety of drinking water services in Mangochi District	**Integrated Water Resources Management (IWRM) Theory** • IWRM is a holistic approach that ensures sustainable and coordinated management of water resources. • It integrates water quality, water safety, environmental conservation, and infrastructure development. • Promotes a multi-stakeholder approach, involving government, private sector, and communities.
2	To evaluate affordability of drinking water services in Mangochi District	**Willingness-to-Pay Theory (Economic Theory of Demand and Pricing)** • Based on microeconomic principles, this theory examines how pricing structures affect people's ability and willingness to pay for water services. • Affordability is determined by household income levels, water pricing policies, and alternative water sources.

		• The theory also considers subsidies, cost recovery models, and water tariff structures.
3	To investigate factors that influence universality of access to drinking water services in Mangochi District	**Human Rights-Based Approach (HRBA) to Water and Sanitation** • The HRBA framework considers access to safe, affordable, and equitable drinking water as a fundamental human right. • It aligns with SDG 6.1, which promotes universal and equitable access to safe and affordable drinking water for all. • It emphasizes non-discrimination, participation, accountability, and transparency in water service provision.
4	To analyse dynamics in equitability of access to drinking water services in Mangochi District	**Human Rights-Based Approach (HRBA) to Water and Sanitation** **Integrated Water Resources Management (IWRM) Theory**

2.1.1 Integrated Water Resources Management (IWRM) Theory

Integrated Water Resources Management (IWRM) is a holistic approach that ensures sustainable and coordinated management of water resources. IWRM is guided by four principles, commonly referred to as the Dublin Principles, established at the 1992 International Conference on Water and Environment in Dublin, Ireland (Solanes and Gonzalez-Villarreal, 1999). Based on the Dublin Principles, IWRM integrates water quality, water safety, environmental conservation, and infrastructure development, promoting a multi-stakeholder approach that involves the government, private sector, and communities. IWRM ensures water resources development with appropriate quantities and adequate quality. Water quality deterioration reduces the usability of the resource; as such, water quality management forms an integral component of the IWRM (Agarwa et al., 2000). IWRM also ensures that there is decentralised decision making and responsibility at the lowest effective management level, and that there is a balance between top-down and bottom-up management (Xie, 2006). In addition, IWRM promotes both financial and economic sustainability in the management of water resources and water infrastructure (Meran et al., 2021; Xie, 2006).

The practicality of IWRM implementation involves three key stages of investigation, planning, and decision making and implementation (Nagata et al., 2022), as illustrated in Figure 2-1. The investigation stage involves identifying problems and analysing water resource issues in the local context, engaging all relevant stakeholders at all levels. The planning stage seeks to find and prioritise solutions to the identified water related issues by formulating multi-stakeholder partnership. The last stage of decision making and implementation involves preparing the financial resources and implementing the prioritised solutions.

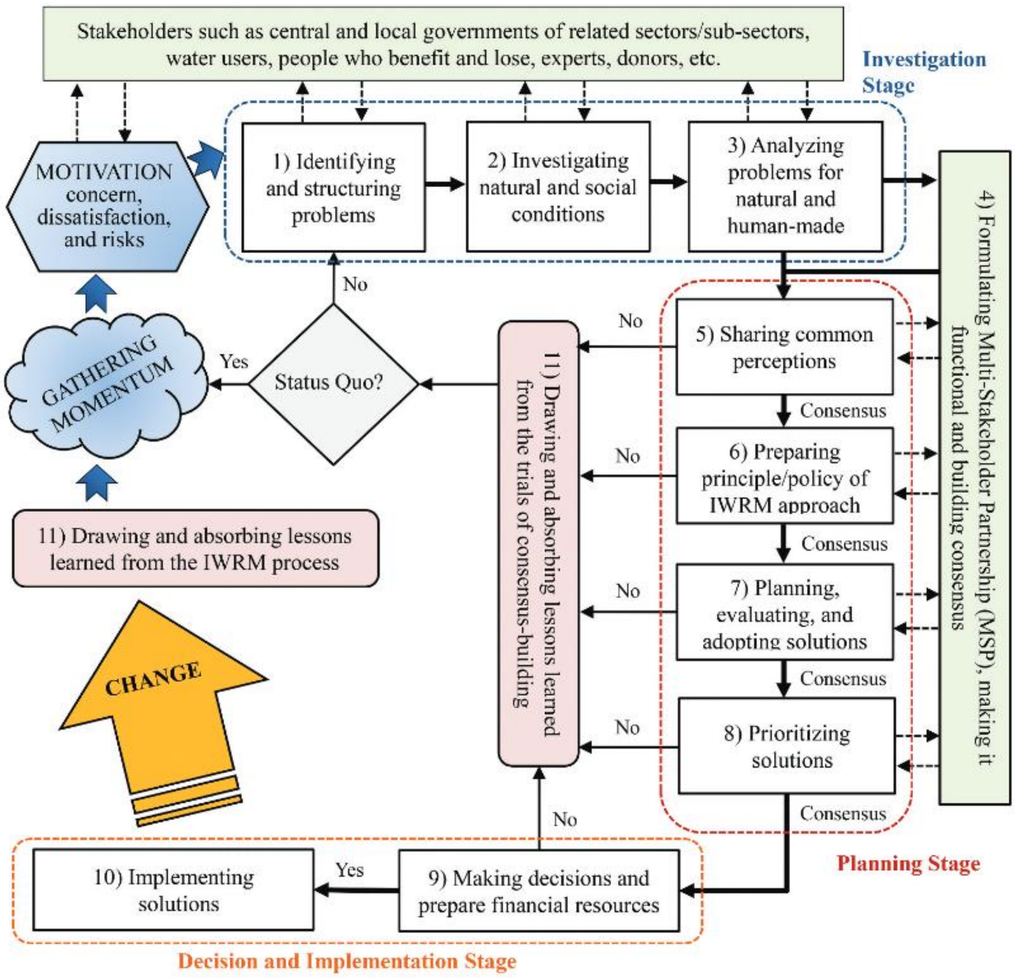


Figure 2-1: Practical IWRM Approach

Source: Adapted from Nagata et al. (2022)

2.1.2 Economic Theory of Demand and Pricing, and Willingness-to-Pay Theory

While the human right to water does not equate to services being free, they do need to be affordable so that no one is denied access due to inability to pay (Murthy, 2013). As such, the Economic Theory of Demand and Pricing (ETDP) and the Willingness-to-Pay (WTP) Theory are vital. ETDP describes how the changes in the quantity of a good or service demanded by consumers may affect its price in the market, and inversely how the pricing of the good may also affect the demand. The demand for a good or service depends on the service provider's readiness to satisfy a want or a need, and the customer's ability and willingness to pay for the service (Hayes and Boyle, 2024). It is, therefore, essential to base the pricing of a good or service on the WTP of consumers because as a fundamental principle in microeconomic analysis, higher prices will lead to reduction of the quantity demanded by the consumers, and vice-versa (Brent and Ward, 2019; Klingemann et al., 2022).

From a basic economic model perspective, WTP has two determinants of income and use, where we see income having a positive effect on WTP (Carson et al., 2001) on the one hand, and on the other hand, WTP being linked to the ability of the good to increase one's well-being, expressed by the concept of 'use values' (Liebe et al., 2011). Similarly, the ETDP theory also speaks to the affordability of the services, which is determined by household income levels and water pricing policies (Gutorova and Schellekens, 2018,). The theory also considers subsidies, cost recovery models and water tariff structures, in line with the call to affordable services (Andres et al., 2021; Beard and Mitlin, 2021; Mitlin and Walnycki, 2020).

2.1.3 Human Rights-Based Approach (HRBA) to Water and Sanitation

The Human Rights-Based Approach (HRBA) framework considers access to safe and clean drinking water as a fundamental human right, following the resolution by the United Nations General Assembly in 2010 (Kirschner, 2011; United Nations, 2010). As such, the normative human rights criteria of availability, quality, acceptability, accessibility and affordability are also applied in drinking water services (Bos, 2016). The human right to safe drinking water therefore promotes access to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use, without anyone being discriminated (UNHRC, 2018). The human right to safe drinking water also provides a platform for individuals and communities to claim their rightful and vital water needs, while imposing an obligation to states to adequately supply clean and safe water for all, and this calls for an explicit and full recognition of this human right by both parties (Cavallo, 2012). The human right to water, though being widely recognised by member states (UN Water, 2018a), will not in itself solve the drinking water challenges (Cavallo, 2012; Murthy, 2013), rather it acts as a vehicle for raising attention to perceived inequities and injustice, and provides the moral, political, and legal momentum to efforts of improving access to drinking water services (Murthy, 2013). In the current global development agenda, HRBA in drinking water services aligns with SDG 6.1, which promotes universal and equitable access to safe and affordable drinking water for all (Spijkers, 2020), and it emphasizes on participation, accountability, and transparency in water service provision (UNECE and WHO-Europe, 2019).

2.1.4 Relevance and Interdependence of the Theories

In this present study, IWRM's relevance is realised in the sense that it is key to achieving universal and equitable access to safe drinking water through the promotion of efficient use, management and sustainability of water resources, investing in infrastructure, and promotion of community participation. IWRM pays attention to social, economic and environmental factors, thus helping to allocate water resources fairly and sustainably. By allocating water resources fairly, IWRM speaks to the HRBA, which considers access to safe water as a human right. The HRBA requires implementation of IWRM principles for its success, thus HRBA cannot be implemented void of IWRM. On the other hand, IWRM can best be implemented with the HRBA in mind. Similarly, the WTP/ETDP guide in the water pricing, with IWRM and HRBA in mind. The balance between sustainability of water sources [IWRM] and the realisation that water is a human right [HRBA], provides the basis for fair and sustainable water tariffs that do not hinder anyone from access the good (safe water). The application of the three theories ensures that these is equitable apportionment of water infrastructure, sustainable and safe management, and affordable and sustainable pricing of the good.

2.2 Conceptual Framework

The conceptual framework of this study (Figure 2-2) is based on the key concepts of drinking water service provision according to the aspirations contained in the SDG Target 6.1. The target is to ensure that drinking water service is safe, affordable, equitable and universal (WHO and UNICEF, 2017a). Based to WHO and UNICEF (2017a, p. 11), the key concepts are described below:

i. **Safety:** Drinking water must be free from pathogens and elevated levels of toxic substances at all times. This is to ensure that there are no health risks emanating for the drinking water.

ii. **Affordability:** Payment of drinking water services should be affordable in such a way that it does not present a barrier to access or prevent people from meeting other basic human needs.

iii. **Equitability:** There should be fair distribution of drinking water services, eliminating all service disparities and inequalities.

iv. **Universality:** Every one everywhere must have access to safe water, be it at home, workplace, or any public institution and space, leaving no one behind.

For complete and comprehensive drinking water services, these four concepts must be met simultaneously.

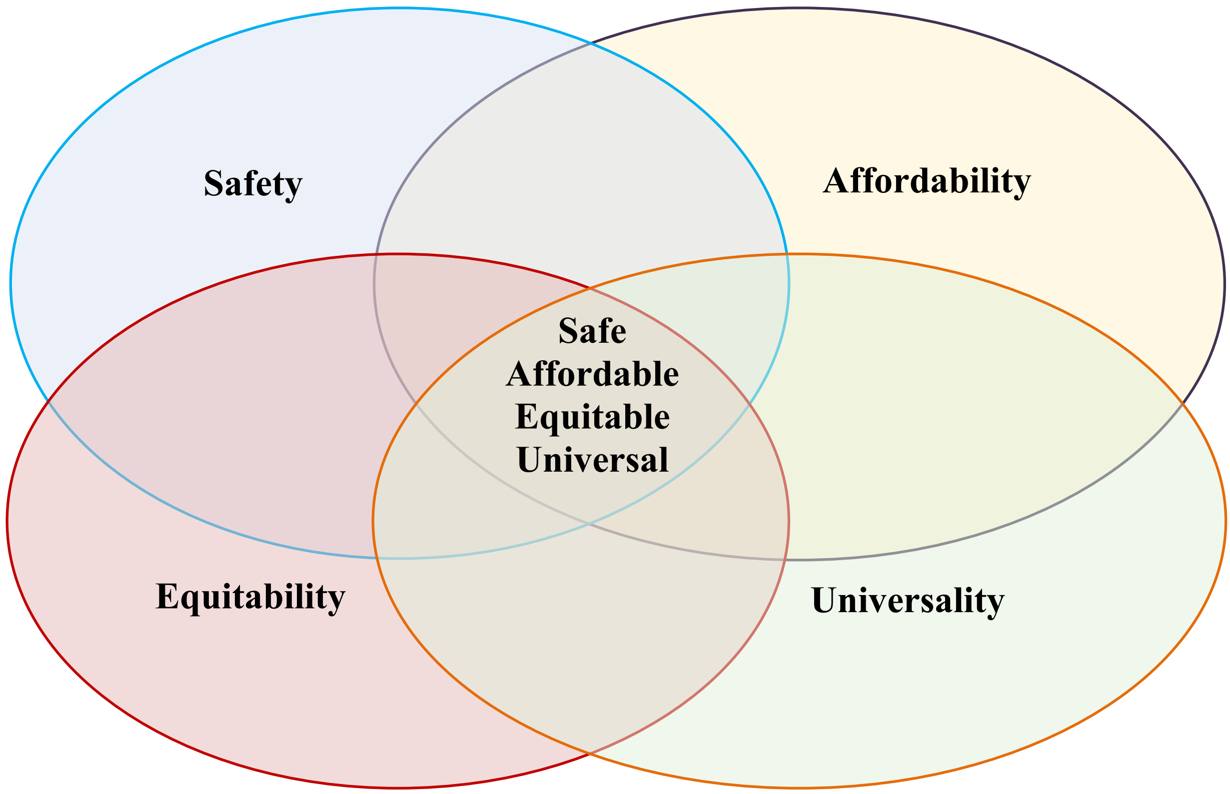


Figure 2-2: Conceptual framework for universal water services

Source: Author

2.3 Safety of Drinking Water

2.3.1 Drinking Water Quality and Human Health

The World Health Organisation (WHO) recognises that access to safe drinking-water is of paramount importance to human health, with a consequential bearing on the national development (WHO, 2017). Water is essential for the functionality of the blood, lymph and immune systems of the body. In general, water also works as a construction material in muscles, bones, fat tissues and tooth dentin. (Akbaba and Kurt, 2016). Although water is life, WHO (2017) highlights that drinking water can contribute to a disease burden when contaminated with waterborne microbes and toxic chemicals. On the one hand, microbial contamination can lead to severe and sometimes life-threatening diseases such as, cholera, infectious hepatitis (caused by hepatitis A virus or hepatitis E virus) and diseases caused by *Shigella* and *E. coli*. On the other hand, the prolonged exposure to chemicals of greatest concern in some natural waters, e.g., arsenic (As) and fluoride, or sequences of exposures over a short period, may have adverse effects health effects like different types of cancer. Through a systematic review of the impact of water pollution on human health and the heterogeneity of diseases, Lin et al. (2022) found that poor drinking water quality related to over 50 diseases and contributed to 80% of the world's diseases and 50% of the world's child deaths.

Lin et al. (2013) conducted a study in 138 villages in the southwest coast area of Taiwan, with the aim of evaluating the dose–response relationship between arsenic in drinking water and mortality of liver cancer. Using multivariate and post hoc analyses, they established that there was a significant association between arsenic levels above 0.64 mg/L and an increase in the liver cancer mortality. This implies that the WHO drinking water guideline value on arsenic (0.01mg/L) and Malawi Standard value (0.05mg/L), are both within the range and provide sufficient protection against the carcinogenic effect of arsenic on liver cancer mortality. However, the study fails short of establishing the length of exposure that leads to liver cancer mortality at the arsenic dose of more than 0.64mg/L.

A study in northwestern Iran, Maleki et al. (2022) looked at the association between nitrate concentration in drinking water and rate of colorectal cancer (CRC). Using two databases of nitrate concentration (1999–2013) and age-standardized incidence rate for colorectal cancer (2002–2012), found a significantly strong correlation (r = 0.624, p-value = 0.040) between colorectal cancer and nitrate in men, and an insignificantly weak correlation in women (r = 0.289, p-value = 0.351). This suggests that there is a clear association between nitrate ingestion and CRC, especially in men. However, the study is silent on why there is that difference between men and women, and did not provide the CRC risk threshold. Although Maleki et al. (2022) did not provide CRC risk threshold for nitrate ingestion, Schullehner et al. (2018) found a concentration-dependent carcinogenic risk of nitrates which increases significantly with drinking water levels exceeding 3.87 mg/L. The study had calculated individual nitrate exposure for 2.7 million adults based on drinking water quality analyses at public waterworks and private wells between 1978 and 2011. The study then used Cox proportional hazards models to estimate hazard ratios (HRs) of nitrate exposure on the risk of CRC. I should be noted that the CRC risk threshold established in this study is below the current drinking water standard of 45 mg/L according to Malawi Bureau of Standards, and 50mg/L according to the WHO drinking water guidelines (Malawi Bureau of Standards, 2005; WHO, 2017). This implies that the current drinking water standards for nitrate are almost 12 to 13 times the CRC risk threshold, thus increasing the risk while operating within the set standards. This new revelation requires confirmation by other studies before consideration is made by the framers of the standards.

Fluoride contamination in drinking water is another global concern because of its long-term effects on human health, and that is why it is one of the priority chemicals under consideration when it comes to monitoring the progress of Sustainable Development Goal target on drinking water (WHO/UNICEF, 2017). Generally, fluoride consumption in concentrations 0.5-1/5mg/L is considered good for health development of teeth and prevention of tooth decay in children.

However, consumptions below 0.5mg/L lead to development of dental caries while consumption of concentrations higher than 1.5mg/L also have negative health outcomes ranging from dental fluorosis to crippling fluorosis as displayed in Table 2-2 (Siaurusevičiūtė and Albrektienė, 2021). The World Health Organisation therefore regulates the fluoride intake by setting 1.5mg/L as the guideline value for fluoride in drinking water (WHO, 2017). On the other hand, Malawi Standard (MS733-2005) provides for 6mg/L as the maximum limit for fluoride concentration for drinking water from boreholes and shallow wells. However, it is observed that the Malawi standard value of 6mg/L is way above the allowable risk-free upper limit, thereby exposing the consumers to a risk of dental and skeletal fluorosis. The framers of the national standards in Malawi may need to review this in respect of the health risks.

Table 2-2: Fluoride concentration and corresponding health outcomes

Fluoride Concentration, mg/L	Health Outcome
<0.5	Dental caries
0.5–1.5	Optimum dental health
1.5–4.0	Dental fluorosis
4.0–10	Dental and skeletal fluorosis
>10.0	Crippling fluorosis

Source: Adapted from Siaurusevičiūtė and Albrektienė (2021)

In summary, the sample literature reviewed above demonstrates that drinking water quality has got a bearing on human health. Drinking water of good quality supports the health development of the human body, whereas drinking contaminated water may result in serious health complications, some of which may be fatal. Safe water provision will help to ensure good health.

2.3.2 Microbial Drinking Water Quality and Waterborne Diseases in Malawi

The greatest microbial risks are associated with ingestion of water that is contaminated with faeces from humans or animals. Faecal matter can be the source of micro-organisms such as pathogenic bacteria, viruses, protozoa and helminths. These pathogens derived faecal matter are the main basis for setting health-based targets for microbial safety because of the great concern they present (WHO, 2017). For decades, microbial contamination in drinking water has been associated with many registered cases of waterborne diseases including diarrhoea in under five children, cholera and typhoid out breaks in Malawi, and different studies have provided empirical evidence of this association. For instance, using a case control study, Swerdlow et al. (1997) found drinking of river water, and placing hands into stored household drinking water, as some of the key risk factors for the epidemic that broke between 23 August and 15 December 1990 among the Mozambican refugees in Malawi. The epidemic registered 1931 cases at an attack rate of 2.4 % and case-fatality rate of 3.5 %. It can be argued that both risk factors mentioned above point at drinking of microbially contaminated water, whether contaminated from the source or contaminated at household storage through poor handing.

A study by Kamanula et al. (2014) used a household survey and water quality testing to assess the prevalence of cholera and determine the sources and quality of drinking water in five locations within Ndirande Township in Blantyre City. As at the time of the study, 176 cholera cases were prevalent in the township. There were 150 households and 15 water samples from unprotected shallow wells (5), boreholes (5) and taps (5). Results of the study showed that all the samples from boreholes and shallow wells, which were main sources of drinking water for 85% of the respondents, contained high levels of E. coli, suggesting pollution by faecal matter, and thereby making the water not suitable for human consumption. However, the study would have benefited from a case-control design which would also check the quality of water used by the controlled population. Secondly, the study referred to an outdated and replaced drinking water standard, MBS214:1990, which was two versions behind, instead of the relevant current standard as of 2014, which was MS214:2013, and had replaced the 2005 version, MS214:2005. Despite this, the standard value for E. coli presence (0/100mL) had not changed and therefore the microbial results were not compromised in any way.

From 3 March 2022 through 5 August 2023, Malawi recorded the worst cholera outbreak in the country's history, registering 59,376 cases and 1,772 cumulative deaths, representing a case fatality rate of 3% (Chitatanga et al., 2025; WHO, 2024). Following this epidemic, Freeman et al. (2024) carried out a study in 17 cholera affected districts and found widespread faecal contamination of drinking water during the cholera epidemic. Using logistic regression, it was shown that household water had three times more risk of being contaminated by *E. coli* and two and a half times more risk of being contaminated by thermotolerant coliform compared to water at the source. The study concluded that the widespread contamination which included most of the drinking water at the household level might be the plausible reason for the protracted nature of the epidemic.

Contrary to other studies that focussed on cholera, Gauld et al. (2020) carried a case-control study between April 2015 and November 2016, focussing on domestic river water use and risk of typhoid fever in Blantyre. Out of the 189 eligible cases of children diagnosed with blood culture–confirmed typhoid in the study period, 125 cases were included in the study, with a median age of 5 years and interquartile range of 3 - 7. The study also included 514 controls. A standardized questionnaire, designed to record demographic and socioeconomic indicators, as well as potential risk factors for typhoid, was administered to the guardians of participants (>18 years of age). Using multivariate analysis, the study identified use of river water and use of water open dug well as some of the risk factors, with use of river water having higher odds than open dug well. This provides clear evidence of an association between that the domestic use of unsafe sources and typhoid fever. As such, domestic use of unsafe sources, especially river water, puts the consumers at risk of contracting typhoid fever.

In summary, the evidence gathered demonstrates the contaminated water has been at the centre of waterborne diseases including the worst ever cholera outbreak in the history of Malawi. Some cases have been registered in areas where there is supposed to be treated piped water supplied by water boards. What is not clear is why the water users would opt for unsafe sources in cases where there is municipal water coverage. Some of the issues to be investigated are safe water coverage and affordability. Provision of safe water sources coupled with promotion of effective household sanitation and hygiene practices can help in the reduction of these waterborne diseases.

2.3.3 Factors that Influence Faecal Contamination of Water Sources

Different studies have found factors that influence level of faecal contamination at the water source. The review in this section explores on these established factors and linkages to microbial contamination. Some of these factors include but are not limited to: type of water source, seasonality, distance between the water source and potential source of faecal contamination, faecal disposal practice, topographic factors, and aquifer characteristics.

The first factor that studies have highlighted is **type of water source**. Results from different studies have shown that shallow wells, more especially unprotected wells, are more prone to faecal contamination as compared to boreholes and treated tap water. For instance, a study by Freeman et al. (2024) assessed drinking water quality in 17 of the districts that were hit by the 2022 -2023 cholera epidemic in Malawi. The results indicate that the percentage of contaminated drinking water sources was significantly higher for unprotected shallow wells (80.0% for *E. coli* and 95.0% for thermotolerant coliform) than for boreholes (26.0% for *E. coli* and 72.4% for thermotolerant coliform). Mkwate et al. (2017) also found evidence of higher faecal contamination levels in shallow wells in Balaka, compared boreholes and tap water. A study by Kanyerere et al. (2012) assessed microbial contamination of groundwater in upper Limphasa River catchment in northern Malawi, involving 17 boreholes and 6 protected shallow wells (PSW), found that PSWs were significantly more contaminated with E. coli bacteria than boreholes. Another study by Kaonga et al. (2013), who assessed water quality of 5 open wells and 5 boreholes in Bangwe Township in Blantyre, also found that the levels of faecal coliform presence in boreholes were significantly lower than in open shallow wells. In a study that analysed water samples collected from 21 covered/protected and 5 open/unprotected shallow wells at four different times in a year to determine the change in quality with different seasons, Pritchard et al. (2007) made a similar observation that faecal contamination in covered wells was much lower than in open wells. Similarly, Malla et al. (2018) found that deep tube wells were less likely to be positive for E. coli compared to shallow dug wells.

As observed by Chavula and Mulwafu (2007), most of the hand-dug wells get contaminated by pollutants that get washed away into the well because they are neither covered with concrete top slabs nor grouted with cement. On the other hand, most boreholes abstract water from deep and confined aquifers which are usually safer from microbial and chemical contamination than shallow or unconfined aquifers (WHO, 2017). However, although boreholes are perceived to produce safe drinking water, results of other past studies provide proof that some boreholes still provide unsafe microbially contaminated water (Freeman et al., 2024; Taonameso et al., 2019; Vunain et al., 2019). As such, borehole water should be used with caution as raw water borehole water may be contaminated and hence, risky.

Another factor that studies have highlighted is **seasonality**. Many water quality studies have shown that microbial water quality mostly gets worse in the wet season than in the dry season. For instance, a study of biological, chemical and physical drinking water quality from shallow wells in some districts of the southern region of Malawi by Pritchard et al. (2007), found that faecal contamination using faecal coliform counts as an indicator, increased in the wet season as compared to the dry season, with the proportion of water sources failing to meet Malawi's guideline value of 50 FC/100ml increasing from 50% in the dry season to 94% in the wet season. Some of explanations to this seasonal variations include but are not limited to: faecal matter being washed away to the water sources during the rainy season; and rising groundwater table that matches with the depths of most latrines in the rainy season, and water table being far below depths of most latrines in the dry season (Chavula and Mulwafu, 2007; Dzimbiri et al., 2021).

Another factor is the **distance** from a water source to potential source of faecal contamination. Different research findings have shown that,

the longer the distance of a water source from a potential source of contamination, the lower the chances of contamination (Dzimbiri et al., 2021; Dzwairo et al., 2006). This is based on the understanding that microbes from pit latrines move through the sub-surface soils and contaminate groundwater (Onda et al., 2012). However, depending on aquifer and soil characteristics, there are differences in the threshold of influence by the potential source on the contamination level of the water source, beyond which there would be no clear relationship. For instance, Dzwairo et al. (2006) assessed the impacts of pit latrines on groundwater quality in rural areas in Marondera District in Zimbabwe and found that a pit latrine could have influence on the level of faecal coliform concentration in a borehole located within 5 meters (m) of its radius, beyond which the faecal coliforms greatly reduced. On the contrary, a study by Kanyerere et al. (2012) in Limphasa River catchment in the northern region of Malawi found that the water source with the highest E. coli concentration had the shortest distance (10 m) from nearest source of contamination; and the rest of the water sources (22 out of 23) were located at distances ranging from 30 to 210 m, such that the study did not establish any significant relationship between distance of water source from potential contamination sources, and degree of contamination. However, the determination of the separation distance would also be dependent on aquifer depth and soil permeability (Mvongo and Defo, 2025).

Literature also proves that **faecal disposal practices** contribute greatly to faecal contamination status of the water sources. One of the studies was conducted by Okullo et al. (2017) in Kenya, and aimed at identifying faecal pollution sources, contamination pathways, and contributory factors. The study was cross-sectional and assessed the faecal disposal practices in open defaecation free (ODF) and open defaecation not free (ODNF) areas in a study of 150 households, and conducted sanitary surveys and bacteriological analyses for 15 sampled community water sources. Using descriptive and inferential statistics, the study found that open defaecation was practiced by 51% of the study households in ODNF villages and in 17% households in ODF villages. The study also established that faecal contamination was significantly higher in water samples from ODNF areas (2.0, 7.8, 5.3, and 7.0 ($\times 10^3$)) than those of ODF villages (1.8, 6.4, 3.5, and 6.1 ($\times 10^3$)). A correlation analysis revealed a significant relationship between sanitary surveys and contamination of water sources, signifying the effect of open defection practice on the microbial water quality of the water sources. Another study, conducted by Mogane and Momba (2025) in South Africa aimed at tracking the prevalence of diarrhoeagenic bacterial pathogens from open defecation sites to water sources. The study analysed 111 human and animal faecal samples and 1032 water samples both in wet and dry seasons. Through a regression model, the study established associations among the target enteropathogenic bacteria in faecal matter and their presence in the water sources, suggesting that open defecation and unmanaged animal waste, had direct impact on the quality of the sampled water sources.

Another factor is the **topographic layout** of latrines and water sources plays. Dzimbiri et al. (2021) observed that when a latrine is placed at an altitude above water source, groundwater can pass through it and get contaminated, and then move into the well or borehole. Another topographic perspective is where Mogane and Momba (2025) also observed that wells are susceptible to contamination from nearby open defecation sites and livestock activity when the wells are located in low-lying areas prone to surface runoff, especially during the wet season, making them highly contaminated.

2.3.4 Fluoride Occurrence in Malawi's Groundwater

Fluoride concentrations are usually detected in groundwater which interacts with minerals that harbour fluoride such as fluorspar, cryolite and fluorapatite in the earth's subsurface (WHO, 2017). The level of fluoride concentration depends on a number of factors namely: geological, chemical and physical characteristics of the aquifer; porosity and acidity of the soil and rocks; temperature; and depth of the wells (Sajidu et al., 2008). Researchers have studied on fluoride concentrations in Malawi's groundwater. Although the findings on the fluoride concentrations established from different areas are site specific and may not be generalised, they still provide indicative data for decision making in some areas.

A study by Sajidu et al. (2008) looked at fluoride concentrations in some boreholes in Nsanje (n = 6), Machinga (n = 11), Chikhwawa (n = 4), Mangochi (n = 16) and Zomba (n = 11) and found concentration values ranging from 0.24 mg/L to 7.51 mg/L across the districts, with both minimum and maximum registered in Machinga District. In addition, Nsanje District registered the highest proportion (83%) of boreholes with concentrations above WHO's guideline value of 1.5mg/L, while Machinga District registered the highest proportion (18%) of boreholes with concentrations above MS value of 6.0 mg/L.

A study by Pritchard et al. (2008) assessed groundwater quality in shallow wells in Balaka (n = 8), Chikhwawa (n = 8) and Zomba (n = 10) districts in Malawi for both dry (August and October) and wet (February and April) seasons, and found maximum fluoride concentrations of 10mg/L, 14mg/L and 0.7mg/L for Balaka, Chikwawa and Zomba districts respectively. This shows that some samples in Chikhwawa and Balaka districts had exceeded both WHO guideline and Malawi Standard values. Another study by Sajidu et al. (2007) analysed groundwater fluoride concentrations at 19 boreholes in Machinga District in Malawi and found concentrations in the range of 0.68 -10.3 mg/L. Vunain et al. (2019) also assessed groundwater quality from 10 boreholes in the Phalombe plain in which fluoride was one of the parameters and results showed concentrations range of 0.52 - 2.90 mg/L. In other related studies, Msonda et al. (2007) analysed groundwater samples from 176 boreholes at Nathenje in Lilongwe District in Malawi and found fluoride concentrations ranging from 0.5mg/L to 7.02mg/L; while Addison et al. (2020b) analysed data set for 1365 groundwater sources archived by Government of Malawi and found 3% to be above 6mg/L, 14% ranging from 1.5 to 6.0 mg/L and the majority (83%) below 1.5mg/L.

The above review demonstrates that, in the Malawi's groundwater, there are chances of getting groundwater fluoride concentrations that are higher than both the WHO guideline value of 1.5mg/L and the Malawi Standard value of 6.0 mg/L. However, in most studies, there have been fewer samples, which would not provide a better understanding of fluoride concentration distribution within each of the study districts because of limited sampling points.

In the study of prediction of groundwater vulnerability to geogenic fluoride national-wide in Malawi by Addison et al. (2020), it was predicted that the highest risk zone in Mangochi District, according to their classification, is "elevated geological fluoride risk zone" where there is more than 60% likelihood of fluoride exceeding 1.5mg/L and 0% likelihood of exceeding 4mg/L. This prediction implies that fluoride concentrations for all groundwater sources (boreholes and shallow wells) in Mangochi District would fall within Malawi Standard value of 6mg/L and that the highest that can be recorded is 4mg/L. This prediction, in part, agrees with other studies that found fluoride concentration levels up to 4mg/L in some boreholes in the district. For instance, a study by Sajidu et al. (2008) found that 5 out 16 boreholes in Mangochi District had fluoride concentration values above WHO's guideline value of 1.5mg/L, with a maximum value at 3.64mg/L. However, the same prediction contradicts findings of other studies where concentrations above 4mg/L were detected in groundwater sources. For example, a study by Chimphamba and Phiri (2014) analysed borehole water quality data collected by the Ministry responsible for water affairs in Malawi since the 1980s, and established that out of 5,324 boreholes assessed for the whole Malawi, 139 boreholes had fluoride concentrations exceeding WHO limit of 1.5mg/L, out of which 63 cases, representing 45% (of 139) were registered in Mangochi District alone, with a maximum value of 7mg/L. This study, however, did not indicate how many boreholes had values exceeding Malawi's standard maximum value of 6.0mg/L.

According to the Government of Malawi (2021), fluoride concentrations ranging from 1.15mg/L to 14.5mg/L were detected in 11 boreholes that were tested in TA Chowe and TA Chiunda in the District. Out of the 11 boreholes, 7 had values above 6mg/L representing 64%, with values ranging from 7.2mg/L to 14.5mg/L. One would certainly except results of this nature in Mangochi District, being within the alluvial plains, bearing in mind that UN (1989) as cited in Mapoma and Xie (2014) had reported fluoride concentrations between 2mg/L and 10mg/L from the alluvial regions in Malawi.

2.3.5 Arsenic Occurrence in Malawi's Groundwater

Literature shows that in most African countries, arsenic presence in groundwater may not be alarming. For instance, in a study conducted by Lapworth et al. (2020) in three countries of Malawi, Ethiopia and Uganda, it was suggested that As contamination was likely not be a widespread issue in the region's groundwater after finding no As concentrations above10µg/L in any of the handpump boreholes in the study. After a review of literature from Nigeria, Libya, Tanzania, Ghana and Malawi, Ahoulé et al. (2015) observed that arsenic concentrations in most African countries' groundwater were lower than 10µg/L. However, extremely high concentrations had been registered in some parts of Africa (1760µg/L in Ghana and 1630µg/L in Burkina Faso).

Other studies conducted in Malawi have also found that arsenic concentrations in Malawi's groundwater range from no detection to less than 10µg/L. For instance, studies conducted on groundwater quality in shallow wells in Chikhwawa (n=8), Zomba (n=10), Balaka (n=9), Mulanje (n=8), Chiradzulu (n=9) and Blantyre (n=9) districts present As concentration results of less than 0.3µg/L (Pritchard et al., 2008, 2007). In their study of microbial contamination of groundwater in upper Limphasa River catchment in Nkhatabay district, Kanyerere et al. (2012)

did not detect any As groundwater contamination in the sampled boreholes and shallow wells (n=23).

In addition, data held by the Ministry responsible for water in Malawi, as reviewed by Rivett et al. (2019), show that samples analysed for some boreholes in Kasungu (n = 27) and Dowa (n = 229) districts were below the detection limit of 1μg/L and less than 3.7μg/L in Machinga district (n=65). A study on arsenic occurrence in Malawi groundwater conducted in Chikhwawa district between 2014 and 2018, also found that As concentrations in all 306 borehole samples were below 10μg/L, with 9μg/L as the highest (Rivett et al., 2019). Using a Rapid Arsenic Test Kit, Pritchard et al. (2008) tested, in duplicates, water samples from 21 covered and five open shallow wells in three districts in southern Malawi namely, Balaka, Chikwawa and Zomba districts to determine the level of arsenic concentrations in the shallow aquifers, whose results showed levels below detection limit (< 0.002 mg/L).

Although literature reviewed above points to groundwater As concentrations in Malawi being less than 10μg/L, Karonga District registered four cases of boreholes with concentrations above 10μg/L, with a maximum value of 14.5μg/L, in a study of hydrochemistry and quality of groundwater in alluvial aquifer in the district (Mapoma et al., 2017). Another study of geothermal groundwater also found a higher value of 12μg/L in Manondo Village, at the southern tip of Ntcheu District (Rivett et al., 2019).

In summary, the available literature therefore shows that in Malawi, As concentrations in groundwater are likely to be below the Malawi Standard limit of 50μg/L, with the majority being below the WHO limit of 10μg/L, also as suggested by British Geological Survey (n.d.). The highest ever recorded arsenic value in the northern region of Malawi, which is also the highest in Malawi, is 14.5 μg/L in Karonga District, while the highest in the central region is 12 μg/L, recorded in Ntcheu District; and the highest in the southern region is 9 μg/L, recorded in Chikhwawa District. There is, however, no literature on arsenic concentrations in Mangochi

District, which shows a high likelihood that arsenic studies might have not been done in the district so far.

2.3.6 Household Water Treatment

Atalay et al. (2024) undertook a comprehensive examination of the relevant primary studies on the implementation of small-scale water treatment in sub-Saharan Africa, with an aim of determining the pooled prevalence of water treatment practices and associated factors in sub-Saharan Africa. In total, 927 articles were reviewed and only 28 were eligible for inclusion. The overall pooled prevalence of water treatment practices in sub-Saharan Africa was 36.31%, with the rural at 41.31% and urban at 25.77%. As for the factors associated with water treatment practices, it was found that HWT was significant associated with formal education, sex, income, and training in water treatment, with higher odds for those with formal education, male headed households, those with higher income and those who received HWT training. The study concluded that the pooled prevalence of HWT practices in sub-Saharan Africa was considerably low. A recommendation for strengthened health education and intensive training in small-scale water treatment practices, targeting the household heads, was made.

A study by Daniel et al. (2018) analysed five socio-environmental characteristics and behaviour determinants using Qualitative Comparative Analysis (QCA) from 41 case studies in Africa, Asia, and South America. The objective was to analyse the interactions between the socio-environmental characteristics, to explain the adoption of HWT. The study identified perceived threat, existing HWT before intervention, affordability, connection to pipe scheme, parental education level, subsidies, intensive promotion activities, durability of the product, or household's preference for a specific type of HWT item, as social-economic drivers for adoption of HWT. The absence of prior water treatment practices was the most consistent condition attributed to the successful adoption of HWT. The study further noted that the type of water sources used by the households would influence their perception of quality of water.

Mercy et al. (2021), in a review on water availability, quality and treatment methods in Malawi, found that the commonly available HWT methods used by low-income residents at are boiling, solar disinfection or chlorination and filtration. They also noted the HWT methods were of low cost, simple, and effective and capable of reducing the disease burden by 47%. Further findings indicate that, although the HWT methods treatment could recover the quality of the microbially contaminated water, their effectiveness was very low in the removal of high turbidity from the unprotected water sources polluted was low. It was also found that about 5% of the Malawian households practiced chlorination and 25% practiced boiling methods of treatment. The study however did not specify the overall proportion that practiced HWT, including filtration and solar treatments.

In another cross-sectional study, Kumwenda et al. (2017) assessed the use of water guard (a local chlorine product used for point of use water treatment) in Chikhwawa District in Malawi. The study used both quantitative and qualitative methods of data collection and employed a household survey with 349 households, and four focus group discussions with women having at least an under-five (u/5) child. Samples of drinking water were also tested for residual chlorine. The results showed over 99% were collecting water from improved sources and only 0.3 from unimproved source (unprotected well). Ninety five percent (n = 349) reported to have ever used water guard for treatment of their drinking water. Of those who ever used water guard (n = 330), 72% (238) were able to explain how they treated their water and 45% (107) of the mothers the right dose of water guard for treating their water. Thes study established that cost, bad taste of treated water, and not being aware that the product exists for sale in their village, were some of the reasons given by those not using water guard. The study recommended awareness campaigns as a way of promoting the use of water guard, which is liquid chlorine. This study, however, should have benefited from finding out how many the households that ever used water guard were still using it and how many quit using it and why, to understand actual progress in the adoption of HWT by chlorination (water guard) in the study area.

Brockliss et al. (2022), different from others, focussed on quite an uncommon HWT technology, the solar water disinfection (SODIS), which is a new household water treatment technology. This study aimed at evaluating the efficacy of the technology in rural communities in the Chikwawa District in southern Malawi. The results showed that the SODIS bucket was effective for E. coli inactivation (<1 CFU/100 mL) only in two of seven experiments, and in one of seven for total coliforms (<50 CFU/100 mL), despite having greater UV doses than were seen in the evaluation carried out under controlled conditions during the bucket's development. On the contrary, results for the control (PET bottles) reached inactivation targets for both E. coli and total coliforms in five of seven experiments.

2.3.7 Literature Gap on Water Safety

Literature is full of research papers on water safety in Malawi. However, there are limited studies that have focused on the occurrence of arsenic in Malawi's waters, despite it being listed as a priority chemical under the SDG monitoring. Another gap is that many studies have failed to develop context specific solutions that auger well with localised socio economic and cultural context. For instance, the context of one district cannot be the same as another district. Lastly, the role of gender and social dynamics in water safety have been limitedly explored. Upcoming studies should therefore focus on filling these gaps.

2.4 Affordability of Drinking Water Services

2.4.1 Measurement of Affordability in Water Services

Goddard et al. (2021) noted that there is a gap between the aspirations for affordable water and the availability of means of tracking the affordability since SDG drinking water indicator does not include measures of tracking it. Despite this being the case, different countries and organisation have tried to come up with ways of measuring this affordability. Currently, affordability is measured as a ratio (usually expressed as a percentage) of household water expenditure to total household, or to disposable income, which is then compared against an agreed upon affordability threshold that is usually set a national level (Goddard et al., 2021;

WHO and UNICEF, 2021). In a European setting, affordability ratio (AR) can also be defined as "ratio of basic water and sewer costs to individual free disposable income" (Gutorova and Schellekens, 2018, p. 22).

Different organisations have suggested different affordability thresholds for water supply services, for example 2.5% by the United States Environmental Protection Agency (USEPA), 3% by the Organisation for Economic Co-operation and Development (OECD), 3–5% by the World Bank and 5% by Asian Development Bank (Fagundes and Malheiros, 2023). The available literature has therefore used one of these affordability thresholds in their affordability studies. For example, a number of studies adopted 3% as the most reasonable threshold (Goddard et al., 2021; Gutorova and Schellekens, 2018; WHO and UNICEF, 2021), while other studies, like the study of Cardoso and Wichman (2022), have gone as high as 4.5%.

Studies that measured affordability in different parts of the globe, have yielded different results, with some exceeding the AR threshold range of 3-5%. Cardoso and Wichman (2022), in their study that assessed water affordability in the United States (US), found that 10% of households exceeded the AR threshold of 4.5% for essential water and sewer services, with the households reaching an average of 6.8%. Teodoro (2018), in a study that measured household affordability for water and sewer utilities in the US, found an average AR value of 11.4%, with the lowest at 4.8% in Phoenix and the highest at 26.9% in San Francisco. A similar study, also in the US, established that low-income households had an average AR of 9.7% for basic monthly water and sewer service, with variations across the country (Teodoro, 2019).

On the local scene, Chiumya and Gumbo (2023) conducted a study in Mzuzu to establish the impact of Northern Regional Water Board's (NRWB) prepaid meters. was affordable, with AR = 1.8 %. The study found that the prepaid meters would not allow people to buy water on credit, forcing those who did not have cash at that particular time fail to pay and thus, going without water or opting to use unsafe water sources. In addition, the prepaid meters were leading into low pressures or completely no water flow on cloudy days. With these two revelations, the established affordability ratio can be challenged as being cosmetic since there is a possibility that the low water expenses could be as a result of not accessing enough due to the observed issues.

The AR of 1.8 % established in Mzuzu by Chiumya and Gumbo (2023) contradicts the finding of Beard and Mitlin (2021), who found an AR of 6.2 % for Mzuzu City, and 6.9 % specifically for Zolozolo, in a study that analysed both primary and secondary data to establish water affordability for 15 cities in the sub-Saharan Africa, South Asia, and Latin America. The 15 cities include: Kampala, Uganda; Lagos, Nigeria; Maputo, Mozambique; Mzuzu, Malawi; Nairobi, Kenya; Bengaluru, India; Colombo, Sri Lanka; Dhaka, Bangladesh; Karachi, Pakistan; Mumbai, India; Caracas, Venezuela; Cochabamba, Bolivia; Rio de Janeiro, Brazil; São Paulo, Brazil; and Santiago de Cali, Colombia. Beard and Mitlin (2021) also demonstrated that informal and rural settlements are more vulnerable when it comes to water affordability after establishing that ARs were higher in all the informal settlements than the respective average ARs for the 15 cities.

The affordability measure using the affordability ratio has been challenged in many ways, especially on how to estimate the numerator and the denominator. Water affordability measures that base on the expenses associated with piped water consumption would be misleading as it may under or over-estimate the affordability ratio. For instance, in the case of service quality problems such as intermittent supply, common in developing countries, it would result in less consumption which in turn would reflect low affordability ratio Martinez-Espiñeira and Pérez Urdiales (2024). Another complication for accurate measurement of affordability is in contexts where households have access to households use multiple sources of water which may also be free, thus, providing false indication that the water is affordable (Israel, 2007; Komarulzaman et al., 2019). It is further argued that this approach fails to capture heterogeneity within groups, as such, a true reflection of the extent of affordability constraints may not be revealed, particularly in for poor, large households that may require significant quantities of water Andres et al. (2021).

Researchers have thus argued that, instead of using water expenditure or average water bill as the numerator in the affordability ratio, using the cost for minimum amount of water for basic needs would help in avoiding over- or under-estimations (Goddard et al., 2021; Mastracchio et al., 2020; Teodoro, 2018). Another complication for accurate measurement of affordability is in contexts where households use multiple sources of water, some of which may also be free, thus, providing false indication that the water is affordable (Israel, 2007; Komarulzaman et al., 2019). On the contrary, where the consumption exceeds the basic household domestic requirement, the service would seem unaffordable because of high water expense in water bills. Fagundes et al. (2023) summarise from the reviewed studies, the authors' 15 possible affordability ratio combinations as shown in Figure 2-3.

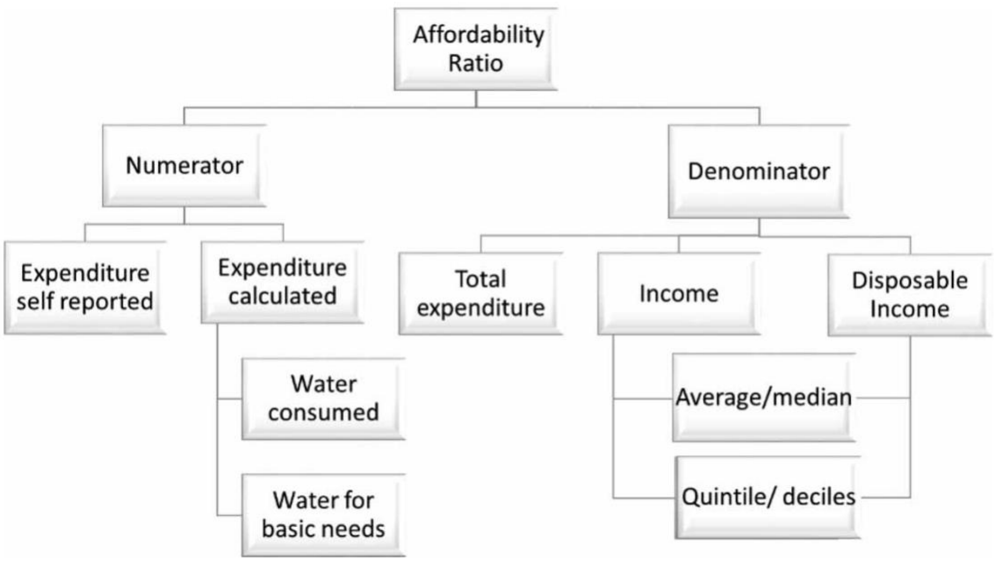


Figure 2-3: Possibilities of Affordability Ratio

Source: Fagundes et al., 2023

Figure 2-3 demonstrates that authors have proposed possible affordability ratio combinations namely: Self-reported expenditure and Total expenditure; Self-reported expenditure and Total income (average); Self-reported expenditure and Total income (quintile); Self-reported expenditure and Disposable income (average); Self-reported expenditure and Disposable (quintile); Calculated expenditure (water consumed) and Total expenditure; Calculated expenditure (water consumed) and Total income (average); Calculated expenditure (water consumed) and Total income (quintile); Calculated expenditure (water consumed) and Disposable income (average); Calculated expenditure (water consumed) and Disposable (quintile); Calculated expenditure (basic needs) and Total expenditure; Calculated expenditure (basic needs) and Total income (average); Calculated expenditure (basic needs) and Total income (quintile); Calculated expenditure (basic needs) and Disposable income (average); and Calculated expenditure (basic needs) and Disposable (quintile).

Although water affordability is monitored in developed countries, Cook and Whittington (2020) observed that tools used for assessing affordability are not compatible with rural areas in the Global South where most households do not use piped water. This is because there are no clear affordability standards in many countries and regions, and literature does not provide any for Malawi. Despite having these definitions, formulae and thresholds, Holm, Singini and Gwayi (2016) observed that data on household water expenditure could scarcely be sourced. Adams and Smiley (2018) also noted that there was still no country level baseline data for Malawi provided by the JMP on affordability, which in essence could lead to difficulties in tracking its progress. This means that there has to be a better way of measuring water affordability in a Malawian local setup. In addition, there are not many studies that have measured the affordability of water in Malawi using the affordability ratio, and the literature is limited to municipal water supply. No study has examined the affordability of non-piped systems. Perhaps, the limited literature mirrors the absence of affordability standards and standardised means of measuring.

2.4.2 Water Pricing and Affordability

Water pricing with affordability in mind is a complex exercise that has no one size fits all, or superior option. The pricing has to strike a balance between affordability by consumers and other pricing objectives, although the final decision may eventually be influenced by political preferences of any country (Lehmann, 2011). Literature underscores the need to consider the communities with severe affordability issues due to low income to extreme poverty such as those in the rural areas and informal settlements (Beard and Mitlin, 2021; Mitlin and Walnycki, 2020; Rahaman and Ahmed, 2016; Zhang et al., 2022).

A study in rural Kenya by Hope and Ballon (2021) found that vulnerable groups such as women and low-income individuals prioritised household water payments of not exceeding $1 per month. This implies that any payments exceeding the $1 per household per month would result in extreme pressure on the households, who may not even afford to pay, and eventually resulting in payments defaulting and going for alternative unsafe water sources. While recognising that tariffs are essential, Andres et al. (2021) argue that they are not the only means to address affordability, as the water services providers also need to operate on a cost recovery basis (Mitlin and Walnycki, 2020). One way of ensuring affordability has been to subsidise the vulnerable customers, ensuring that they too can access enough quantity (Andres et al., 2021; Beard and Mitlin, 2021). Studies have also shown some of the pricing mechanisms that are used ensure that the commodity is affordable to all while ensuring that there is cost recovery for the sustainability of service provision. One of the ways is tariff differentiation. Tariff differentiation generally implies that “the marginal cost of water supply is not imposed on each customer and unit of water consumed” (Lehmann, 2011, p. 19).

Based on analysed literature, Lehmann (2011) details five different forms of tariff differentiation. *Differentiation by consumption* is the form of differentiation that sets low tariff for the first specified volume, beyond which the tariff is higher. The problem with differentiation by consumption is that it grants subsidies to low-volume customers irrespective of whether they are poor or rich. *Differentiation by service quality* is where tariffs are set low for lower service quality such as communal stand pipes than those with house hold connections, just as an example. This is considered more effective in reaching the poor because the willingness to accept a low-quality service such as public standpipes could be a better indicator of poverty than consumption. *Differentiation by individual welfare considers* the subsidisation of the poor connected to the network, and this ensures that they too can enjoy the service and not left behind. *Differentiation by geographical location* is where different locations are given different tariffs based on the social-economic status of the area. This is considered as a good means to make tariffs affordable if poor and wealthy customers live in clearly segregated neighbourhoods. The last form is *differentiation by economic activity,* which is applied based on economic activity taking place on the premises. However, there is no clear-cut evidence from empirical studies, as to what extent tariff makes water more affordable to the poor. Despite this being the case, it can be argued that higher tariffs in case of economic activities can help subsidise the vulnerable groups.

A study by Marewo (2025) looked at differential water pricing by the service provider, Northern Region Water Board (NWRB) in Mzuzu City in Malawi. Analysing from the study results as provided by Table 2-3, the NWRB applied a mixture of differentiation by service quality (for household consumption customers) and differentiation by economic activity (for institutional and commercial customers). Those accessing communal water points had the lowest tariff, and for argument's sake, we attach a factor of 1.0 as our benchmark. Households with own standpipe connection had a factor of 1.37, which implies that the tariff was 1.37 times that of communal water point. Similarly, households with water facilities in homes had a factor of 1.87, institutional customers at 3.0, while the commercial customers were the highest at 4.25.

Table 2-3: Differential pricing factor at NRWB in Mzuzu as at September 2024

Customer Category	Pricing Factor

Communal water points/standpipes	1.0
Households with standpipes only	1.37
Households with water facilities in homes	1.87
Institutional customers	3.0
Commercial customers	4.25

Source: Modified from Marewo (2025)

2.4.3 Literature Gap on Affordability of Drinking Water Services

There are limited studies on drinking water affordability in Malawi in general. Few studies have touched on the water pricing policies and their impact on household affordability and willingness to pay. Although insufficient, the available literature also shows that past studies have focussed on users of piped water systems because of the ease to access water expense data which is mostly based on water bills. but no studies have been conducted to assess the affordability by households using unmetered water sources, like the case of handpumps. Assessing drinking water affordability by handpump users would be a plus to the body of knowledge, as both generated data and methodology would be contextual.

2.5 Equitability of Access to Drinking Water Services

2.5.1 Forms of Drinking Water Access Inequalities – An Overview

Equitable access by the JMPs normative interpretation implies progressive reduction and elimination of inequalities between population subgroups (WHO and UNICEF, 2017b). The purpose of having equitable access is to ensure that no population subgroup enjoys better access than the other. However, studies have established disparities in the access to safe drinking water between the rich and the poor; and the urban and the rural populations; with the rich households and urban population having advantage over the poor households and rural population respectively (Cassivi et al., 2020; Chitonge et al., 2020; Hernández-Vasquéz et al., 2021; Oskam et al., 2021).

A study by Mulenga et al. (2017) examined household data from 2013-14 Zambia Demographic and Health Survey, with a sample size of 15,920 households, established that access to improved water and sanitation was concentrated among the wealthier households and increased with increasing wealth quintile in both urban and rural setup. Further, study showed that wealth index, gender of household head, region and type of place of residence were all positively associated with access to improved sanitation. To enhance access to improved water and sanitation among the poor households it is imperative that government and other stakeholders intervene by providing the amenities or by subsidising the provision.

There has also been evidence equity concerns being linked to low income areas and some ethnic groups (Allaire and Acquah, 2022; Frone et al., 2013), and this too needs serious consideration. Beard and Mitlin (2021) also pointed out that some of the existing inequalities are as a result of peri-urban and informal settlements being excluded from public policies. In addition, sidelining of rural areas from water supply infrastructure investment and limited awareness of water supply inequalities in the political and social arena are other factors leading to persistent inequalities in water supply (Huber et al., 2024).

2.5.2 Strategies and Approaches for Eliminating Inequalities in Access to Water

While inequalities in access to drinking water need to be eliminated, Adams and Smiley (2018) argue that it is almost impossible to eliminate inequalities in water access if a “one size fits all” approach is used in the implementation. UNECE (2013) argue that some people, such as those living in small rural communities, the homeless, or the urban poor, who cannot afford to pay their water bills, require special attention. Otherwise, disparities in access to water would continue to exist and undermine efforts towards achieving SDG 6.1. It is recommended that specific approaches that are adaptive to the needs of vulnerable groups e.g., people with disabilities, ethnic minorities, illegal settlers and institutions e.g., schools, prisons, refugee camps, are needed if disparities in access to safe water are to be eliminated (UNECE, 2013).

The understanding of equity in water access should be that every population subgroup must be considered contextually following laid down procedures and guidelines. However, in a study in Ghana, it was observed that failure of communities to express effective demand in a demand driven approach, lack or limited knowledge of procedures that have to be followed in acquiring new water sources, negligence by district or national officials in applying guidelines, resource allocation mechanisms that are based on population formulae other than demand, political interference, as well as NGOs channelling funds to specific districts or localities without necessarily following an equity criteria, are some of the factors that are affecting equitable distribution of water sources (Water Aid, 2005).

For the provision of equitable access to water, UNECE and WHO-Europe (2019) identify three key dimensions that countries should consider during water service provision: reducing geographical differences, preventing discrimination or exclusion of vulnerable and marginalised groups, and ensuring financial affordability for users. Further to this, Bos (2016) emphasises on the need for service providers to engage in consultative processes with specific individuals or groups and government authorities in order to ensure the elimination of barriers to safe water access by marginalised or vulnerable individuals or groups. This is echoed by Mactaggart et al. (2018), who also call on programme implementers and policy makers to ensure a comprehensive and participatory way of incorporating the needs of persons with disabilities (and other vulnerable groups) into programme design. Mulenga et al. (2017) went further to suggest the provision of amenities or subsidies from government and other stakeholders.

2.5.3 Literature Gap on Equitability of Access to Drinking Water

Literature has failed to demonstrate the existence of studies that have analysed on the governance dynamics shaping equitability of access Studies have also focused on water access disparities and inequalities from a broader perspective like global, regional and national level, and less done to explore more on the dynamics around the equitability of access to water at the lowest community level, like village level, with a special focus on the marginalised populations. Leaving no one behind depends specific solutions to the specific needs of a specific lowest subgroup in society. New research direction should therefore focus on micro units and establish the dynamics involved.

2.6 Universality of Access to Drinking Water Services

2.6.1 Understanding the Impact of Distance and Time in Drinking Water Services

Aiga and Umenai (2003) observed that access to safe water had different definitions across nations worldwide and among various organisations and authors. They further observed that governments would formulate country-specific definitions which were either distance based, time based, quantity based, or a combination of any of the three factors, as a modification to the UNDP definition "The proportion of the population using any piped water, public tap, borehole with a pump, protected well, and springs or rainwater" and the World Bank definition "In urban areas, such a source [of safe water] may be a public fountain or standpoint located not more than 200 meters away; and in rural areas access implies that members of the household do not have to spend a disproportionate part of the day fetching water*"*. WHO, (2017) In Malawi for example, "a household has access to an improved source if the household has access to a minimum 27 litres per person per day from an improved source at a maximum one-way distance of 500m in rural areas, and 200m in urban areas at a maximum round trip of less than 30min" (Government of Malawi, n.d., p. 10).

In another definition, Dinka (2018, p. 168) states that "accessibility to water refers to the accessibility to a reliable supply of water continuously close to the point of demand: within everyone's reach: home, school, work, public places. It is related to the distance of the water source from the point of demand (30-minute walk or 0.2 km). That means that the water must be accessible for everyone, including children, elders and disabled ones". Similarly, Bos (2016, p. 9) states that "accessibility refers to the distance or time to a reliable water supply (from the house, but also from the workplace, school or other public places) and whether the services can be accessed by, for example, people with disabilities". In both cases, time and distances have been mentioned, signifying their relevance in safe water access as observed by Akoteyon (2019) and Kithinji (2015) that walking distance and round trip time to and from an improved water source are vital in gaining access to water. WHO (2017) also agrees to agrees by saying that the quantities of water that households collected and use are primarily a function of the distance to the water source or total time required for a round trip. Apart from time and distance considerations, the definitions of access to safe water also provide for consideration of those disadvantaged, such as people with physical disability, the elderly and children.

The JMP defines access to safe water as having sufficient water to meet domestic needs reliably available close to home (WHO and UNICEF, 2017b). Although "close" was not defined, this implies that the water users should not walk long distances to fetch water in order for them to be able to collect as much water as they need for domestic and other purposes. Mathew (2005) validates the linkage between the proximity of water source and consumption by saying that people consume more water if the source is relatively close to the home, and vice versa. In agreement, the findings of Manda (2009) suggest that distance to water source is one of the factors that affect access to adequate safe water. A similar observation was also made by Aikowe and Mazancová (2021) who stated that distance to a water source is a factor that influences water source usage.

Piped water systems are seen to be the most practical way of bringing water closest to homes. However, Malloy-Good and Smith (2008) observed that due to scatteredness of some rural population, some villages may still not be able to have piped water, and at the same time, provision of boreholes would also not be sufficient to enable the rural masses have access to a nearby water source. As such, water would still be fetched from a considerable distance. Furthermore, Dangana and Muhammad (2016) observed that the choice of which water sources to fetch water from is based on ease. In other words, one would choose to go a longer path to a water source if the shorter path has obstacles which include but are not limited to poor terrain, path roughness, thickets and reports of vicious wild animals.

Studies have shown that the amount of time taken to collect water also determines the quantity of water a household will collect. Hutton and Haller (2004) and (WHO and UNICEF, 2010) agree that spending more than 30minutes per round trip of water collection increases the risk of people failing to meet their minimum water needs. In this case, the need for more water would result in more time being spent on water collection, thereby paralysing other daily socio-economic activities. Much as longer collection time could also be associated with long walking distances, there are also other factors that can lead to this. Longer waiting times are sometimes due to low boreholes yields or malfunctioning of the handpumps (Adams and Smiley, 2018; SKAT-RWSN, 2009). Manda (2009) suggests that longer waiting times lead to lengthened collection times and, eventually, result in the collection of less water quantity. Longer waiting times are sometimes due to low flows as result of low boreholes yields or malfunctioning of the handpumps (Adams and Smiley, 2018; SKAT-RWSN, 2009). On the other hand, increased number of waterpoint users could also lead to longer waiting times as a result of long queues. Piped water to homes would be the best solution to ensure reduced time spent fetching water, thereby alleviating the disproportionate burden placed on women and girls (UNICEF, 2016).

2.6.2 Universal Access to Drinking Water: What It Takes

Jaiyesimi (2016) therefore highlights that policy, financing, and financial prudence and accountability, capacity building, and technology and data to drive improvement are areas to consider during implementation of the SDGs. The paper is challenging the policy makers and implanters on the need for policy realignment to respond to the SDG aspirations for universal water access. The paper signals the need for massive investment if progress is to be seen on the ground, which is highly dependent on donor support. The need for prudence and accountability in the handling of the finances, is not only to gain donor confidence and trust, but also to ensure development effectiveness, where every coin translates to development on the ground.

Technology brings answer to some of the challenge related to data management and infrastructure development. Capacity is cross-cutting as it bridges gaps in all the aspects.

Other scholars also echoed the requirement for significant financial resources to hugely invest in new infrastructure as well as increasing functionality of the existing infrastructure (Holm et al., 2016b; Hutton and Varughese, 2016; Machete and Marques, 2021; World Bank, 2018). Leigland et al. (2016) noted that the current donor and public funds would not be sufficient for the realisation of safe and affordable water for every person on the globe, and that dramatic increase in investment would be required. Hutton and Varughese (2016) then suggested that capital investments amounting to about three times the investment levels as at that time, were required to achieve the universal water supply, sanitation, and hygiene aspirations, and that these capital investments should translate into effective service delivery. This is an indication that without enough financial resources, which mostly is external support, there would be no achievement. Akpabio et al. (2022) attributed donor support as the key contributor to Malawi's progress on water supply and sanitation.

In addition to capital investments, achieving universal access to drinking water requires deployment of the right tools and approaches in a way that is sensitive to local setting (Ait-Kadi, 2016), and not "one size fits all" approaches (Adams and Smiley, 2018; Andreah, 2022). It was further highlighted that, if no one is to be left behind, the targets must make sense at the national level and should be contextualised at the community level (Machingura *et al.,* 2018), with increased attention on disadvantaged groups (Cetrulo et al., 2020; UN Water, 2018b). In principle, for efficiency and effectiveness, these investments require good coordination and collaboration among stakeholders at all levels (Huber et al., 2024; Kolker et al., 2016), engaging all the actors from local communities to the highest decision-making level alike (Tang et al., 2022).

Attainment of universal water access also the sustainable development of the water sector, which, according to Dinka (2018), is dependent on the sustainable developments of other sectors. This is because unsustainable developmental activities, both within the sector and in other sectors, are threatening the quantity and quality of our precious freshwater resources. Sustainability of water supply services also involves sustenance of existing water infrastructure through strengthening of O&M services; and this has an impact on the progress of universality of the access. Truslove et al. (2020) and Bos (2016) agree in that national and SDG targets on drinking water would unlikely be met until there are long term investments in O&M. The investments in O&M are aimed at increasing the functionality rate of existing infrastructure, thus ensuring the sustainability of the systems and thereby providing continuous access to safe drinking water (Fisher et al., 2015; Jaiyesimi, 2016). However, it is worth noting that, in some cases, despite enhancing the operation and maintenance of existing infrastructure, functionality will still be a problem due to environmental factors such as lowering levels of groundwater, leading to drying up of some wells. For instance, Mkandawire et al. (2019) found that 48% of rope pumps in Rumphi District in Malawi was non-functional due to unavailability of water in the well. This signifies that, instead of only focusing on adding new infrastructure in areas where there are none, these dry wells need to be replaced as well, which in itself is counter-productive.

Dinka (2018) also observed that, high population growth rate; high rate of urbanization; significant land cover and climate change; high demand for new energy supplies; and poor governance, are some of the threats to the sustainability and universality of water supply services, the majority of which fall within the control of other sectors. In extension to what Dinka (2018) outlined, other studies have also shown that there are factors that require serious consideration if the battle for universal access is to be won. Some of these are factors include but not limited to: geographical location, geology and hydrogeology, climate, relief, environmental degradation, population pressure, urbanization, community participation, politics and political will, vandalism, poor maintenance culture, tradition and functionality of infrastructure (Obeta and Nwankwo, 2015; Phiri et al., 2023).

2.6.3 Literature Gap on Universality of Access to Drinking Water

The main identified gap is that there are limited studies on the scalable and sustainable technologies and other solutions that can respond to the growing concerns of poor water quality and hard to reach rural areas to ensure universal access to safe water

2.7 Water Policy in Malawi

Government of Malawi (GoM), through the Ministry responsible for water and sanitation issues, developed the National Water Policy to guide implementation of water related activities in the country. Specifically, Nation Water Policy of 2005 was developed to guide in areas of water resources management and development, water quality and pollution control, water utilisation and disaster management. In summary, among others, the policy aims at: Achieving sustainable provision of water supply and sanitation services that are equitably accessible and used by individuals and entrepreneurs for socio-economic development at affordable cost; ensuring sustainable and integrated water resources management and development; ensuring water of acceptable quality for all needs; ensuring sustainable provision of water and sanitation services;;promoting international cooperation in the management of trans-boundary and cross-boundary waters; and promoting the participation of the private sector in water resources development, management and service delivery. The policy also promotes the use of IWRM principles, environmental protection and improvement of institutional and legal framework (Government of Malawi, 2005). Through the same policy, GoM promotes community-based management (CBM) in rural water supply and sanitation programmes in consultation with Local Governments. The arrangement ensures that each water point or rural water supply scheme should have a committee that is trained to manage the water facility at community level. The policy also promotes demand responsive and demand driven approaches in rural water supply and sanitation services.

In summary, the policy is very relevant to the study because it promotes the sustainable provision of drinking water that is of good quality and affordable in an equitable manner. This encompasses all the four dimensions of study namely: safety, affordability, equitable and universal water services.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study Area

3.1.1 Selection of the Study Areas

The study was conducted in four Traditional Authorities (TAs) of Nankumba, Chilipa, Namavi and Katuli in Mangochi District. Surveys done by the National Statistical Office have shown that there has been a drop in the proportion of households using improved water sources in the district, from 92.7% in 2014 to 84.8% in 2019 (National Statistical Office, 2020, 2016). At the same time, Mangochi District benefits from huge investments in community water supply from various partners, the most conspicuous partner being Government of Iceland, which has been rolling back to back programmes in the district worthy over 3 million US Dollars (Mangochi District Council and ICEIDA, 2017). The 8% drop in safe water coverage on the one hand, and the huge investments on the other, seemed not to corelate; and this aroused interest to conduct the study in the district.

3.1.2 General Overview of the Study Area

Mangochi District is one of the 15 districts of the Southern Region of Malawi. It is located at the southern end of Lake Malawi and surrounds the eastern arm of the lake (see Figure 3-1). The district is located between latitudes 13°28'59" S and 14°47'53" S, and longitudes 34°43'20" E and 35°46'11" E; with minimum, maximum and average elevations of 473, 1980 and 726 meters above sea level (masl) respectively ("Mangochi topographic map," n.d.). In addition, the district's land area of 6,729 square kilometres is the largest in the whole Southern Region; it constitutes 21.2% of the Southern Region's land area and 7.1% of Malawi's total land area (National Statistical Office, 2019). Mangochi District is divided into 13 Traditional Authorities, with a total of 306 group villages and 1569 villages. In terms of political administration, the district is divided into 12 constituencies and 24 wards. The district is also divided into 25 development planning areas called area development committees (ADCs) and subdivided into 208 village development committees (VDCs) (Mangochi District Council, 2017).

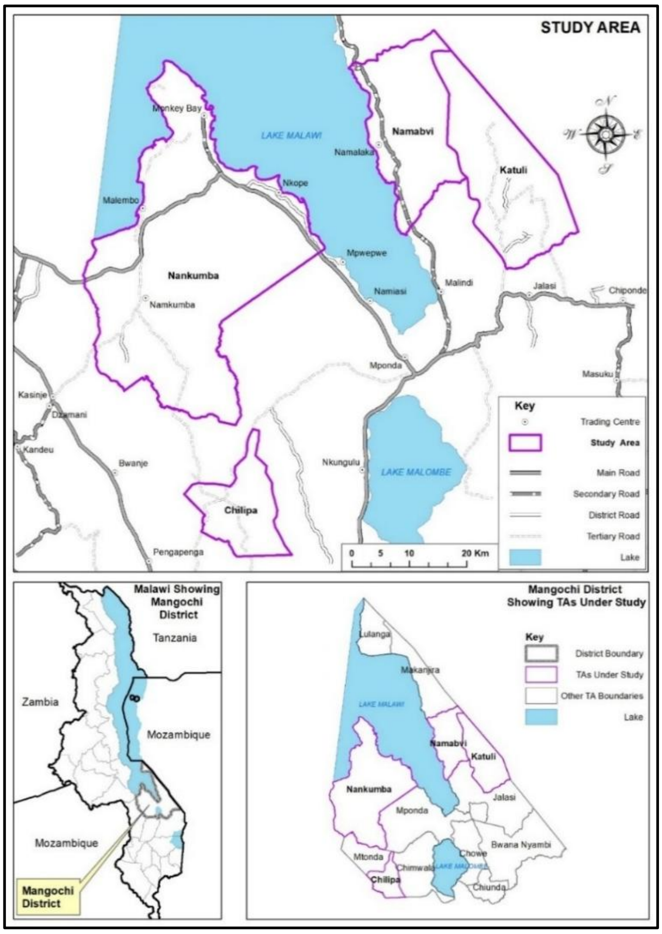


Figure 3-1: Map of the Study Area

Source: Author

The population of Mangochi District (1,148,611 as at 2018 and projected to 1,420,142 as at 2024) is the largest in the Southern Region and constitutes 14.8% of the region's population and 6.5% of the Malawi's population. The population growth rate of the district is 3.6%, which is higher than both the national growth rate (2.9%) and that of the Southern Region (2.7%) (National Statistical Office, 2019). The people in this district are predominantly Yao by tribe and Chiyao is their main language. There are other ethnic groups in the district such as Ngoni, Chewa, Tumbuka, Tonga and Lomwe that are mostly found in TA Nankumba. Islam is the main religion (70%) in the district followed by Christianity (28%). Both monogamy and polygamy are practiced in the district dependent on one's faith orientation. Mostly, the district is a matrilineal society due to the Yao dominance (Mangochi District Council, 2017).

Mangochi District is supplied with potable water through different sources. Southern Region Water Board (SWRB) supplies the urban and peri-urban areas in the district with piped water through connections to premises and public kiosks. The rest of the areas are serviced through rural water supply systems such as boreholes, protected shallow wells and piped water through gravity fed systems or solar powered reticulated systems (Mangochi District Council, 2017). Generally, 78% of the households in Mangochi District uses handpump fitted groundwater sources, which are boreholes and protected shallow wells combined (National Statistical Office, 2020). This is a demonstration of how much the district relies on groundwater for its water supply. It is therefore imperative to understand that the hydrogeology of the district is characterized by two main aquifer types namely: ❶ unconsolidated alluvium which mainly lies in the lakeshore plains of Lake Malawi and Lake Malombe as well as along the Shire River; and ❷ basement aquifers which lie mainly in the upland areas extending eastwards and westwards of the district and some hilly land portions that extend into Lake Malawi (Upton et al., 2018).

3.2 Research Approach and Design

The study employed a cross-sectional mixed methods design. Cross-sectional study is used to obtain an overall picture of phenomenon as it stands at the time of study (Kumar, 2011). In mixed methods study, the researcher collects both quantitative and qualitative data, and uses the qualitative data to further explain the quantitative results (Creswell, 2014). This design was decided bearing in mind that the core of this study is "access to safe drinking water", which is primarily expressed quantitatively at any given time, and the qualitive data would provide more insight into the figures.

3.3 Study Population

The primary unit of analysis in this study was a household. The primary study population was therefore 75,277 households, which is a summation of all households in the four TAs in the study.

3.4 Sample Size and Sampling Technique

The study employed a multilevel mixed sampling design. In this case, multilevel implies that the sampling was done at multiple stages, while mixed design implies that both probability and non-probability sampling techniques were used (Kumar, 2011; Teddlie and Yu, 2007). Specifically, the study applied purposive, stratified, cluster and random sampling techniques. Purposive sampling, also referred to as deliberate sampling, is a non-probability sampling technique in which the researcher handpicks the study units to be included in the sample based on their own judgement (Cohen et al., 2000; Kothari, 2004). Stratified sampling is a probability sampling technique that involves dividing the population into subgroups, known as strata, whose subjects share homogeneity with respect to their characteristics; and it is from these strata that sample items are selected (Cohen et al., 2000; Kothari, 2004; Kumar, 2011). In cluster sampling, as another probability sampling technique, the population is divided into groups called clusters which are then used as sample units rather than individual elements in the groups (Kothari, 2004). Finally, random sampling as name suggests, is a procedure of randomly selecting participants from an accessible population to form a sample, in which each unit has equal chance of being selected without being affected by the selection of another unit (Creswell, 2014; Teddlie and Yu, 2007).

3.4.1 Sampling for Household survey

Arnab (2017, p. 340) suggests that "in cases where the estimates of the population characteristics are needed not only for the entire population but also for its different subpopulations, one should treat such subpopulations as strata." This was the case in the study whereby results were also needed to be understood per TA. As such, the study was stratified by TA. The four TAs that formed the study area were selected using purposive sampling technique, based on two main distinct factors: ❶access to improved water sources; and ❷location and topography. The "access" factor was used in order to understand more on the conditions associated with the disparity. The "location and topography" factor was considered with an understanding that different hydrogeological and water quality conditions could be associated with this. The four TAs were therefore selected based on whether they had highest or lowest access to improved water sources, combined with whether they were located in the lowlands or highlands. Lowlands implied areas along Lake Malawi, Shire River and Lake Malombe, while highlands implied those away from the water bodies and usually bearing higher elevations.

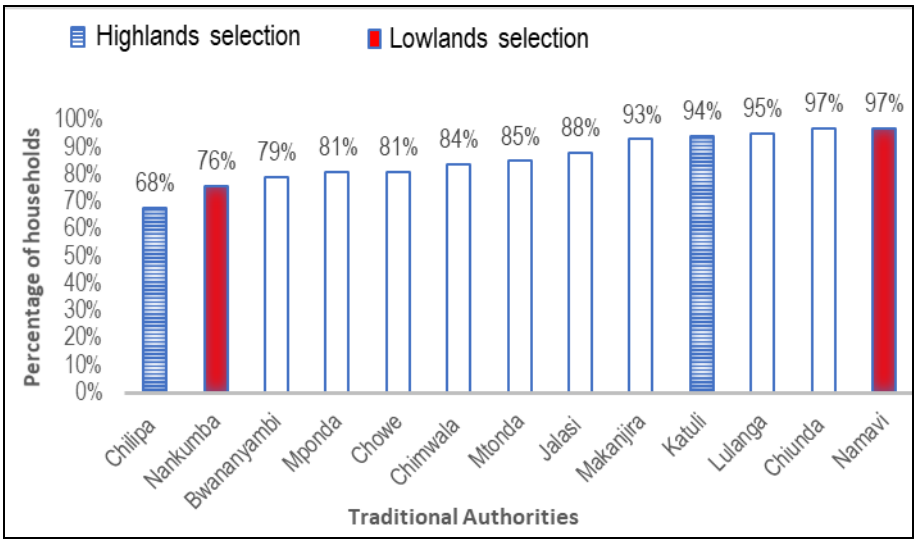


Figure 3-2:Water access by TA in Mangochi District

Source: MH DHO (2018)

Figure 3-2 presents a graphical presentation of proportions of households with access to improved water sources for all the 13 TAs in Mangochi District as at 2018. The analysis showed that: TA Chilipa was the lowest ranked in access and is on the highlands; TA Nankumba was the lowest ranked in access on the lowlands; and TA Namavi was highest ranked in access and is located on the lowlands. However, having taken out the highest ranked

TA in access (TA Namavi), both second and third highest (TA Chiunda and TA Lulanga respectively) could not be selected because they are also located on the lowlands. The fourth highest ranked (TA Katuli) was then selected as the highest ranked on the highlands. In summary, the criteria led to purposive selection of TAs Chilipa, Nankumba, Namavi and Katuli. Table 3-1 presents a summary of the selected TAs and the criteria involved.

Table 3-1: Number of Households and Water access in the study areas

No	Traditional Authority	Total Number of Households	Number of Households using improved water source	Proportional of HHs with access to improved water sources	Criteria
1	Chilipa	10,190	6,953	68%	lowest access in highlands
2	Nankumba	38,140	28,809	76%	lowest access in lowlands
3	Katuli	18,547	17,437	94%	highest access in highlands
4	Namavi	8,400	8,164	97%	highest access in lowlands
	Total	**75,277**	**61,363**	**81.52%**	

*Data Source***:** MH DHO (2018)

The second sampling stage involved the selection of ADCs which are below the TAs. For better spatial representativeness, all the 8 ADCs under the 4 TAs were purposively included. In stages 3 and 4, cluster sampling technique was employed, with the VDCs as clusters under the ADCs, and villages as clusters under the VDCs. Two VDCs were randomly selected from each ADC leading to a total of 16 VDCs. Similarly, 32 villages were randomly selected as clusters under the 16 VDCs. The actual selection of the clusters (VDCs and villages) into the samples followed the systematic random sampling technique which is a probability sampling technique that involves selecting subjects systematically by picking some random point and then selecting every ***n***th element until the desired sample is obtained (Cohen et al., 2000; Kothari, 2004;

Teddlie and Yu, 2007). Lastly, having selected the 32 sample villages for the study, simple random sampling technique was then employed for the selection of the actual participating households.

3.4.2 Sampling for Water Quality Testing

Since the study was looking at simultaneity, the water quality testing was also done in the same villages where household survey was carried out. The water quality testing targeted improved water sources from these villages. However, two villages had no improved water source, and therefore, sampling of the water points for inclusion in the study was done from 30 villages through simple random sampling technique.

3.4.3 Sampling for Key Informant Interviews

Key informants were purposively selected from a pool of stakeholders, based on the researcher's understanding on who would provide the necessary information. The key informants were heads of institutions, departments or directorates relevant to the study such as: Department of Water Supply Services and Department of Water Resources at central government level; Directorate of Planning and Development and District Water Development Office at local authority (Mangochi District Council) level; TA, ADC, VDC and GVH at community level. At community level, all the TAs and ADC chairpersons in the study area were considered as key informants; whereas one VDC chairperson and one GVH per ADC were considered as key informants, all purposively selected.

3.4.4 Sampling for Focus Group Discussions

The focus groups in this study consisted of individuals responsible for managing water facilities in the study area, commonly referred to as water point committees. Basically, these were considered to provide a better overview on water facilities management and sustainability issues. Although three to six focus are enough for the discovery of up to 90% of themes (Guest et al., 2017), it was decided that at least one focus group should be identified at each VDC. Cluster random sampling technique was therefore used, in such a way that the sampled improved water sources (described in 3.4.2) were clustered at VDCs level and then simple random sampling was used to select one improved water source whose committee would form a focus group (Teddlie and Yu, 2007).

3.4.5 Sample Size Calculation for Household

Sample size is the number of items to be selected from the population to come up with a sample (Kothari, 2004). For stratified random sampling (proportion), the following formula was applied to determine sample size, **n** for household survey (Al-Subaihi, 2003).

$$n = \frac{\sum_{i=1}^{L} \left(\frac{N_i^2 p_i (1 - p_i)}{w_i} \right)}{\frac{N^2 e^2}{Z^2} + \sum_{i=1}^{L} N_i p_i (1 - p_i)} \quad ❶$$

where

- n is the sample size needed (*in this case not known)*
- Z is the inverse of the standard normal deviation (*=**1.96** at 95% confidence level)*
- e is the acceptable error margin *(in this case set at **5%)***
- N is the total population *(in this case 75277 households)*
- p_i is the subpopulation proportion for stratum (i) *(in this case access percentages for individual TAs i.e. Chilipa 68%; Nankumba 76%; Katuli 94%; Namavi 97%)*
- N_i is the size of stratum(i) *(Chilipa 10190; Nankumba 38140; Katuli 18547; Namavi 8400*
- w_i is the estimated proportion of Ni to N *(Chilipa 0.135; Nankumba 0.507; Katuli 0.246; Namavi 0.112*
- n_i is the stratum sample size *(in this case not known)*

After inserting the values in the formula, the sample size, **n** = 261 households. After finding 261 as the minimum required sample size, it was necessary to provide additional allowances to cater for potential non-response by the subjects, as suggested by Bujang (2021). The study assumed a 10% non-response rate; hence the revised sample size was calculated as:

n = 261/0.9 = **290** households

Applying strata weights *(N_i / N)*

Chilipa	n1= 0.135*290 = 39.2 ≈ **39**
Nankumba	n2= 0.507*287 = 147.0 = **147**
Katuli	n3= 0.246*287 = 71.3 ≈ **71**
Namavi	n4= 0.112*287 = 32.5 ≈ **33**

3.4.6 Sample Size Calculation for Water Quality Analysis

The study targeted 103 functional improved water sources in the sampled villages. Based on similar past studies, the sample size was determined using a Yamane's (1967) formula (Daniel, 2012; Mikova and Abdalla, 2016; Oyatayo et al., 2015).

$$n = \frac{N}{1+N(e)^2} \quad ❷$$

where

- n is the sample size needed (*in this case not known)*
- e is the acceptable error margin *(in this case set at **5%** at a confidence level of 95%)*
- N is the total population *(in this case, 103)*

In this case, $n = \frac{103}{1+103(0.05)^2} = \mathbf{82}$

3.4.7 Sample Framework

Figure 3-3 presents a sampling framework which demonstrates a step-by-step sampling process for the study.

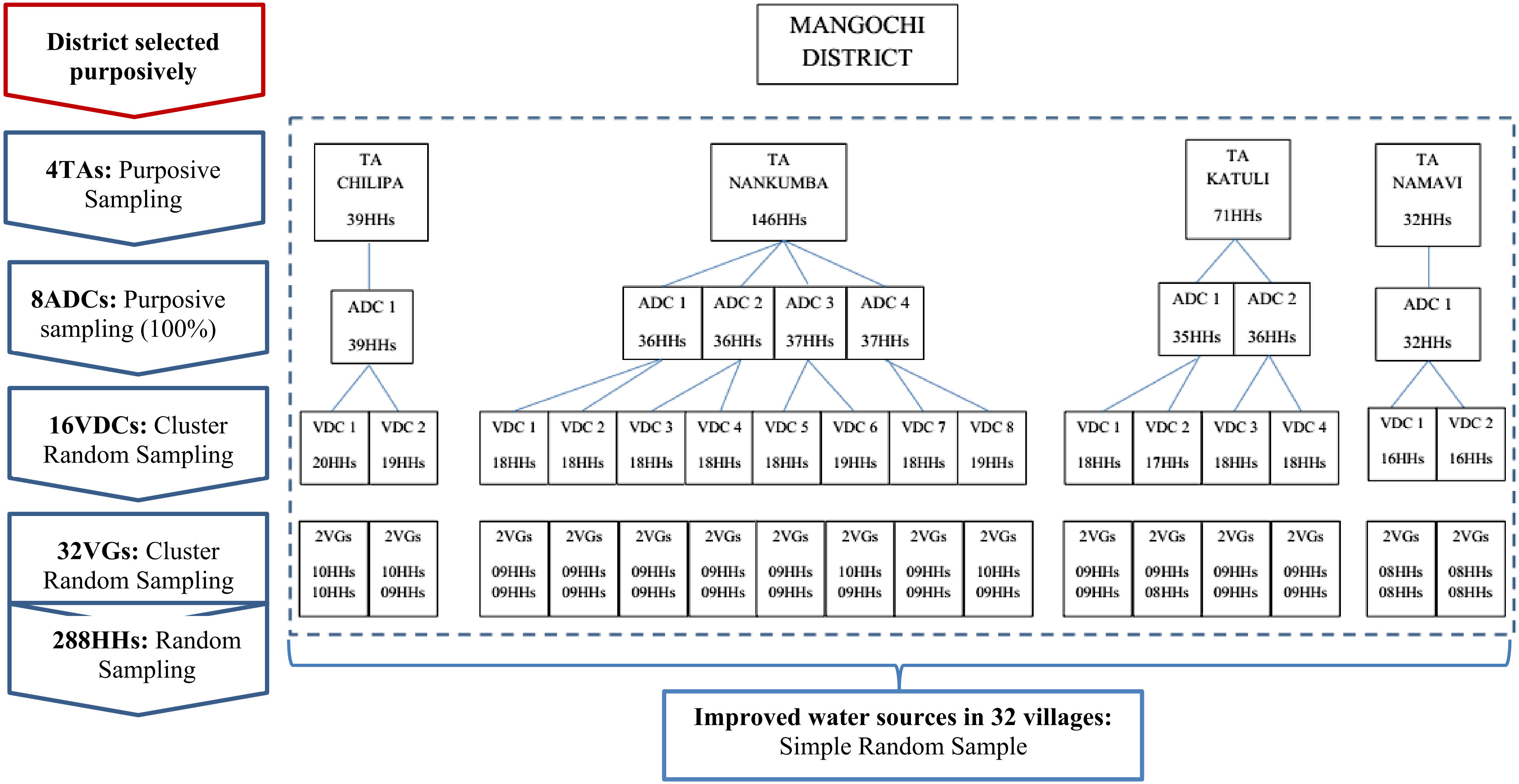


Figure 3-3: Sampling framework

3.5 Data Collection Methods

The study collected and used only primary data, both quantitative and qualitive. Sileyew (2019), describes surveys as one source of primary quantitative data, whereas for primary qualitative data, sources may include field observations, interviews, and informal discussions. The data collection methods that were employed in this study, therefore, included household survey, water quality testing, key informant interviews (KII), focus group discussions (FGD) and observations. Household survey and water quality testing generated quantitative data; while KII, FGD and observations generated qualitative data.

3.5.1 Household Survey

A household survey was conducted in the study area to collect quantitative data using a structured questionnaire as the data collection tool. The questionnaire was administered to heads of the sampled households; and where the household head was not present, the most senior member of the family was the respondent if they were at least 18 years old. The data collection was done using Google My Maps mobile application, in which the questionnaire was generated. Figure 3-4 shows some of the captured data stored on Google My Maps platform.

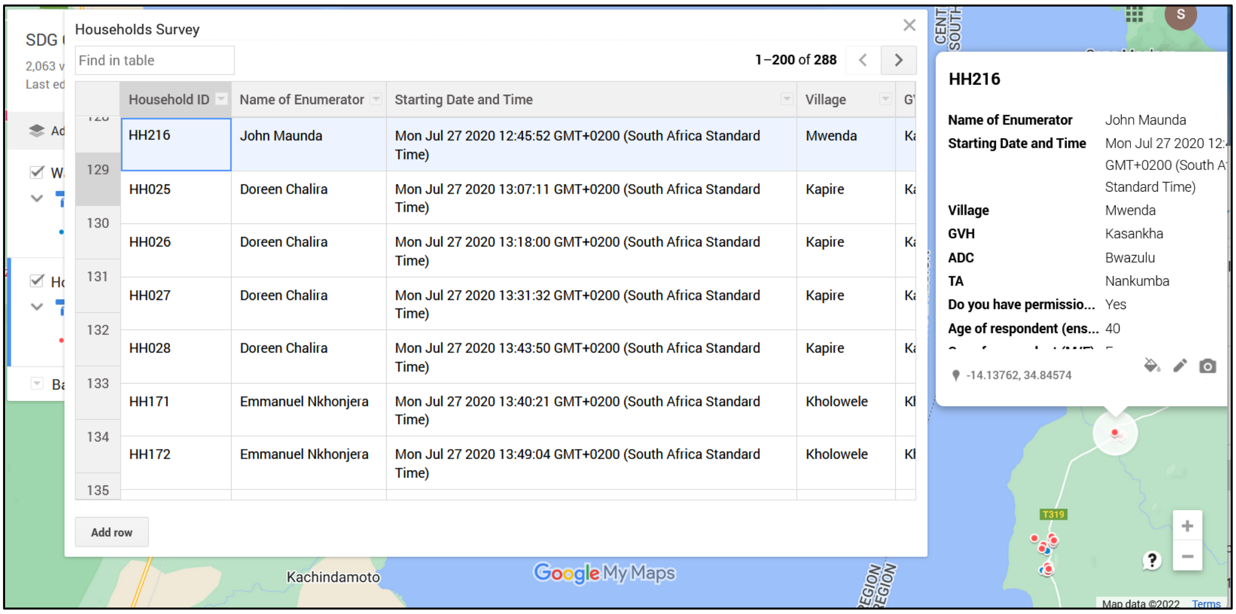


Figure 3-4: Google My Map Household Data Interface

Source: Author

A household survey is considered flexible, as it can accommodate a larger number of questions on various topics in its data collection tools (United Nations, 2008) . The questionnaire for this survey was also designed to capture data on a variety of areas such as: location; demography; access to safe water; expenses on water (contributions towards operation and maintenance); and monthly earnings and expenses (refer to Appendix A). The questionnaire was administered to 290 households as per sample size; however, data on two households collected on the last day of the survey failed to synchronise due to upgrades that the mobile application was going through on that day. As such, the study ultimately included 288 households with complete data sets, which is still a favourable outcome, considering that the actual sample size before accounting for the non-response rate was 261 households. The households were coded HH001 – HH288. Figure 3-5 is a map that shows the distribution of households, which visually appear as clusters representing the sampled villages.

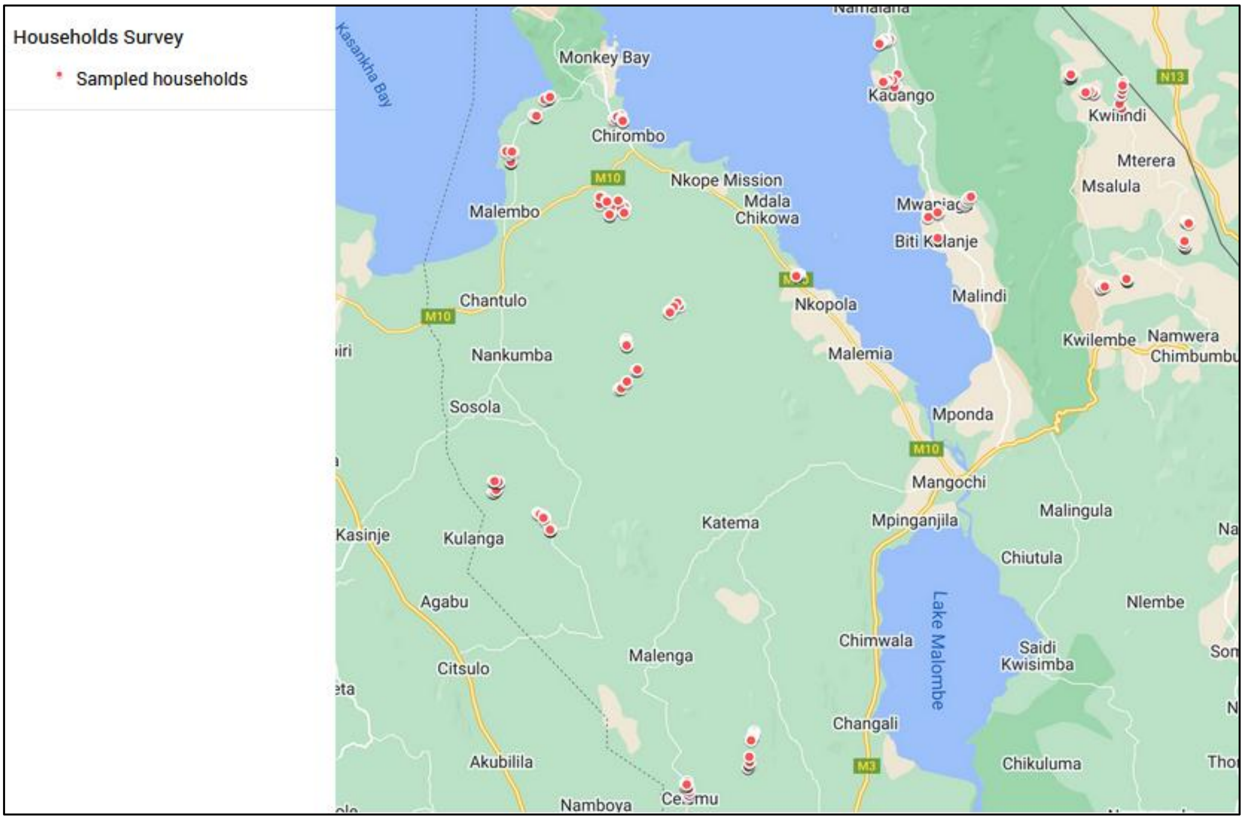


Figure 3-5: Map showing the sampled households

Source: Author

3.5.2 Water Quality Testing and Analysis

Water quality refers to the suitability of water for a particular use with respect its chemical, physical and biological characteristics (Daniels et al., 2010; Shaltami and Bustany, 2021). In this study, water quality testing and analysis was thus conducted for selected chemical, physical and microbial parameters. Specifically, the following nine parameter were tested and analysed: physical parameters namely total dissolves solids (TDS), electrical conductivity (EC) and turbidity; chemical parameters namely power of hydrogen (pH), arsenic (As) and fluoride (F^-); and microbial parameter namely faecal coliform (FC), faecal streptococci (FS) and *Escherichia coli* (*E. coli*) (Das and Behera, 2008; Prastowo and Nurdiyanto, 2021; Sharma, 2013; WHO, 2017). The study targeted 82 improved water sources spread across the study area as displayed in Figure 3-6. The improved water sources comprised of 75 standard machine drilled boreholes which are greater than 25m in depth, and hand auger (Vonder) drilled boreholes whose maximum depths do not exceed 20m (Government of Malawi, 2016a).

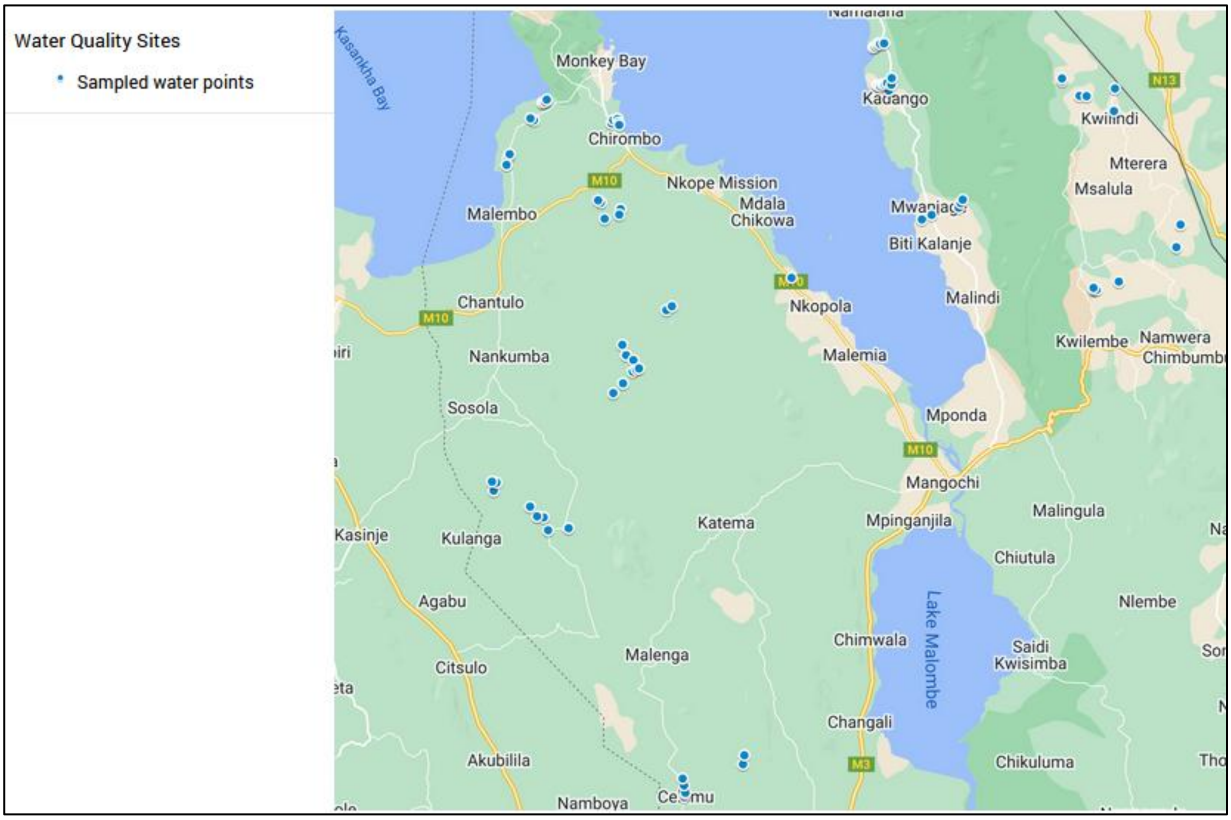


Figure 3-6: Map showing sampled water points

Source: Author

E. coli, arsenic and fluoride were selected in order to assess faecal and priority chemical contamination of drinking water as key water quality parameters under the SDG 6.1 monitoring (WHO and UNICEF, 2017b). However, FC and FS were also included as indicators of faecal contamination that would support differentiation of human from animal faecal matter, as sources of the identified faecal contamination (Morrison and Murphy, 2010). Despite pH, turbidity, TDS and EC having no direct impact on consumers and hence considered as operational indicators, they were included in the study because of their effect on palatability and acceptability of the drinking water. For instance, turbidity on the one hand, was included because any visible turbidity reduces acceptability by consumers because they perceive that the water may not be safe for drinking (Omer, 2019; WHO, 2017); on the other hand, high levels of turbidity would signify poor infrastructure design or poor water treatment e.g., poor well design, poor well development and/or poor filter pack in boreholes (Mannix et al., 2018). TDS and EC were included because, on the one hand, they provide an indication of the concentration of both organic and inorganic salts and level of their ionic activity in the water, without going into specific elements, while on the other hand, high levels would affect palatability of the water, which may lead to consumers preferring other sources (Omer, 2019; WHO, 2017). On the part of pH, its inclusion was for the purpose of determining acidity or basicity of water which also plays a role in the taste of the water as high pH would lead to a bitter taste and low pH a sour taste (Brebbia et al., 2017).

The water quality testing and analysis was conducted twice, in March 2020 for the wet season and October 2020 for the dry season, in order to assess temporal variations between the seasons. On-site testing was conducted for pH, EC, TDS, turbidity and fluoride using calibrated portable digital meters; while FS, FC, and E. coli were analysed at the Central Water Laboratory in Lilongwe. Both on-site and off-site analyses were conducted by laboratory officers. The waterpoints were given codes, WP001 to WP082, which were used throughout the analysis to avoid bias, and the actual area details were only revealed after analysis. Samples were collected and analysed in triplicates; however, the triplicate samples were considered as "single sample" after analysis and averaging. For instance, there were 82 water points, each visited twice for water testing, representing 164 sample sets. The results were also captured in Google My Maps application as shown by Figure 3-7.

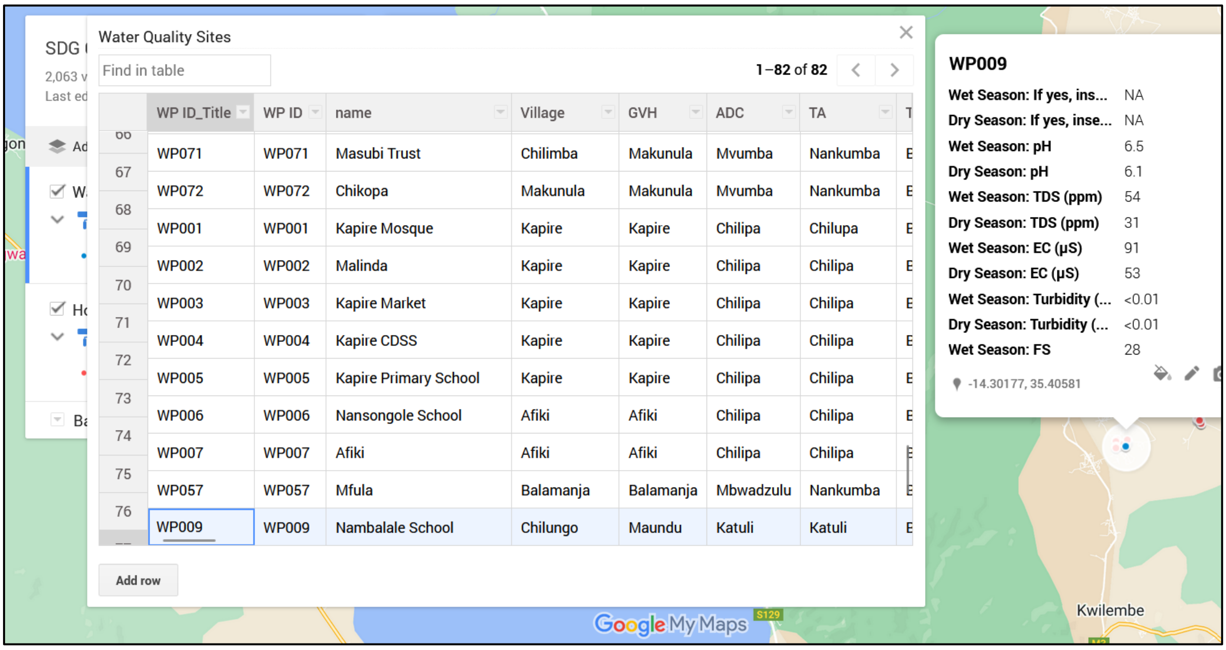


Figure 3-7: Google My Maps Water Quality Data Interface

Source: Author

Sufficient well purging was done before any sample was collected in order to obtain representative groundwater samples. If it was the first pumping of the day, purging of approximately three well volumes was achieved; but where the pumping by the users was occasional, purging was done for almost three casing volume (APHA, 1999; Government of Malawi, 2016b). The volume (in litres) was calculated using equation 3:

$$V = \frac{\pi}{4} D^2 H \times 1000 \qquad ❸$$

where: V is the required volume; D is the internal casing diameter; and H is the water column.

Since it was not feasible to be removing the handpumps to take well depth and static water level readings, and where information about well depth and casing details was not available, the average well depth of 45m, casing length and diameter of 3m and 110mm respectively (Government of Malawi, 2016a), and static water level (SWL) of 5m were assumed for all boreholes. The 5m SWL was reached with guidance from the Mangochi District Water Development Office which was responsible for monitoring of water points in the district.

Thus, for first pumping of the days: $H = 45\text{-}5 = \mathbf{40m}$; $D = 0.11m$

Therefore: $V = 380 litres$

$\approx$ ***19 pails*** *of 20 litre volume; and 3 volumes (3V)* $\approx$ ***57 pails***

The community was therefore allowed to at least draw 57 pails before any sample was collected.

But, for occasional pumping: $L = 3m \times 3 = \mathbf{9m}$; $D = 0.11m$

Therefore: $V = 86 litres$

$\approx$ ***4 - 5 pails*** *of 20 litre volume*

Immediately after purging, the mouth of the water outlet spout was sterilised by flaming methanol to avoid external contamination of the water as it comes. For on-site testing, the water samples were collected in three one-litre sampling bottles, whereas for laboratory analyses, water samples were collected using sterile standard "Whirl Pak" bags for microbiology analyses. The samples were labelled accordingly with identification code, date and time of sample, and then stored in a cooler box before transporting to the laboratory within 24 hours.

The ExStik FL700 fluoride meter from ExTech Instruments was used to conduct onsite fluoride testing of water. Total ionic strength adjustment buffer (TISAB) tablets were used as reagents. For values exceeding the meter's operating range of 0.00-9.99, deionised water was used for dilution. Based on the instrument's user guide, the fluoride meter was calibrated between 1 ppm and 10 ppm fluoride ion by using 1 ppm and 10 ppm fluoride standard solutions which were prepared by dissolving one TISAB tablet in 20ml of 1ppm fluoride standard and another tablet in 20ml of 10ppm fluoride standard respectively as detailed in Box 3-1. After calibration, a 20ml test solution was prepared by adding one TISAB reagent to the unknown sample. After the tablet had fully dissolved, and the solution thoroughly mixed, the test end of the FL700 meter was dipped in the solution until the reading on the meter had stabilised (Extech Instruments, n.d.).

On-site water testing for TDS, EC and pH was achieved using a Hanna Instruments portable digital pH/EC/TDS/°C meter, model HI9813-5. The meter has automatic temperature compensation for pH and conductivity. The meter was first calibrated for pH and conductivity following the procedures outlined in Box 3-2. To test the sample, almost 4cm of the tip of the meter's probe was immersed into the sample and ensured that no air bubbles were trapped inside the tap by lightly tapping the probe on the bottom of the test beaker. The meter's reading was then recorded after stabilisation (Hanna Instruments, n.d.).

Arsenic was tested using Rapid Arsenic Test Kit number 481396 from Industrial Test Systems, Inc, which detects inorganic Arsenic and gives results in 14 minutes. The kit has three types of reagents (first, second and third reagents) and arsenic test strips and easy read colour code (Industrial Test Systems Inc, 2017). The kit has a detection limit of 5 μg/L. The test procedure that was followed is described in Box 3-3.

Box 3-1: Calibration procedure for ExStik FL700 fluoride meter

Calibration

The FL700 can be calibrated between 1.0 ppm and 10 ppm or between 0.5 and 5.0 ppm Fluoride ion. Set the Mode to ppm. The following calibration procedure assumes the normal 1.0 to 10 ppm range has been chosen.

1. Prepare a 1 ppm fluoride standard solution by placing one TISAB tablet into a sample cup and add 20 mls of the 1ppm Fluoride standard into the sample cup.

   Note: if your 1ppm Fluoride standard already contains TISAB do not use a TISAB tablet.

2. Create a rinse solution that can be used between sample measurements buy dissolving 1 TISAB tablet in 20ml of Distilled water. The rinse solution promotes faster response times.
3. Rinse the end of the FL700 module in this Rinse solution or in Distilled water and then **wipe thoroughly** with a paper tissue.
4. Place the FL700 into the prepared 1 ppm standard and switch the instrument ON using the **ON/OFF** button. The instrument will now go through its self-calibration.
5. The instrument will enter HOLD mode in about 35 seconds when stabilized in the 1.0 ppm standard solution.
6. Press and HOLD the **CAL** key, CAL will appear in the display followed by 0.5ppm and 5.0ppm. Continue holding the CAL button until 1.0 ppm and CAL appear in the display. Release the **CAL** key.
7. Wait until the display stops blinking; the instrument will enter the normal measurement mode.
8. The instrument is now calibrated and ready for use.
9. The circled L and H icons on the display indicate that the low range (L) and high range (H) calibrations have been completed.

Calibration frequency

Calibrate the FL700 prior to each new measurement batch or if more than 12 hours has elapsed since the last calibration.

Source: ExStik FL700 fluoride meter user guide by Extech Instruments

Box 3-2: Calibration procedure for HI9813-5

pH CALIBRATION

For greatest accuracy, frequent calibration of the instrument is recommended. The instrument should be recalibrated for pH:

a) Whenever the electrode is replaced.
b) At least once a month.
c) After testing aggressive chemicals.
d) Where extreme accuracy is required.
e) Whenever the CAL CHECK test fails (**HI9813-6** only).

PREPARATION

Pour small quantities of pH7.01 (**HI7007**) or pH4.01 (**HI7004**) or pH10.01 (**HI7010**) solution into a clean beaker.
To obtain accurate readings, use pH7.01 (**HI7007**) if you are going to measure neutral or close to neutral samples, pH4.01 (**HI7004**) if you are going to measure acidic samples or pH10.01 (**HI7010**) for alkaline measurements.
If you need to calibrate to NIST standards, use pH6.86 (**HI7006**) instead of pH7.01 and pH9.18 (**HI7009**) instead of pH10.01.

PROCEDURE

- Connect the probe and switch the meter on, then press the **pH** key to display pH measurement.
- Remove the protective cap from the probe, rinse and immerse it in the buffer and stir gently. Wait a couple of minutes for the reading to stabilize.

- Take the temperature of the buffer solution, e.g. 10.0 °C, as follow: select the °C mode and read the displayed value.

- Adjust the pH calibration knob until the LCD shows the pH value at the above temperature (see the pH versus temperature chart).

- The pH calibration is now complete.

EC/TDS CALIBRATION

Accessories needed:

- Use **HI70031** (1413 µS/cm = 1.413 mS/cm) EC calibration solution or **HI70442** (1500 ppm) TDS calibration solution.

Note: The conversion between EC and TDS is made by a built-in circuit, hence it is requested to calibrate the meter only in EC or TDS range. The other range is thus automatically calibrated.

PROCEDURE

- Pour approximately 4 cm (1½") of a conductivity calibration solution (e.g. **HI7031**) into a beaker. If possible, use plastic beaker to minimize any EMC interference.
- Immerse the probe in the solution.
- Wait for a couple of minutes for thermal equilibrium to be reached.
- Tap the probe on the bottom, then shake it lightly while rotating to make sure no air bubbles remain trapped inside the probe.
- Press the **mS/cm** (or **ppm**) key.
- Turn the EC/TDS calibration knob until the display shows the EC or TDS reading at 25 °C.

Source: Instruction Manual for HI9813-5 & HI9813-6 Portable pH/EC/TDS/°C Meters

Box 3-3: Arsenic Test procedure

WARNING: Hydrogen and Arsine gases are generated during the test. Work in a well-ventilated area away from open flames and other sources of ignition. Review the Material Safety Data Sheet before handling any chemicals.

For better accuracy, we recommend running the test in duplicate for each water sample.

QUICK™ Rapid Arsenic Test Kit

Test Procedure:

(See Instruction Sticker in plastic case cover for visual help.)

FOLLOW KIT INSTRUCTIONS CLOSELY.
Part Number: 481396, 100 Tests

1. For best results, the water temperature should be between 22°C to 28°C / 72ºF - 84ºF . Use a thermometer to verify the temperature of the sample.
2. To the Reaction Bottle, slowly add the water sample to the marked line on the bottle (100 mL).
3. Add **3** level pink spoonfuls of First Reagent **1** to the Reaction Bottle. Cap the bottle securely with yellow mixing cap and shake vigorously for **15 seconds**.
4. Uncap the Reaction Bottle; add **3** level red spoonfuls of Second Reagent **2**. Cap the bottle securely with yellow mixing cap and shake vigorously with bottle upright for **15 seconds**. Allow the sample to sit for **2 minutes** to minimize Sulfide interference.
5. Uncap the Reaction Bottle and add **3** level white spoonfuls of Third Reagent **3**. Cap the bottle securely with yellow mixing cap and shake vigorously for **5 seconds**.
6. Remove yellow mixing cap. Recap the bottle immediately and securely using the white cap (must be dry) with turret up (open).
7. Remove one Arsenic test strip from the test strip bottle and immediately recap the test strip bottle. In order for the results to be accurate, the test strip must be oriented correctly, and inserted to the correct depth. Insert the test strip into the turret as illustrated in Figure 1 and Figure 2:

   a) Position the strip so that the test pad and red line are facing the back of the white cap (see Figure 1).

   b) Insert the strip into the turret until the red line is even with the top of the turret, and close (flip down) the turret (see Figure 2). This will hold the test strip in place. *(**Note:** Steps 6 & 7 should be completed within 30 **seconds**.)*

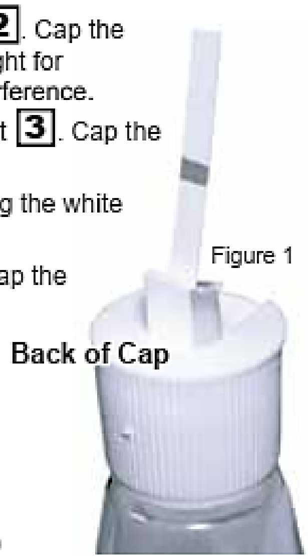


Figure 1

8. Using a timer, allow the reaction to occur in an undisturbed, well-ventilated area for 10 minutes. Reaction generates small hydrogen gas bubbles.

Figure 2

9. After the 10 minute wait (but before 12 minutes), pull up the turret and carefully remove the test strip. Do not touch the reaction pad. Use the Quick™ Easy-Read™ Color Chart to match the reaction pad color. Position the reacted test strip pad behind the punched holes, view center of test strip pad through the hole, and confirm precise color match and Arsenic level. **COMPLETE MATCHING IMMEDIATELY (WAIT NO LONGER THAN 30 SECONDS).** After 30 seconds have elapsed, the colors begin to change (yellow colors fade and browns turn grey or black). For best color matching results use natural daylight; avoid direct sunlight.
10. Record your result.

Source: Instruction Booklet for Rapid Arsenic Test Kit Number 481396

Turbidity of the water was tested using a Bexco digital turbidity meter. The meter has a range of 0 to 1000 Nephelometric Turbidity Units (NTU) with a resolution of 1 NTU. The meter was first calibrated comparing it to a 100 NTU calibration standard. Figure 3-8 shows a water chemist setting up the turbidity meter.

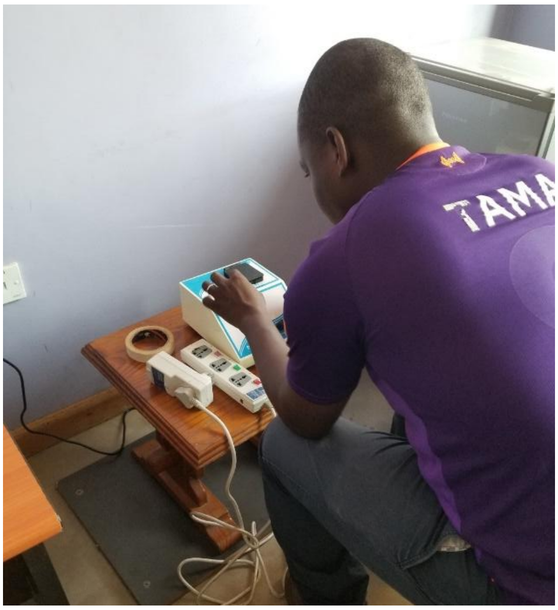


Figure 3-8: Water quality officer setting up the turbidity meter

The three parameters of E. Coli, FS and FC were analysed at the Central Water Laboratory in Lilongwe City. Membrane filtration was the method for the analysis in which 0.45-micron pole sized membrane filters were used. The membrane filters were placed in pre-sterilized disposable plastic petri-dishes of 50 mm diameter. Membrane faecal coliform (mFC) agar was used as the medium for cultivation and enumeration of faecal coliforms whose incubation was for 24 hours at 44.5 °C. Similarly, Kener Faecal Streptococcus (KFS) agar was used for cultivation and enumeration of faecal streptococci with an incubation temperature of 35 °C for 48 hours; while for E. coli, chromogenic agar was used with an incubation temperature of 35 °C for 24 hours.

3.5.3 Key Informant Interviews

Key informant interviews were conducted at different levels i.e., community level, targeting local leaders; and local authority and central government levels, targeting government officials. At the community level, the interviews were conducted with 4 TAs, 9 GVHs, 8 ADC chairpersons, and 8 VDC chairpersons. For the local authority, the interviews were conducted with the Director of Planning and Development and the Assistant District Water Development Officer at Mangochi District Council. The Director of Water Supply Services and the Director of Water Resources in the Ministry of Water and Sanitation were the key informants at central government level. The key informants at community level provided data on water situation at community level as well dynamics in allocation of water sources, while district level key informants provided data on district-level water supply situation and planning matters, and those from central government provided data on matters of policy. All interviews were audio-recorded upon consent by the participants. Appendices B and C are the interview guides that were used for government officials and local leaders respectively.

3.5.4 Focus Group Discussions

Focus group discussions were conducted with 12 selected water point committees. The standard membership size for a water point committee is 10 persons, as such, the size of each focus group was 10. However, due to other factors ranging from absenteeism to quitting the membership, the focus group sizes ranged from 7 to 10 persons. Discussion guides, as in Appendix D, were used for the conduction of discussions. All discussion were audio-recorded upon consent by the participants.

3.5.5 Observations

Field observations were carried out around waterpoints in relation to water quality. The observations were guided by, but not limited to, a checklist as provided in Appendix E. Among other thing, the observations paid particular attention to water point sanitation, water point infrastructure condition, evidence of animal trespass and proximity to potential contamination sources. Photos were also taken to provide pictorial view of some of the observations.

3.5.6 Market Prices Survey

Market prices survey was another method for collecting quantitative data. This particular survey was conducted in order to gather prevailing market prices of all Afridev hand pump parts for the purpose of computing expected annual operation and maintenance costs. A checklist containing all Afridev pump parts and a column for capturing prices was administered to shop owners or their sale agents (refer to Appendix F). Six shops responded and average price for each item was calculated and used for this study.

3.6 Data Management

3.6.1 Management of Household Survey and Water Quality Testing Data

All data captured during both household survey and water quality testing were being stored in cloud through Google My Maps. The data was first checked online for completeness and accuracy after the enumerators had submitted the surveys. The data was then exported as Keyhole Markup Language (KML) file which is a file format used to display geographic data in an earth browser such as Google Earth (Google Developers, n.d.). The KML file was later converted to Microsoft excel spreadsheet using an online geodata-conversion application (MyGeodata Converter, n.d.). While in excel spreadsheet, the data was again checked for any errors and incompleteness. Once validated, it was exported to SPSS v20. As backup, all the three file formats i.e. KML, excel and SPSS were saved in duplicates.

3.6.2 Management of KII and FGD Data

Data from key informant interviews and focus group discussions were captured by audio recording using mobile phone. The raw audio recordings were transcribed using verbatim format. The verbatim transcripts that were in local languages were then translated into English, ready for analysis. All the data formats, i.e., raw audios, transcribed, and translated formats, were saved both in computer and cloud for backup.

3.6.3 Management of Observation Data

The captured observation data were more related to water quality assessment. The data were captured and linked to respective water points and stored in Google My Maps. The procedure of downloading the data followed the description provided in section 3.6.1.

3.7 Data Analysis

3.7.1 General Statistical Data Analyses

The study generated both categorical (both nominal and ordinal) and discrete numerical data through household survey and water quality testing. Descriptive statistics were applied as a method of analysis in form of frequencies, percentages, and averages (mean, mode and median). The study also carried out correlation tests for specific data related to specific objectives. The study also applied thematic analysis for qualitative data generated through KIIs and FGDs, and this involved codes generation and sub-grouping into themes using ATLAS.ti 9.

3.7.2 Analysis for Safety of Drinking Water Services

The collected data on water quality was analysed in two phases. The first phase was an analysis of conformity of which the result of every parameter for every borehole was checked against standard values. The analysis was based on Malawi Standard for borehole and shallow well water quality (**MS 733:2005)** which specifies requirements for untreated or raw ground water in borehole and shallow wells suitable for human consumption and all usual domestic purposes. For comparison with international guidelines, the test results were also checked against World Health Organisation drinking water guidelines of 2017. Descriptive statistics were applied in which the results were presented in form of frequencies, percentages, averages (mean, mode and median), and minimum and maximum values.

The second phase of the analysis was on statistical relationships and statistical differences. Non-parametric correlation using Spearman’s rho was carried out to analyse if there was significant relationship between the distance from a water source to a potential contamination source and the level of contamination (Cohen et al., 2000; Kothari, 2004). Other non-parametric tests such as Kruskal-Wallis Test and the Independent Samples Mann-Whitney U Test were performed to test for spatial and seasonal variations respectively. Kruskal-Wallis test is used to statistically measure significant differences between three or more independent samples, while Mann-Whitney U-test is used to statistically measure any significant difference between two independent samples (Cohen et al., 2000). In both cases, the analyses are based on rankings, in which the data are jointly ranked as belonging to a single sample, by assigning rank 1 to the item with the lowest value, rank 2 to the next higher item and so on until a summed-up rank is obtained (Kothari, 2004).

3.7.3 Analysis for Affordability of Drinking Water Services

The measurement of the affordability of drinking water services involved analysing data on household income and expenditure. It was based on the measurement of water expenditure (which in this case was O&M household contributions) as a proportion of total household disposable income, and comparing it against 3% as the affordability threshold adopted by similar studies, as prescribed by literature. The following affordability formulas were therefore derived and applied in this study to compare between the actual situation and what would be the likely scenario if an ideal tariff is applied:

i. Affordability Ratio (γ_1) = $\frac{\text{Annualised actual water costs}}{\text{Annual income}}$ ❹

ii. Affordability Ratio (γ_2) = $\frac{\text{Annualised required tariff}}{\text{Annual income}}$ ❺

Having calculated the affordability ratios, there was also need to analyse the adequacy of households' contributions towards the sustainability of the water points in comparison to the findings of the affordability analysis. Data on market prices were entered and analysed in a Microsoft Excel template that was designed based on scheduled Afridev hand pump parts and their lifespan. The prices were then used to estimate lifecycle maintenance costs for different parts and the overall lifecycle costing. According to Erpf (2007), the expected lifespan of Afridev hand pumps is 10 to 15years. This study therefore adopted 10 years as worst-case scenario. Different pump parts also have different lifespans, provided as ranges of years. For example, riser pipe assembly has a lifespan of 3 to 5 years while a bearing has a design life of 1 to 2years. In this case, the lower limits were adopted for safer costing of a pump life cycle of 10 years. For pump rod assembly and riser pipe assembly, the costs were distributed from 3rd to 5th year at a 40%-40%-20% distribution because practically, these parts may not all fail at once.

Data from the household survey were entered and analysed in Statistical Package for Social Sciences (SPSS v20). Descriptive statistics, especially mean, median and percentage, were used to summarise the variables for easy visualisation and interpretation of the data. A Microsoft Excel template, created with arithmetical formulas, was used to produce trends of cumulative annualised funds based on the various tariffs. Based on the annualised household contributions, total annual funds were calculated for each tariff and later summed up to find cumulative funds for the life cycle period of 10 years. The annualised household contributions considered Malawi Government recommended maximum of 50HHs per borehole. The cumulative calculations also considered the assumption that prior to construction, WPCs are expected to mobilise through contributions a starter pack amount of not less than MWK20,000 (US$24.26) for their O&M fund. These upfront monetary contributions are meant to ensure that a maintenance fund account is opened before any borehole is constructed or rehabilitated (Chisenga, 2014). The community contributions signify community commitment and ownership (Mamburi, 2014).

Let the annualised household contribution be x; total annualised household contribution be β; cumulative funds be γ; the following formulas as deduced from the above explanation were applied in the analysis:

$$.\beta = 50x \quad ❻$$

$$\gamma = 20{,}000 + \sum_{n=1}^{10} \beta_n \quad ❼$$

3.7.4 Analysis for Universality of Drinking Water Services

The analysis for universality of drinking water access was in two parts: firstly, it was to understand the level of drinking water access in the study area in order to learn what gaps were there to reach 100% water coverage; and secondly, it was to analyse potential factors of universal drinking water access. Measurement of water access was based on the proportion of population or households using improved water sources as discussed in section 2.3. Thus, the quantitative data was analysed using descriptive statistics, specifically relative frequency expressed in percentage. However, factors relating to the water access situations were determined using qualitative data which was analysed using thematic analysis. Braun and Clarke, (2006, p 6) defines thematic analysis as "a method for identifying, analysing, and reporting patterns (themes) within data". Similar to the study done by Ibidunmoye (2018), the thematic analysis sought to establish factors based on respondents' opinions and experiences. The qualitative data was first verbatim transcribed from audio recordings, and later translated from local language to English. The translated scripts were then uploaded in ATLAS.ti v9 where coding and collation of the codes into potential themes were performed. Sankey diagram, originating as alternative view of a code-document table, was used to compare code frequencies in order to understand how different respondents or groups inclined towards a certain view.

3.7.5 Analysis for Equitability of Drinking Water Services

Analysis of equitability was carried out using comparison of different variable outcomes such as access to improved water sources and water quality in order to assess spatial disparities. Past studies have also used Gini index as a way of measuring inequality in water access (Cole et al., 2018; Dongzagla et al., 2022; Jesus et al., 2023). Similarly, this study adopted the method and an analysis of inequality in water points distribution among the Traditional Authorities in the study area, using Gini index derived from Lorenz Curve was carried. The Gini index calculated from Lorenz curve was also applied as a way of measuring inequality. Thematic analysis was also used to analyse the qualitative data in order to understand the dynamics of equitable access to safe drinking water. The generated codes were collated to come up with themes that explain the dynamics in equitability of water access. Similar to 3.7.2.3, Sankey diagram was also applied.

3.8 Data Quality and Reliability

To ensure data quality and reliability for the household survey, enumerators with a minimum qualification of Malawi School Certificate of Education (MSCE) were recruited and oriented. The data collection tools were pre-tested and modified accordingly before actual data collection. The Principal Investigator was checking every submitted survey online and where anomalies were observed, the responsible enumerator was communicated to clarify or correct. All data collection gadgets, mobile phones in particular, were made sure that they had enough space and power, and in good working order, prior to any data collection exercise. All enumerators were provided with power banks for power backup. All water quality test meters were recalibrated at the start of each day, and the battery power was also checked to ensure it was sufficient.

3.9 Ethical Considerations

3.9.1 Ethical Approval

For the protection of human participants, the study protocol was approved by National Commission for Science and Technology (National Committee on Research in the Social Sciences and Humanities) prior to commencement of study. Appendix G is a copy of the approval letter.

3.9.2 Institutional Clearance and Permission for Entry

The research protocol was rigorously assessed and cleared by Mzuzu University. A written permission, as presented in Appendix H, was also obtained from Mangochi District Council to allow the researcher access to the study villages. At community level, entry permission was also granted by the traditional chiefs (TAs and GVHs).

3.9.3 Informed Consent

All human participants in this study were clearly informed about the aim of the study and what their expected roles as participants in the study were. The respondents were assured of confidentiality and that all collected data would solely be used for academic purposes. The respondents were also informed about the approximate amount of time the enumeration would take. They were also assured that the participation was voluntary and free of charge, and that they were at liberty to decline if they were not willing. Finally, the participants were asked to provide written consent to participate by signing a consent form (refer to Appendix I). The consent form was also translated into Chichewa (Appendix J) and Chiyao (Appendix K) for the sake of participants at community level.

3.10 Study Limitations

The study had four main limitations which in one way or the other may have impacted on the study.

The first limitation was illiteracy of some of the respondents such that they were not able to read and write.

The second limitation was on the measure of equitable access where the study only focussed on spatial disparities in access to improved water sources, but did not zero in on analysing the disparities between the vulnerable and marginalised groups such as the elderly and those with physical disabilities, and those non-vulnerable and unmarginalized. However, the analysis of geographical disparities is still enough to paint a picture on progress of equitability, though not a complete picture.

The third limitation was limited financial resources such that the water quality analysis was only conducted once in both wet and dry seasons.

The fourth limitation was on the unavailability of other would-be respondents. For instance, after KIIs and FGDs, it was noted that there was need for follow-up data collection with members of parliament who unfortunately were in a parliament session as at the time of study. As such, the collected data may be biased to some extent, although not to an extent of affecting the overall results of the study.

The last limitation was on non-functionality of some sampled water points at the time of the study. It was noted that, during the second phase (dry season) sampling of water points, some two water points had failed, rendering it impossible to have their water sampled for testing. As such, these two water points only had a single (wet season) result unlike the rest of the water points who had dual (wet and dry season) results. However, this did not affect the results in anyway as the collected samples were still enough to come up with a conclusion.

Although there were these limitations, the collected data was of good quality, well managed and analysed. As such, it is believed that the limitations did not entirely alter the would-be results of the study. Therefore, the product of this study should be understood and trusted in the context of the prevailing declared limitations.

CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter presents findings on the safety of drinking water services, affordability of drinking water services, factors that influence universality of access to drinking water services and dynamics in equitability of access to drinking water services in Mangochi District. The findings were obtained through water quality analysis, household survey, key informant interviews and focus group discussions.

4.2 Assessment of Drinking Water Safety

In order to assess the safety of drinking water, improved water sources were used as units of analysis with water samples as unit of observation.

4.2.3 Water Quality Test and Analysis Results

Results of the 162 water samples collected and tested in this study showed turbidity levels ranging from <0.01 to 165 NTU, with a mean of 3.17 NTU, median of <0.01 NTU, and a standard deviation (SD) of 18.33. Values of pH ranged from 5.5 to 7.7 with a mean value of 6.87, median of 7.0, and SD of 0.41. EC varied from 24 to 4122µS/cm with a mean value of 831µS/cm, median value of 756µS/cm, and SD of 581.9, while the TDS ranged from 14 to 2477ppm with 494ppm, 443ppm and 344.6 as mean, median and SD values respectively. While arsenic presence in the water samples was below detection limit (As < 0.001mg/L), fluoride presence was detected in values ranging between 0.2 and 27.2mg/L with a mean value of 3.7mg/L, median value of 3.1mg/L, and SD of 3.45. Lastly, the presence of faecal streptococci, faecal coliforms and E. coli was detected in ranges of 0 - 280, 0 - 128 and 0 - 92 counts/100mL respectively, with 0 as a median value in all the cases, while the respective mean values were 11, 6 and 4 counts/100mL with SD values of 35, 19.2 and 12.7 respectively. The frequencies of values for each tested parameter are presented by histograms in Figure 4-1, and detailed results are presented in Appendix L.

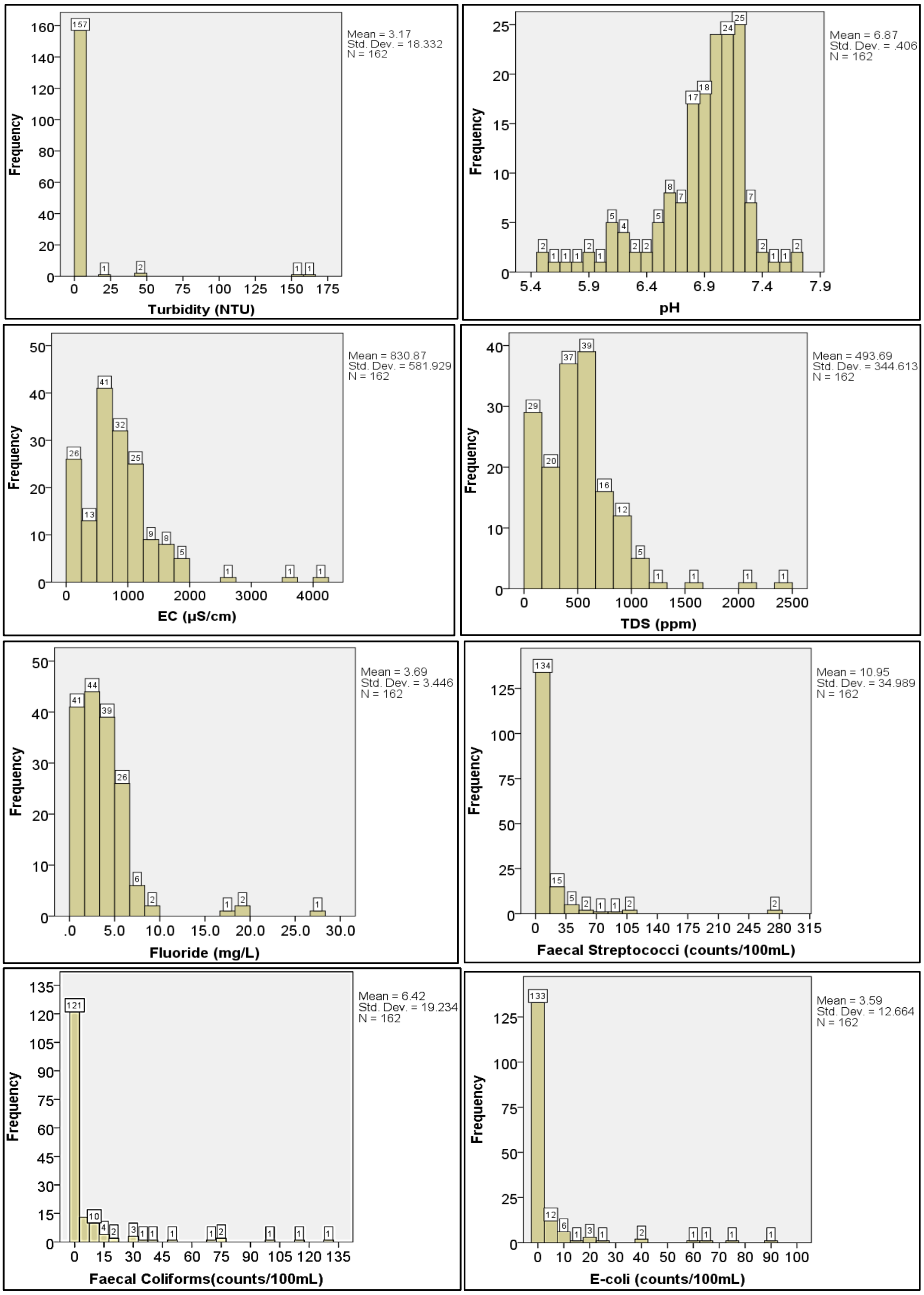


Figure 4-1: Frequences of Water Quality Test Results

4.2.4 Conformity of Individual Parameters

Out of 162 cases, 158 had values of ≤ 25 NTU, thus 97.5% of the samples met the Malawi Standard requirement for turbidity in drinking water from boreholes and shallow wells, with the four non-conforming cases being from three boreholes (wet season samples from two boreholes, and both wet and dry season samples from the third borehole). For pH, 155 samples satisfied Malawi Standard requirement (6.0 ≥ pH ≤ 9.5), representing 95.7% conformity. On EC and TDS, 160 of the 162 samples were within specified Malawi Standard requirements of EC ≤ 3,500µS/cm and TDS ≤ 2,000ppm, representing 98.8% conformity in both cases. Furthermore, all the samples fulfilled the requirements as specified by both Malawi Standards (As ≤ 0.05mg/L) and WHO guidelines (As ≤ 0.01mg/L), while 145 samples (89.5%) fulfilled Malawi Standards for fluoride ($F^- \leq$ 6mg/L) and only 35 samples (21.6%) fulfilled the WHO guidelines ($F^- \leq$ 1.5mg/L). In terms of microbial conformity, 104 samples (64.2%) and 127 samples (78.4%) registered no presence of Faecal Streptococci and E. coli respectively, thus conforming to the Malawi Standard of FS = 0 count and E. coli = 0 count. The zero presence of E. coli also conforms with WHO guidelines for drinking water. Lastly, 156 samples (96.3%) satisfied MS requirement for FC by registering counts not exceeding 50, out of which 117 samples (72.2%) showed no presence at all, thus conforming to WHO guidelines. Table 4-1 provides a summary.

4.2.5 Overall Conformity with Malawi Standards and WHO Guidelines

Table 4-1 presents a summary of results for conformity assessment based on WHO guidelines and Malawi Standards. The assessment for the water samples revealed that 77 samples, conformed to MS733:2005 at every individual parameter stage, thus representing 47.5% overall compliance with the Malawi Standards. On the other hand, 19 samples conformed to the 2017 WHO guidelines on drinking water, for the parameters whose guideline values were set i.e. arsenic, fluoride, faecal coliform (e. coli inclusive), representing 11.7% conformity.

4.2.6 Water Quality Conformity for Safely Managed Water Services

The last part of Table 4-1 displays results of a conformity assessment with a focus on water quality requirements for safely managed water services. i.e., priority chemicals (arsenic and fluoride) and microbial contamination (thermotolerant coliforms). Using WHO guideline values, 12% of the samples met the requirement for safely managed water services. On the other hand, after applying of local standard values of MS773:2005 in the assessment, 72% of the samples met the requirements for localised safely managed services level.

Table 4-1: Water Quality Conformity with Malawi Standards and WHO Guidelines

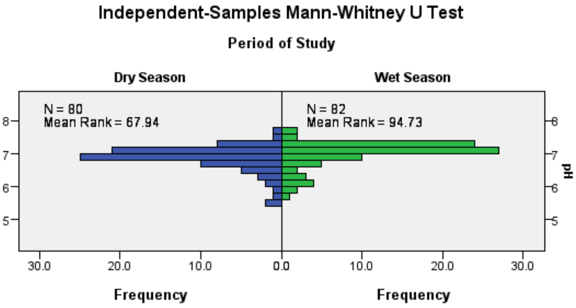
	Does not conform		Conforms		STANDARD	
Description	Count	%	Count	%	MS733:2005	WHO 2017
Turbidity conformity with MS	4	2.5%	158	97.5%	**25 NTU**	
pH conformity with MS	7	4.3%	155	95.7%	**6.0-9.5**	
EC conformity with MS	2	1.2%	160	98.8%	**3500**	
TDS conformity with MS	2	1.2%	160	98.8%	**2000 ppm**	
TDS conformity with WHO	9	5.6%	153	94.4%		**1000 ppm**
Arsenic conformity with MS	0	0.0%	162	100.0%	**50 µg/L**	
Arsenic conformity with WHO	0	0.0%	162	100.0%		**10µg/L**
Fluoride conformity with MS	17	10.5%	145	89.5%	**6 mg/L**	
Fluoride conformity with WHO	127	78.4%	35	21.6%		**1.5 mg/L**
Faecal Streptococci conformity with MS	58	35.8%	104	64.2%	**0/100ml**	
Faecal Coliform conformity with MS	6	3.7%	156	96.3%	**50/100ml**	
Faecal Coliform conformity with WHO	45	27.8%	117	72.2%		**0/100mL**
E. coli conformity with WHO & MS	35	21.6%	127	78.4%	**0/100ml**	**0/100ml**
Overall conformity with Malawi Standards	85	52.5%	77	47.5%	**Based on MS values**	
Overall conformity with WHO guidelines	143	88.3%	19	11.7%		**Based on WHO values**
SDG6 water quality conformity for safely managed water services (priority chemicals and thermotolerant coliforms)	143	88.3%	19	11.7%		**Based on WHO values**
SDG6 localised water quality conformity for safely managed water services (priority chemicals and thermotolerant coliforms)	46	28.4%	116	71.6%	**Based on MS values**	

4.2.7 Correlation of Proximity of Sanitation Facilities and Faecal Contamination

Non-parametric correlation using Spearman's rho showed a weak negative relationship, at a correlation coefficient of $\rho = -0.159$, between distance from latrines to the water source and faecal coliform counts. Although this implies that there was an increase in faecal contamination with a decrease in distance between latrine and water source and vice-versa, the relationship was found to be insignificant with a p-value of -0.113 at a significance value of $\alpha = 0.05$.

4.2.8 Seasonal Comparisons

The results of an Independent Samples Mann-Whitney U Test, with significance value set at $\alpha = 0.05$, showed that the distribution of all the tested parameters, except pH, were statistically the same across wet and dry seasons. As presented in Figure 4-2, pH mean ranks of 67.94 and 94.73 for the dry and wet season respectively, were found to be significantly different at $p \approx 0$. On the other hand, the rest of the parameters had significance levels greater than the significance value ($p > \alpha$), thus, the statistical differences were insignificant. The mean ranks of turbidity were 77.92 and 84.99 for dry and wet seasons respectively and the significance level was $p = 0.157$. EC had mean ranks of 83.59 for dry season and 79.46 for wet season with a p-value of 0.576, while TDS had 82.58 and 80.45 for dry and wet seasons respectively with a p-value of 0.772. Test results for fluoride were 79.99 and 82.97 for dry and wet seasons respectively and a p-value of 0.686. Faecal streptococci, faecal coliforms and E. coli wet and dry seasons ranks were 82.82 and 80.21, 82.76 and 80.27, and 83.13 and 79.87 respectively, with p-values of 0.679, 0.672 and 0.513 respectively.



Total N	162
Mann-Whitney U	2,195.500
Wilcoxon W	5,435.500
Test Statistic	2,195.500
Standard Error	296.555
Standardized Test Statistic	-3.657
Asymptotic Sig. (2-sided test)	.000

Figure 4-2: Independent Mann-Whitney U Test Result for pH Seasonal Comparisons

4.2.9 Spatial Comparisons

rejected As demonstrated in Figure 4-3 (top left), a pairwise comparison for turbidity showed that there were significant differences in distribution between Katuli with mean rank of 99.77 and Namavi with mean rank of 76.20 at a significance level of 0.018, and between Katuli and Nankumba (with a mean rank of 78.71) at a significance level of 0.019. On the contrary, the turbidity pairwise difference between Katuli and Chilipa (with a mean rank of 79.54) was insignificant at $p = 0.409$. while the pairwise differences between Nankumba and Chilipa, Namavi and Chilipa, and Namavi and Nankumba were all insignificant at $p = 1.000$. Similarly, the pH mean ranks for Katuli, Nankumba, Chilipa and Namavi were 14.21, 107.35, 74.08 and 74.81 respectively as presented in Figure 4.3 (top right). The test fuether revealed that pH distribution was significantly different between Katuli and Namavi at $p \approx 0$, Katuli and Nankumba at $p \approx 0$, and Katuli and Chilipa at $p = 0.001$. There was also significant distribution difference between Nankumba and Namavi at $p = 0.001$.

For EC, Nankumba, Namavi, Chilipa and Katuli had mean ranks of 114.91, 63.45, 62.79 and 13.90 respectively. As displayed in Figure 4-3, it was also observed that EC (bottom left) and TDS (bottom right) shared the same pattern for pairwise comparisons such that in both cases, distribution for one TA was significantly different from distribution of any other TA paired with, except for a pairing of Namavi and Chilipa. The pairwise comparisons for Katuli - Chilipa, Katuli - Namavi, Katuli - Nankumba, Chilipa - Nankumba and Namavi - Nankumba revealed significant differences at p - values of p = 0.017, p ≈ 0, p ≈ 0, p = 0.002 and p ≈ 0 respectively, while Namavi and Chilipa no significant difference in the distribution and the p - value was 1.000. Similarly, Nankumba, Namavi, Chilipa and Katuli had TDS mean ranks of 114.87, 63.38, 63.25 and 13.96 respectively. Katuli-Chilipa, Katuli - Namavi, Katuli - Nankumba, Chilipa - Nankumba and Namavi - Nankumba had significant differences at p - values p = 0.016, p ≈ 0, p ≈ 0, 0.002 and p ≈ 0 respectively, while Namavi and Chilipa also had no significant difference in distribution and the p - value was 1.000.

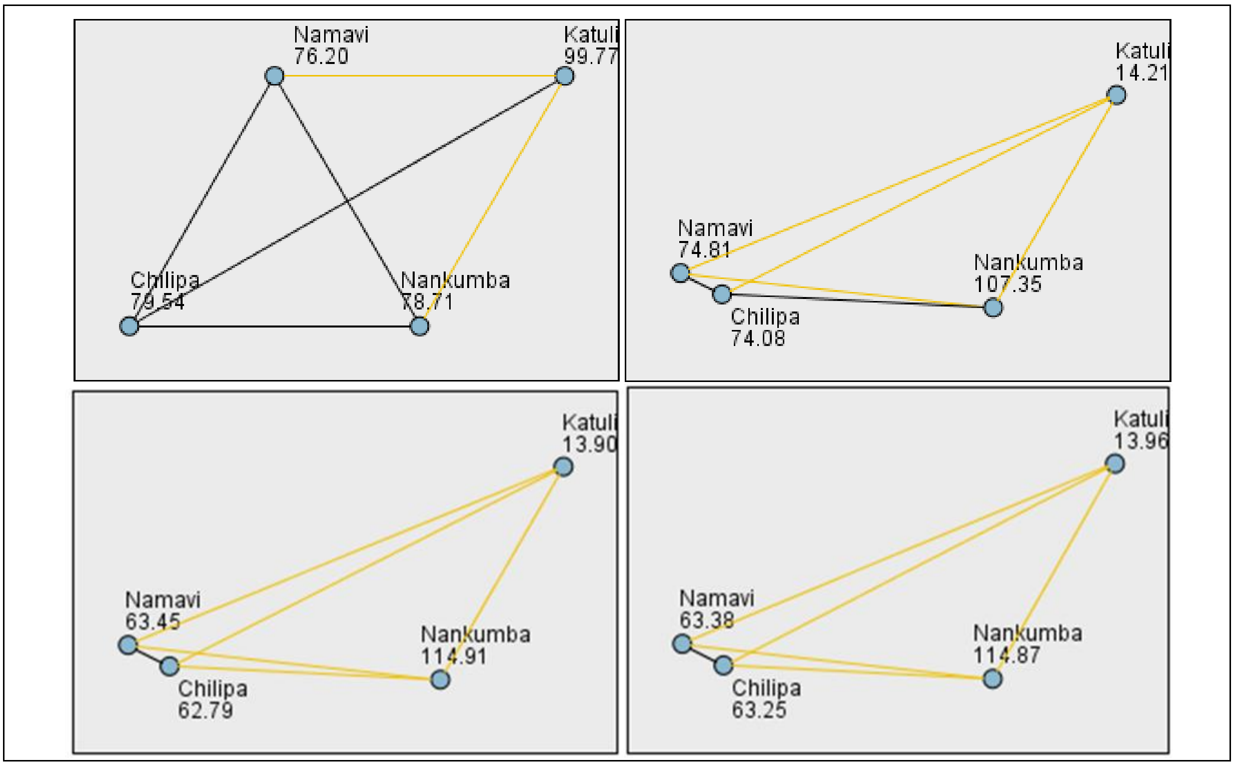


Figure 4-3: Pairwise Comparisons for Turbidity (top left), pH (top right), EC (bottom left), TDS (bottom right)

Differences were also observed for fluoride distribution within the TAs, with the highest mean rank appearing for Nankumba at 100.77 followed by Chilipa at 93.92. Namavi and Katuli had 77.21 and 21.92 respectively as demonstrated in Figure 4.4 (top left). Pairwise comparisons showed significant differences on the pairing of Katuli-Namavi, Katuli-Chilipa, Katuli-Nankumba at significance level $p \approx 0$ for all, and Namavi-Nankumba at significance level of 0.019. Namavi-Chilipa and Nankumba - Chilipa both had significance levels of $p = 1.000$. On Faecal streptococci, Katuli had highest mean rank at 120.60, followed by Namavi at 79.70. Nankumba had 71.39 while Chilipa had 72.17 as shown in Figure 4-4 (top right). Significant differences in FS distribution were found at the pairing of Katuli-Namavi, Katuli-Chilipa, and Katuli-Nankumba, all at significance level of $p \approx 0$. The remaining pairs of Chilipa-Namavi,Nankumba-Namavi and Nankumba-Chilipa were all very insignificant in distribution differences at $p = 1.000$.

Difference in faecal coliform distribution was only noted between Katuli with mean rank of 94.46 and Chilipa with mean rank of 58.50 at $p = 0.035$ as observed in Figure 4-4 (bottom left). The rest of the pairings did not yield any significance in distribution differences. Chilipa-Namavi, Namavi-Nankumba and Nankumba-Katuli were all at $p = 1.000$, while Chilipa-Nankumba was at $p = 0.165$ and Namavi-Katuli at $p = 0.237$. Mean ranks for Nankumba and Namavi were 83.93 and 75.30 respectively. Contrary to all other parameters, the null hypothesis that the distribution of E. coli was equal across all TAs was retained. The means ranks were 93.75, 83.51, 66.00 and 74.43 for Katuli, Nankumba, Chilipa and Namavi respectively as presented by Figure 4-4 (bottom right). The significance levels were 1.000 for Chilipa-Namavi, 0.471 for Chilipa-Nankumba, 0.081 for Chilipa-Katuli, 0.824 for Namavi-Nankumba, 0.97 for Namavi-Katuli and 0.945 for Nankumba-Katuli.

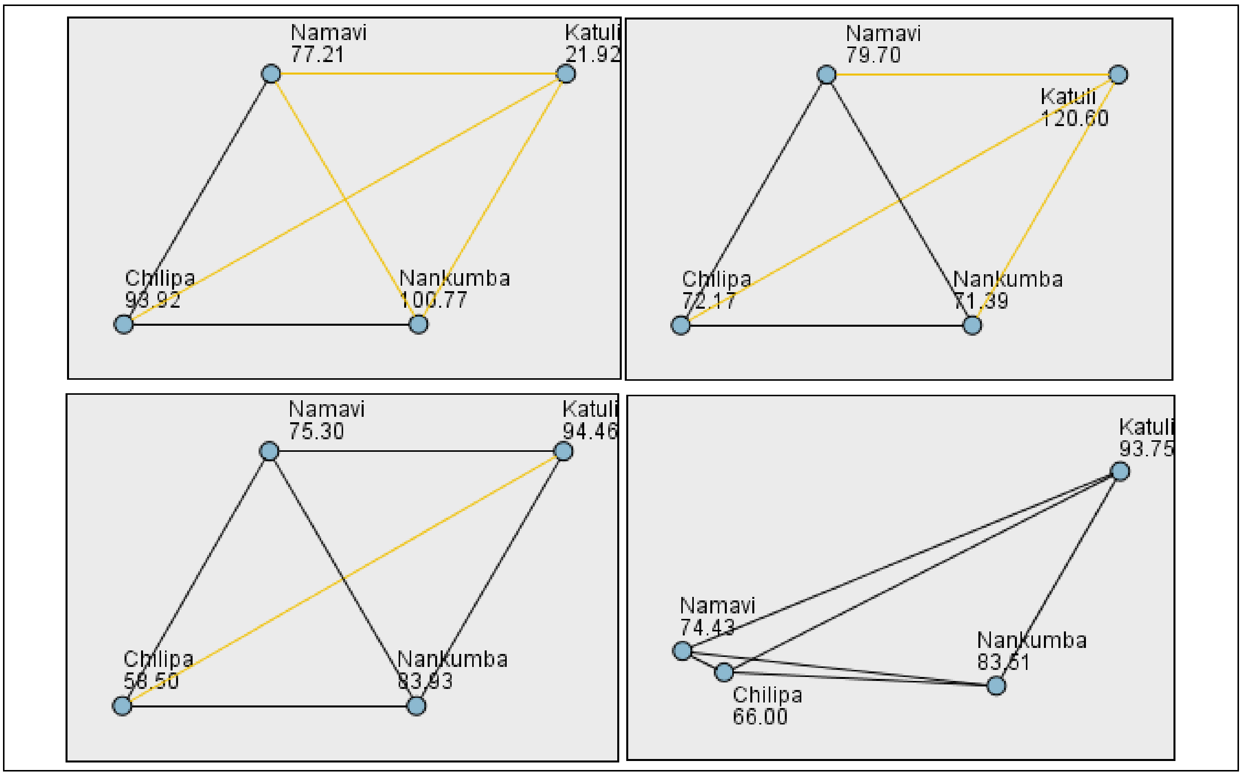


Figure 4-4: Pairwise Comparisons for fluoride (top left), FS (top right), FC (bottom left) and E. coli (bottom right)

4.2.10 Qualitative Water Quality Aspect

Observations showed that 46% of the water points had clean surroundings, with proper sanitation and hygiene as seen in Figure 4-5, while 54% had unclean surroundings that looked unswept, bushy and/or with stagnant water as captured in Figure 4-6. The study further found that the majority of the water points had unclean surroundings because most water point committees (WPCs) ended up getting frustrated and gave up because they were not receiving the necessary support from the water users. Some WPC members complained that even when they tried to come up with cleaning duty rosters, they would just end up being insulted by the water users as lamented by one committee member from FGD 03:

"They also insulted me, citing words like 'do you think this borehole belongs to your uncle or grandfather?".

Another participant from FGD 05 also made similar lamentations saying:

"I remember one person told me that, at their borehole, some people went as far as insulting them saying 'was this borehole drilled by your uncle or grandfather?"

Some water users refused to take part in water point hygiene tasks because they felt that they had no direct benefits like those of committee members who received allowances and enjoyed snacks and refreshments during water point community-based management (CBM) training, as explained by a participant in FGD 06:

"Some refuse to take part saying that the committee members should be the ones to sweep because they are the ones who drank Fanta [refreshments during trainings]".

A participant in FGD 03 also echoed the same sentiments saying:

"We are always insulted saying 'you were the ones drinking Fantas [soft drinks during training] and therefore you should also be the ones to do the work. So don't worry, remember you were given five thousand kwachas [allowance during training] ... that was being paid in advance and this is now the time to work".

Figure 4-5: Water points with clean surrounding

Figure 4-6: Poor waterpoint surrounding

The study found that some water points had poorly done, damaged or non-existent headworks. Figure 4-7 depicts a borehole with space between the concrete works and the pedestal while Figure 4-8 shows a borehole with a poorly constructed apron, suspected to have been made of bricks and some plastering on top but in a completely eroded state. Figure 4-9 shows a borehole with only a hand pump planted and no apron but drilled in a water way.

Figure 4-7: Borehole with space on the apron and the pedestal

Figure 4-8: Apron made of bricks and plaster

Figure 4-9: Borehole with no apron

Other observations revealed that some water points were producing muddy and silted water while some water points produced water whose suspended solids could flocculate and settle after some time as depicted by pictures in Figure 4-10. Water users at one of the newly constructed water points at a mosque (picture on the left) complained that the water had been muddy since it was commissioned three months before the day of the study, and cited that the drillers did not do any well cleaning and development but promised the users that the water would clear on its own with the passing of time as explained by a female participant of FGD 6:

"When all the work was done on this borehole, we were surprised to see that muddy water was coming out. When we asked the contractor who came to do the work, they said that the water would clear on its own after some few days. But since then, the water has been like the way you see it now [muddy]. But we believe that this contractor did some shortcuts because what we saw when they were drilling that borehole you passed on your left when coming here was that, after drilling, they inserted a pipe of air into the borehole, and they were blowing the water until it was clean; but that was not done at this borehole".

Others complained of changes that take place in the rainy season whereby some water points start producing unclear or muddy water. An FGD 4 participant explained:

"Yes, it is true that during the rainy season, we drink dirty water here. I don't know what should be done to stop this from happening. Is this not dangerous to our health? The problem is that not all of us can afford chemicals like chlorine to safeguard our drinking water."

From FGD08, one participant echoed the sentiments by saying:

"Our borehole works well, and the water is enough. The only problem is that the water turns brownish (muddy) during the rainy season."

Figure 4-10: Turbid water and silt from poorly constructed boreholes

Another disturbing observation was that there was evidence of livestock like cattle, goats, and sometimes pigs, visiting the water points. Animal excreta and footprints were seen at some water points as evidenced by pictures in Figure 4-11. Comments coming from some water point committee members showed that the livestock keepers were so rude such that they could not be controlled. One female member in TA Katuli explains:

"We tried to reason with them to have a trough which they can be using to water the animal far from the water point, but they are so rude; they tell us that they have no time for that. They say that they water their animals at any water point that is closest to

where they took the animals for feeding, so they cannot be carrying the trough everywhere."

When asked if the matter had been brought before the village chief, a wife to one GVH in TA Nankumba said:

"What can a village chief do? These livestock owners are feared people here; no one can tell them what to do."

Figure 4-11: Animal excreta within waterpoints' premises

Observations specific to WP081 in TA Nankumba which registered highest electrical conductivity, total dissolved solids and fluoride in both wet and dry seasons, showed that its surrounding was covered in whitish substances which could be an indicator of high level of salinity (Stavi et al., 2021; Zaman, 2018) as seen in Figure 4-12. The users of the borehole complained that they were suffering despite having a borehole because the borehole water was too salty to use for drinking. One member of the community said:

"We are asking government to consider us; they should not be considering that we already have a borehole. We do not drink from this borehole, even if you taste the water, you cant like it. We only use it for cooking, but of course not beans, and other household uses. We are sure that this borehole did not go through District Council

because it was meant to be for a mosque that was to be constructed here but that project failed; so it is now used as a community borehole."

Apart from WP081, complaints of water salinity were also made at other water points. From FGD07, it was reported that their water point produced water that tasted salty as lamented by one participant from the group:

"The water from our borehole is salty and the taste is too much that one cannot use to quench their thirst".

Some traditional leaders also expressed concern that some boreholes in their areas were producing salty water as by explained by GVH07 in TA Namavi:

"Yes, some boreholes are salty. Water from some boreholes is only used for bathing and other domestic purposes but cannot be used for cooking or drinking."

Figure 4-12: Whitish substance on ground surface as evidence of high salinity

4.3 Drinking Water Affordability

In the evaluation of drinking water affordability, households (HHs) were treated as units of analysis. Therefore, the discussion that follows talks more about the status of households in the study area as regards to affording payments related to drinking water.

4.3.3 Household Income, Estimated Expenditure and Cost of Basic Needs

The study found that the main sources of income were farming (35%) followed by unskilled piece work (28%) and petty trading (24%). Other sources of household income included fishing, employment, support from family members, mostly staying in South Africa, as depicted by Figure 4-13. From these varying sources of income, 52% earned monthly average maximum of MWK7,500, 23% earned above MWK7,500 to MWK15,000, 10% earned above MK15,000 to MK28,000, 3% earned above MWK28,000 to MWK35,000, and 12% earned more than MWK35,000. In terms of cost of basic household needs, it was found that 27% of the households needed up to MWK7,500 per month to meet the costs of their basic needs, 18% needed above MWK7,500 to MWK15,000, another 18% needed above MK15,000 to MK28,000, 4% (n=12) needed above MWK28,000 to MWK35,000, and 33% (n=96) needed more than MWK35,000.

Comparison of income and estimated cost of basic household needs showed that only 51% of the households were able to meet the cost of their monthly basic needs while 49% could not meet their needs. Figure 4-14 presents the distribution percentages of average monthly households' incomes, while Figure 4-15 presents the distribution percentages of cost of basic needs.

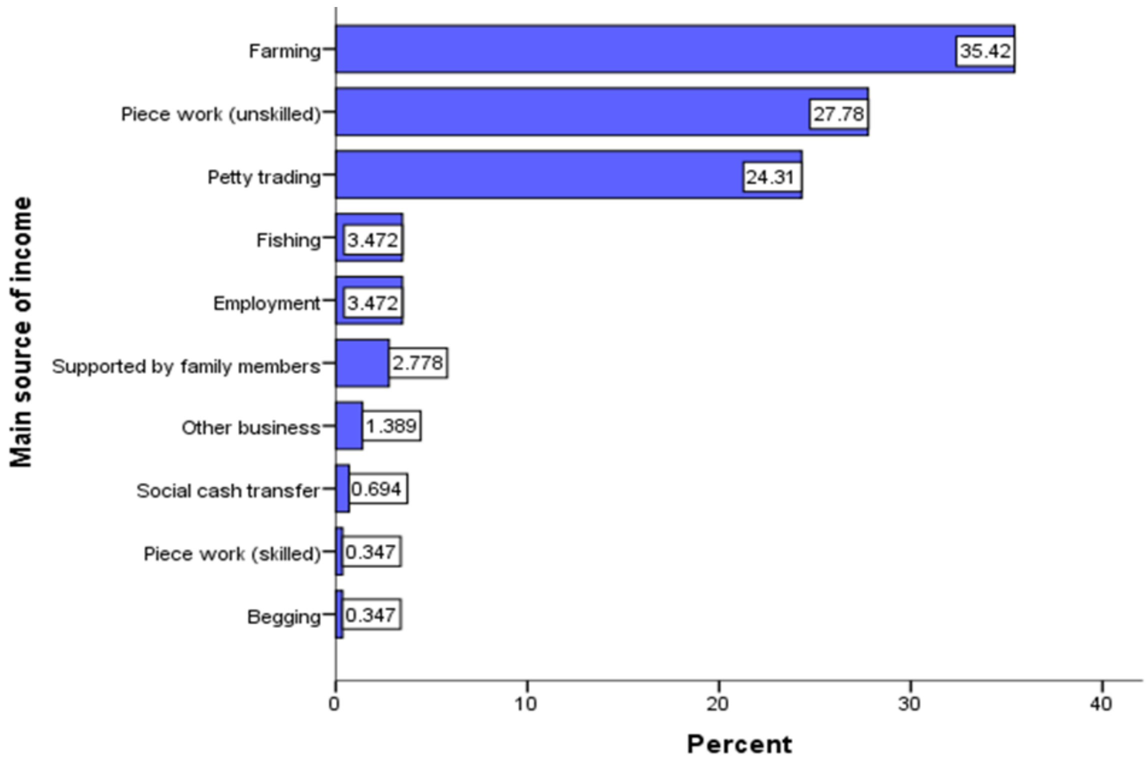


Figure 4-13: Households' main sources of income

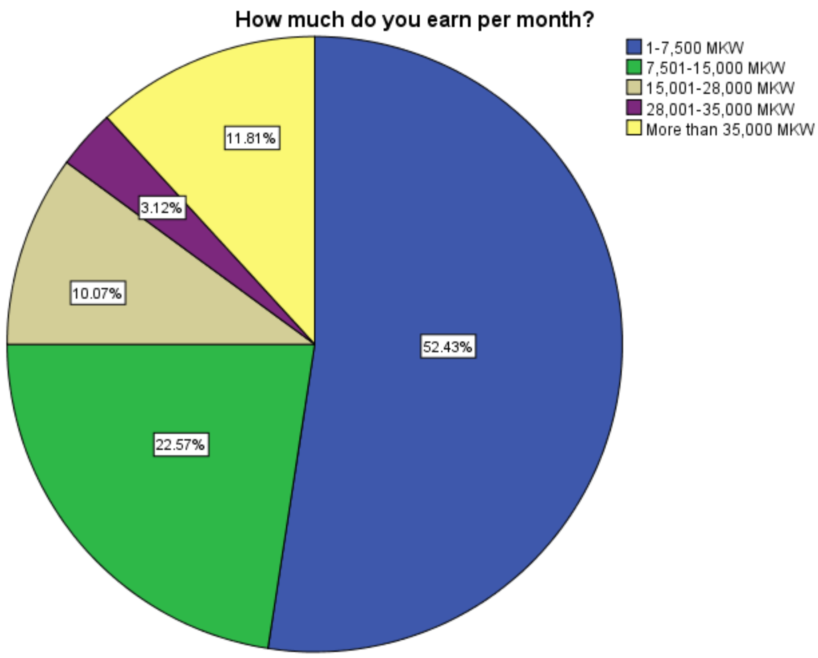


Figure 4-14: Households' monthly earnings

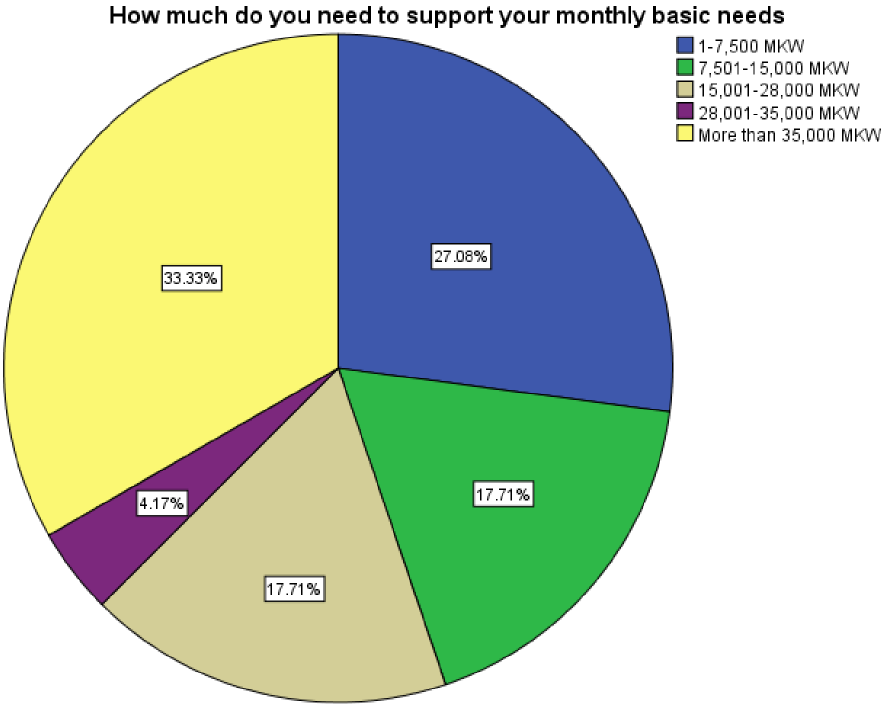


Figure 4-15:Households' cost of basic needs

4.3.4 Contributions towards Operation and Maintenance as Water Expenses

The study found that, out of the 264 households using Afridev hand pump fitted water sources, 97.3% were contributing towards O&M fund and 2.7% were not contributing. All the contributing households (n=257) claimed that they were contributing willingly. On the other hand, out of the 7 HHs that were not contributing, 6 HHs were due to unwillingness to pay while 1 HH was exempted due to old age. Some households were unwilling to pay to an extent that they would boycott the water point for unsafe sources until the period for collections was over as quoted from a participant from FDG04:

> *"It is strange that some choose to go back to using river water when it is time for money collection and come back to the borehole when the period is over…"*

Out of the 257 contributing respondents, 61% was contributing on a monthly basis, 29% on annual basis, and 10% was contributing after a breakdown. This shows that the majority of households practiced the monthly contributions modality. For those that had a regular mode of payment i.e., monthly or yearly, the annual water payments ranged between MWK500 and MWK6,000. As displayed in Figure 4-16, the highest proportion (30.2%) was paying the lowest amount of MWK100 monthly, translating to MWK1,200 per annum, followed by 29.7% that was making yearly payments of MWK1,000, and 28% that was paying MWK200 per month, translating to MWK2,400 as annual payment. Other higher payments were MK250 (5.2%) and MK300 (3%) monthly, translating to MK3,000 and MK3,600 per annum respectively. The highest amount was MK500 monthly, translating to MK6,000 per annum, and was being paid by the lowest proportion of 2.2 %.

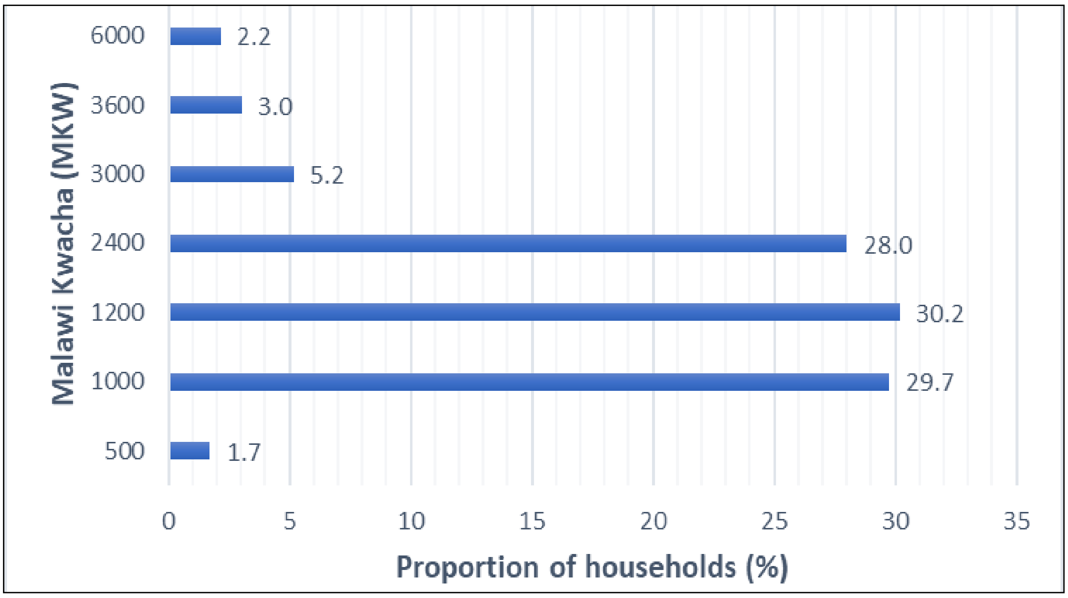


Figure 4-16: Annual households water payment (Contributions towards O&M)

4.3.5 Potentially Available O&M Funds

After applying equation 1 as described in section 3.7.2.2 ($\beta = 50x$), the study found that the total annualised contributions per borehole ranged from MWK25,000 (US$30.32) to MWK300,000 (US$363.87) for an assumption of 50HHs per borehole (US$1 = MWK824.48 as of April 2022).

Thus:

$$MWK25{,}000 \leq \beta \leq WK300{,}000$$

On the other hand, the calculated cumulative 10-year life cycle funds based on the household contributions ranged from MWK270,000 (US$327.50) to MWK3,020,000 (US$3,662.91) as presented in Table 4-2, after applying the formular below:

$$\chi = 20{,}000 + \sum_{n=1}^{10} \beta_n \qquad ❽$$

In summary,

$$MWK270{,}000 \leq \chi \leq MWK3{,}020{,}00$$

Table 4-2: Cumulative funds for cost recovery based on actual household contributions

Current Tariffs (Household contributions)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Cumulative contributions at MKW500 per HH per annum	20,000	45,000	70,000	95,000	120,000	145,000	170,000	195,000	220,000	245,000	270,000
Cumulative contributions at MKW1000 per HH per annum	20,000	70,000	120,000	170,000	220,000	270,000	320,000	370,000	420,000	470,000	520,000
Cumulative contributions at MKW1200 per HH per annum	20,000	80,000	140,000	200,000	260,000	320,000	380,000	440,000	500,000	560,000	620,000
Cumulative contributions at MKW2400 per HH per annum	20,000	140,000	260,000	380,000	500,000	620,000	740,000	860,000	980,000	1,100,000	1,220,000
Cumulative contributions at MKW3000 per HH per annum	20,000	170,000	320,000	470,000	620,000	770,000	920,000	1,070,000	1,220,000	1,370,000	1,520,000
Cumulative contributions at MKW3600 per HH per annum	20,000	200,000	380,000	560,000	740,000	920,000	1,100,000	1,280,000	1,460,000	1,640,000	1,820,000
Cumulative contributions at MKW6000 per HH per annum	20,000	320,000	620,000	920,000	1,220,000	1,520,000	1,820,000	2,120,000	2,420,000	2,720,000	3,020,000

4.3.6 Estimated Life Cycle O&M and Replacement Costs

As presented by Table 4-3, the market prices survey revealed that the costs ranged from MWK500 (US$0.61) to MWK65,000 (US$78.84) for pump pats and MWK300,000 (US$363.87) for a complete pump set. The results of this analysis yielded an estimated total cost of MWK1,420,500 (US$1,722.90) over a life cycle of 10 years, and this includes replacement of the whole pump assembly at the end of the period. This implies that, with other factors constant (factors like environmental, construction, and external factors like theft and vandalism), the users would have to contribute the sum of MWK1,420,500 for the sustainability of their water point beyond the life cycle of the pump. In simpler terms, the users will have to contribute an average total of MWK142,050 (US$172.29) per annum, which translates to MWK2,841 (US$3.45) per household per annum for setup of 50HHs/pump.

4.3.7 Life Cycle Funds versus Life Cycle Costs

Figure 4-17 presents a graphical view of the cumulative O&M contributions at different household amounts, and the cumulative life cycle costs. From the figure, one observes that lines for cumulative contributions at MWK500/HH/year and MWK1000/HH/year remains above the line for cumulative costs until they intersect between year 2 and year 3. Similarly, lines for contributions at MWK1200/HH/year and MWK2400/HH/year remain above the cumulative costs line until they intersect almost at year 3 and between year 9 and year 10 respectively. This implies that consistent contributions between MWK500 and MWK1,000 per household per year are only enough to fully support O&M cost recovery for a period of not more than 2 years, and contributions of MWK1,200 per household per year can fully support O&M for a period of 3 years, beyond which, the funds will tend to be insufficient until the pump completely fails. On the other hand, contributions of MWK2,400 per household per year seem to be enough to support O&M costs for the whole period of 10 year, but not enough to support replacement of whole pump system at the end of the life cycle.

Table 4-3: Cost estimate for operation and maintenance and replacement

Description of spare part	Replacement interval		Life time O&M and replacement cost for Afridev hand pump														
	Quantity per pump	Approximate lifetime	Recommended replacement interval	replacement inteval	Assumed quantity	Unit Cost (2021)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Pump assembly	1	10 to 15 years	replace asrequired	10 years	1	300,000											300,000
Fulcrum pin assembly	1	5 to 8 years	replace asrequired	5 years	1	9,000						9,000					
Hanger pin assembly	1	5 to 8 years	replace asrequired	5 years	1	7,500						7,500					
Rodhanger assembly	1	5 to 8 years	replace asrequired	5 years	1	10,000						10,000					
Bearing bush	4	1 to 2 years	every year	1 year	4	3,000		3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	
Top rod assembly	1	3 to 5 years	replace asrequired	3 years	1	9,000				9,000			9,000				
Pump rod assembly	1 to 15	3 to 5 years	replace asrequired	3 years	10 (spread from 3 to 5	10,200				40,800	40,800	20,400	40,800	40,800	20,400		
Rod centraliser	1 to 15	2 to 3 years	every second year	2yrs	10	1,000			10,000		10,000		10,000		10,000		
Riser pipe assembly	1 to 15	3 to 5 years	replace asrequired	3 years	10 (spread from 3 to 5	10,000				40,000	40,000	20,000	40,000	40,000	20,000		100,000
Top sleeve	1	3 to 5 years	replace asrequired	3 years	1	1,500				1,500			1,500				
Flapper	1	3 to 5 years	replace asrequired	3 years	1	2,000				2,000			2,000				
Centraliser	2 to 15	3 to 5 years	replace asrequired	3 years	10	1,750				17,500			17,500				
Cylinder assembly	1	5 to 8 years	replace asrequired	5 years	1	65,000						65,000					
Valve body assembly	1	3 to 5 years	replace asrequired	3 years	1	26,000				26,000			26,000				
Bobbin	2	2 to 3 years	every second year	2 years	2	500			1,000		1,000		1,000		1,000		
Cup-seal	1	2 to 3 years	every second year	2 year	1	1,000			1,000		1,000		1,000		1,000		
O-ring	1	2 to 3 years	every second year	2 years	1	500			1,000		1,000		1,000		1,000		
Gasket	1	5 to 8 years	replace asrequired	5 years	1	9,500						9,500					
Compression cone	1	5 to 8 years	replace asrequired	5 years	1	5,500						5,500					
Double end socket	1 to 15	3 to 5years	as required	3 years	10 (spread from 3 to 5	3,500				14,000	14,000	7,000	14,000	14,000	7,000		
Solvent cement	1	N/A	as required	N/A	1	4,000				4,000	4,000	4,000	4,000	4,000	4,000		4,000
Portland cement	1 to 12	10 to 15yrs	as required	10 years	12	8,000											96,000
Labour (Civil works)	1	N/A	N/A	10 years	1	65,000											65,000
Labour (Area Mechanic)	1	N/A	N/A	1 year	1	6,000		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
						Annual cost estimate		**9,000**	**22,000**	**163,800**	**120,800**	**166,900**	**176,800**	**107,800**	**73,400**	**9,000**	**571,000**
						Cumulative annual cost estimate		**9,000**	**31,000**	**194,800**	**315,600**	**482,500**	**659,300**	**767,100**	**840,500**	**849,500**	**1,420,500**

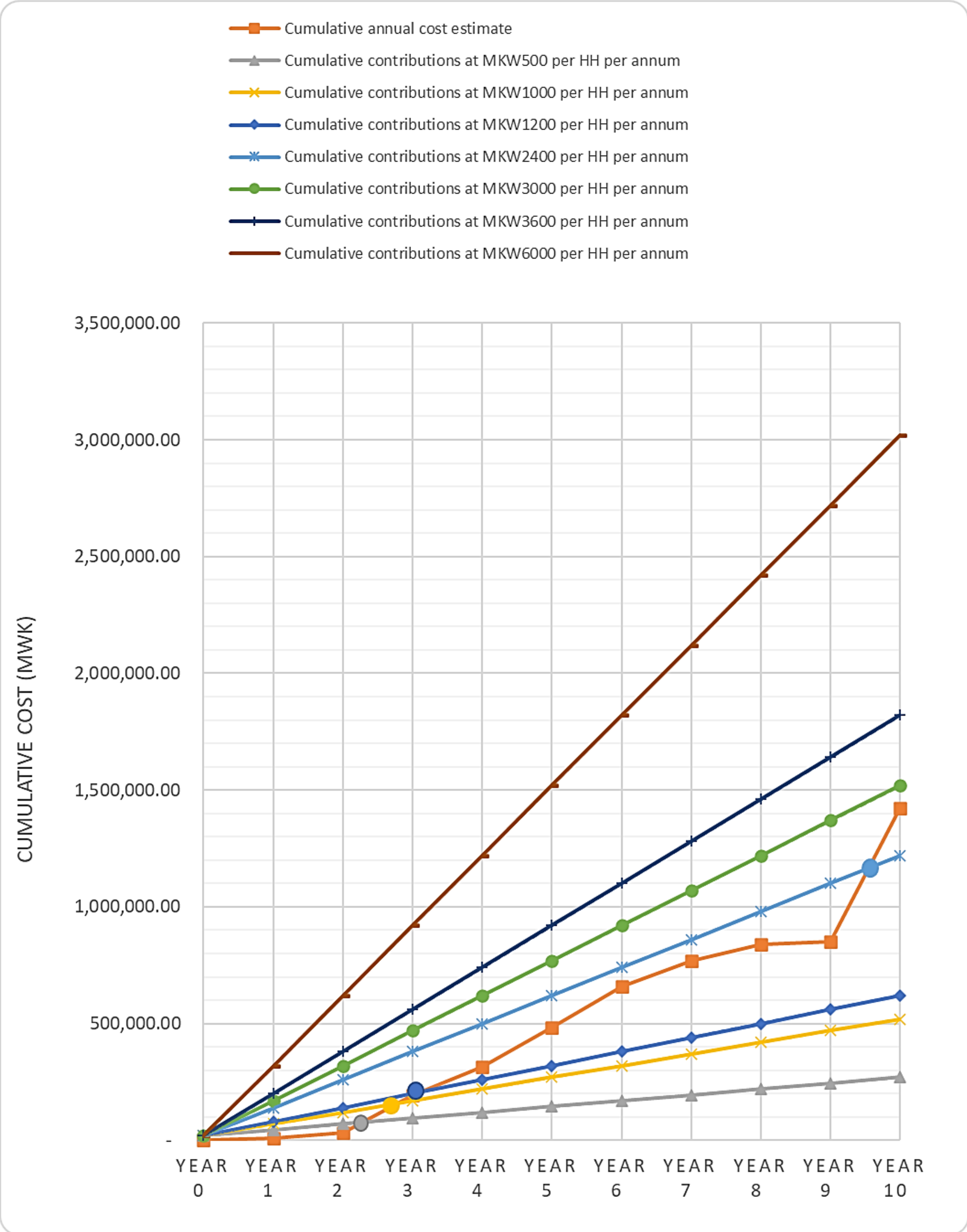


Figure 4-17: Graphical comparison between funds and costs

4.3.8 Affordability Ratio

For the sake of this analysis, the following equations 4 and 5 are referenced as discussed in Section 3.7.2.2:

i. Affordability Ratio (γ_1) = $\frac{\text{Annualised actual water costs}}{\text{Annual income}}$

ii. Affordability Ratio (γ_2) = $\frac{\text{Annualised required tariff}}{\text{Annual total expenditure}}$

As presented in Table 4-4, the study found that the minimum and maximum for γ_1 were 0.001 (0.1%) and 0.133 (13.3%) respectively, while both mode and median were at 0.22 (2.2%). For γ_2, the minimum ratio was 0.007 (0.7%) while maximum, mode and median were all tied at 0.067 (6.7%). On the one hand, as presented by Table 4-5, the study further found that 79% of the HHs were falling within the set threshold of 3% and 21% of the HHs were above the threshold, after using Affordability Ratio γ_1. On the other hand, using Affordability Ratio γ_2, 47% of the HHs were falling within the set threshold of 3% while 53% of the HHs were above the threshold.

Table 4-4: The measure of affordability ratios

		Affordability Ratio (γ_1)	**Affordability Ratio (γ_2)**
N	Valid	232	232
	Missing	56	56
Median		.022	.067
Mode		.022	.067
Range		.132	.060
Minimum		.001	.007
Maximum		.133	.067

Table 4-5: Affordability ratio distribution

Ratio range	Frequency	Percentage
$\gamma_1 \leq 0.03$	183	79%
$\gamma_1 > 0.03$	49	21%
$\gamma_2 \leq 0.03$	110	47%
$\gamma_2 > 0.03$	122	53%

4.3.9 Influence of O&M Funds versus Age on Water Point Functionality

A logistic regression analysis was carried out to ascertain the influence of tariff, which is associated with O&M funds, on the sustainability of water sources as compared to age of the water source. In the first set of the analysis, all water sources that were producing water, i.e., functional and partially functional, were grouped into one category called *functional* and coded as "1"; and the other category was *non-functional* and coded as "0". In this case, the value of the tariff had higher odds of influencing the functionality of water points, with an odds ratio (OR) of 1.047, a 95% confidence interval (CI) of 1.024 to 1.069 and p-value < 0.001. The age of water point had a lower predictable effect (OR: 0.495; 95% CI: 0.373-0.656, p-value <0.001). Similarly, in the second set of regression, all water sources with issues, i.e., non-functional and partially functional, were grouped into one category called *with issues* and coded as "0"; and the other category was *without issues* and coded as "1". In this case, the value of the tariff still predicted higher functionality (OR: 1.058; 95% CI: 1.041-1.076, p-value <0.001), while age had a smaller effect (OR: 0.745; 95% CI: 0.635-0874, p-value <0.001).

4.3.10 Qualitative Results of Tariff Setting for Water Points O&M

As observed from the above quantitative results, the majority of the households were contributing below the estimated required monthly contribution of MWK250/HH/month. The study found that 89.7% of the HHs was contributing MWK200/HH/month at most, of which

61.6% was contributing MWK100/HH/month at most. This obviously raises questions as to what basis these tariffs are set and what challenges are faced during the tariff collections.

The qualitative study revealed that most of the water point committees set a tariff in consideration of the water users' economic ability, even when they knew that the set amount is not enough to sustain all O&M requirements of the water point. For example, a participant of FGD05 was quoted saying:

"The one hundred kwacha (MWK100) was basically set on the basis that people earn low here because most of us don't do any economic activities, and we thought that this is an amount that each one of us could afford to give… however, the money we collect is only enough to buy small items but cannot suffice the purchase of big spare parts. As we speak now, there are spare parts that we were advised by Area Mechanic to buy, but up to now we are failing."

From FGD08, it was also explained that they considered people's affordability when setting a tariff of MWK100 despite recognising that set amount was not enough, as explained by one participant:

"We set one hundred kwacha (MWK100) because we thought would be affordable, looking at how people earn in this village. But the truth is that the money is not enough that is why when the borehole breaks down, we also do additional contributions to meet the cost of restoring functionality."

The study further found that the WPCs' decisions on the tariff are sometimes influenced by water users' complaints such that it compromises the requirement to set a realist tariff for the waterpoint's sustainability. Some WPCs were failing to raise the tariff to meet the cost of maintenance because of the users complaints and insults on them, as explained by one participant from FGD03:

"As a committee, we know that the one hundred kwacha (MWK100) we collect is not enough because the prices of spare parts have gone very high; for instance, a rod

[pump rod] in some cases goes up to MWK12,500. But we are failing to adjust upwards because we know the people we are dealing with, they complain and insult us because of a mere MWK100 that they cannot even use for meaningful things at their home; what more if we take it [tariff] up to K300 that we think is more realistic?"

It was also found that WPCs needed to trade carefully and find ways of convincing the users of any intentions to raise the tariff as quoted from one participant from FGD01, who said:

"We understand that this amount is not enough when we consider the prices of spare parts, and we are planning to raise it; however, we are still trying to find ways of convincing these people so that they can accept this proposed rise in the contribution amount."

4.4 Factors that Influence Universality of Access to Drinking Water

In this section, the unit analysis is still households. The section starts by providing the state of affairs in terms of households' access to improved water sources then looks at the factors.

4.4.3 Water Sources Used by Households

Based on the results of the household survey as presented in Appendix M, the study found that the sampled households used different water sources for the purposes of drinking. Disaggregated by drinking water source category, 92% of the households (n = 288) were using improved sources, while 8% were using unimproved sources. The improved sources included boreholes (88.5%), protected dug wells (2.8%) and tap (0.3%) while the unimproved sources included unprotected dug wells (4.9%) surfaces water (3.1%) and unprotected spring (0.3%). Out of the 264 households that were using improved sources, 96.6% had their sources located within their village of dwelling while 3.4% had their sources located in another village. For those that were drinking from unimproved sources, it was mainly because there were no improved sources within their reach.

4.4.4 Water Access Rates

In this section, two access rates are being discussed. The first one is 'access to improved water sources', being defined as proportion of households using improved water sources; and the second one is 'access to basic water services', being defined as the proportion of households spending not more than 30 minutes of round trip to get water from improved water sources.

The study found that the overall access to improved water sources was 92%. When it comes to access to improved sources per Traditional Authority, TA Namavi had 100%, TA Nankumba had 97%, TA Katuli had 85% and TA Chilipa had 77%. Access to basic water services was at 62% overall, with TA Namavi at 91%, TA Nankumba at 73%, TA Katuli at 42% and TA Chilipa at 20%. Figure 4-18 is the graphical presentation of the values discussed above.

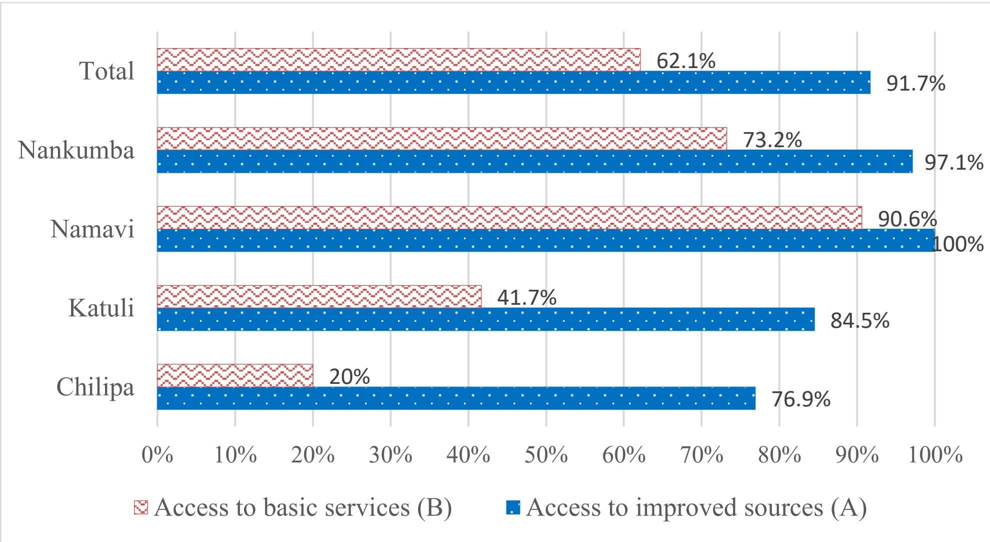


Figure 4-18: Level of water access

4.4.5 Qualitative Analysis of Factors Affecting Progress of Universal Water Access

As presented in the preceding section, it is clear that water access gaps exist and need to be filled to attain universal access. Following the collation of the codes into sub-themes, a Sankey diagram was generated to provide visualisation of the issues brought to light through KIIs and FGDs in regards to universal access to safe drinking water. The sub-themes were treated as factors for universal access to safe water. The analysis identified seven factors namely: water supply technology; financing for infrastructural projects; planning and coordination of projects; rapid population growth; sustainability of water sources; groundwater quality; and geographical and hydrogeological setting.

As observed from the Sankey diagram presented as Figure 4-19, *water supply technology* had the highest code application frequency (g = 53), of which g = 34 was under local leaders while g = 11 was under government officials and g = 8 was under water point committees. *Financing for infrastructural projects* is next with g = 41, of which g = 25 was under local leaders and g=16 was under government officials. *Planning and coordination* had g=38 with g=33 falling under local leaders and g=5 under government officials. *Rapid population growth* had g=26, with g=21 local leaders, g=4 under water point committees and g=1 under government officials. *Sustainability of water sources* had g=21, with g=14 under local leaders and g=7 under water point committees. *Groundwater quality* had g=15, of which g=8 was under water point committees, g=6 under local leaders and g=1 under government officials. Lastly, *geographical and hydrogeological setting* had 11, with 6 under local leaders and 5 under government officials.

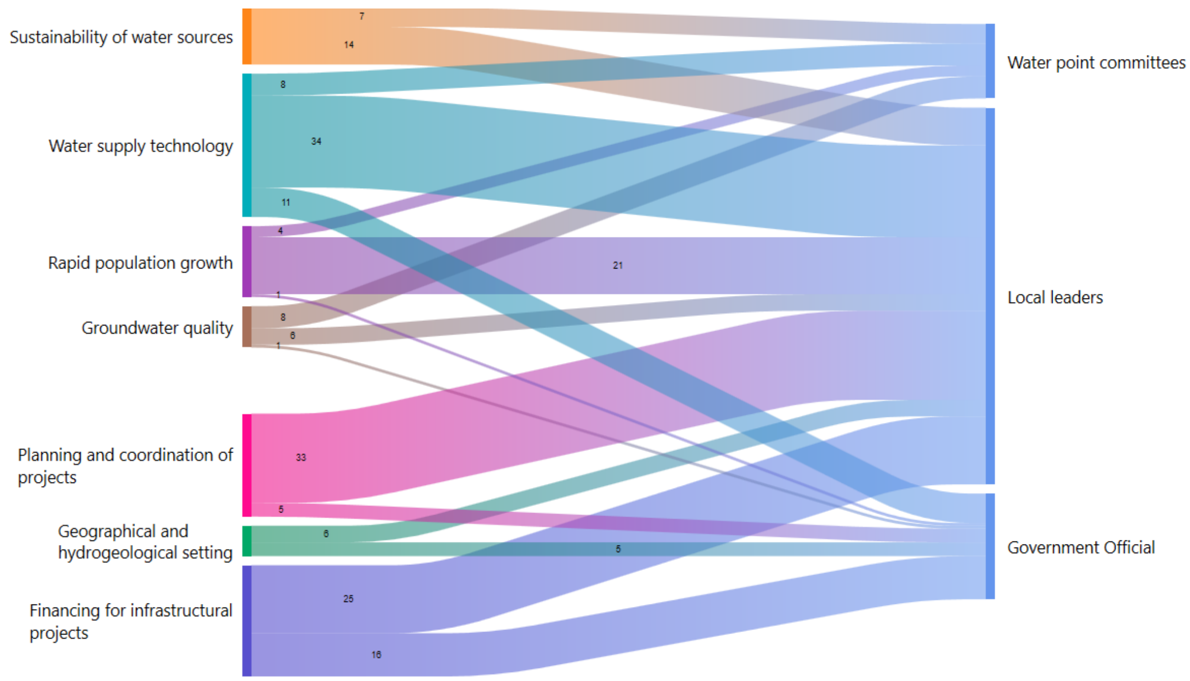


Figure 4-19: Sankey diagram on factors affecting universal access to water

A. Geographical and Hydrogeological Setting

The study found that there were areas that did not have any water sources because of failed attempts to provide boreholes due to their geographical landscape and hydrogeological formation. Key informants emphasized that there are some areas where drilling machinery has failed to reach due to poor terrain coupled with poor access roads while other areas have had several drilling attempts that yielded dry holes. According to Government of Malawi (2016), a borehole is declared dry if it yields less than 0.25 litres per second. An official from the Ministry of Water and Sanitation (KIICG02) noted that many villages had at least benefited from one or more water supply projects and those remaining were mainly had-to-reach; he explains:

"…villages have already benefited from that [water supply projects] and maybe the areas that are remaining are becoming or proving to be hard to reach, very difficult to assist."

An official from Local Authority (KIILA01) also echoed by saying:

"In some areas, it is very difficult to provide safe water, very hard to reach areas; boreholes cannot be drilled because of the terrain. Some are hilly areas, but still more, you find that people live there and we have an obligation and duty to supply water, but maybe we fail"

At community level, local leaders also raised the same concerns based on their observations and experiences on the ground. One Area Development Committee Chairperson (KIIADC01) said:

"The other problem is that there are other areas that naturally would be difficult to drill boreholes."

A Group Village Headman (KIIGVH03) echoed by saying:

"…some of the areas have had several attempts for borehole drilling but they failed; so that village is always bypassed when allocating new boreholes projects."

Similarly, a Village Development Committee Chairperson (KIIVDC08) expressed that:

"…drilling rigs fail to reach some areas, as such, those areas remain without boreholes…. There are also certain areas that have had a number of drilling attempts but all have yielded no water."

This is a clear indication that geographical and hydrogeological factors have a bearing on the attainment of universal water access.

B. Groundwater Quality

The study found that one of the factors affecting progress of access to safe water is groundwater salinity. The study established that there are certain areas which either do not have any improved water sources due to high groundwater salinity, or have boreholes with high salinity levels and cannot be used for drinking and other domestic purposes. The study further found that government and other partners had ever allocated borehole projects to some of the areas but failed to materialise as the drilled boreholes could not pass water quality tests due to high salinity; as such, they remain without improved water sources as lamented by one Group Village Headman (KIIGVH04):

"…and government gave us one borehole, unfortunately it was found to be salty [after drilling]."

The same sentiments were echoed by one Village Development Committee chairperson (KIIVDC02) who said:

"The other problem is that sometimes we choose a site but after drilling, the water is tested and found to be saline. As such it makes us stop allocating boreholes to that area and in the end the area is left with few or no boreholes as compared to the need of that area."

The Local Authority also expressed concern that salinity of groundwater in some parts of the district was retarding progress of access to safe drinking water as such areas can no longer be allocated boreholes to avoid wasting resources, as said by one official (KIILA02):

"One of the challenges we are facing is salinity of groundwater in some parts of the district, and this makes us fail to allocate boreholes to such areas. As a result, these areas still remain behind when it comes to access to safe water."

One example of wasted investments is the case of existing water sources that do not fully fulfil their intended purpose due to poor water quality as explained by one Area Development Committee chairperson (KIIADC07):

"*Some boreholes are giving us problems, some of which are water quality in nature, especially saline water. As such, people may just draw water for bathing from such boreholes and go to other boreholes for drinking and cooking".*

In some instances, the community has no alternative improved water sources when their only source is producing salty water, as such, people are forced to still use the same water or use unimproved sources such as unprotected well or surface water. This is evidence by what was spoken by a female member of FGD11 who said:

"*Our borehole is functioning well although the metal parts always corrode. The only major problem is that the water is salty and we do not have any good water borehole nearby. This forces us to still drink the same unpalatable water, but the majority go to the lake".*

C. Rapid population Growth

The study found that rapid population growth in Mangochi District is a threat to the attainment of universal water access. According to the 2018 Malawi Population and Housing Census Report, Mangochi District had the second highest district-level intercensal population growth rate of 3.6%, and exceeded both the national (2.9%) and the Southern Region (2.7%) population growth rates by a wide margin. The population had grown from 796,036 in 2008, to 1,148,611 in 2018, and projected to be at 1,471,267 in 2025 (National Statistical Office, 2019). Some key informants expressed concern that the population in the district was growing at a very rapid rate, such that water sources that used to be enough were no longer enough resulting in congestions, as explained by one Traditional Authority KIITA01:

"Yes, we may have many boreholes but the population is increasing at an alarming rate. Most of these boreholes were constructed in early 2000s, based on the population of that time. But now the boreholes can't much the population; the population is more and the boreholes are no longer enough. There is need for more water supply interventions."

Other key informants felt that the investments being made in water infrastructure were not matching the rapidly growing population such that the progress being made was slow despite new water sources being constructed. In additional, there were also concerns that due to the growing population, some people were relocating to other isolated places with no water sources, and worse still, to hilly areas. One Traditional Authority (KIITA04) water quoted saying:

"Increase in population is also bringing us backwards despite the efforts. It is like going forward and backwards at the same time. The government is trying but we are reproducing a lot. This increase in population is rendering a lot of things inadequate. Scramble for resources due to high population is forcing others to relocate to hilly places; and when this happens, you find that the relocated population needs their own water source".

Government officials also felt frustrated that despite several interventions in the district by different partners, there seemed to be no remarkable progress towards universal access to safe water. One official (KIILA02) said:

"The progress is so slow. You know what? We have been having projects in water supply by different partners such as drilling of boreholes. Suffice to say that, the more we drill boreholes, the more it looks like we have stagnated in terms of safe water access, all because how rapidly the population is growing in the district".

D. Water Supply Technology

The study found that water supply technology was considered highly, among the key informants and focus groups, as one key factor that could aid the attainment universal water access. The understanding is that some of the existing challenges would only be answered if there are shifts or changes in rural water supply technological orientation. The existing technologies, like handpump boreholes and protected shallow wells, have been used for decades but have limitations that need to be addressed if universal access is to be attained. For instance, boreholes have proved not to be a good technology in some areas with ground salinity, as discussed in section 4.4.3.2. In some cases, shallow wells were used as a solution to groundwater salinity in areas where the saline aquifer was deeper, but with climate change, they dried up as explained by VDC chairperson (KIIVDC04):

"As a solution [to groundwater salinity], we were provided with so many shallow wells and we were hopeful that water problems would be things of the past. Unfortunately, almost all these shallow wells dried up just after a short period and we are back to the old days".

Such being the case, shifting the focus on handpump boreholes or protected shallow wells to water reticulations, apart from being a more advanced technology, was considered to be the answer to geographical, hydrogeological and salinity challenges being faced in some areas in the sense that a high yielding borehole could be drilled in another village and transported to another village through pipes. For instance, a VDC chairperson (KIIVDC 08) said:

"There are certain areas that have had a number of drilling attempts but all have yielded no water. I was thinking that, if possible, we can drill a borehole in another village and take the water to another village through pipes."

This was echoed by a GVH (KIIGVH04) who said:

"Just take good water from another area, through pipes, to this place. This would solve our groundwater salinity problem"

Even those from central government recognise the fact that most of the areas remaining to be provided with safe water are those that are hard to reach and piped water systems could be a better solution in such cases as stated by a Ministry of Water and Sanitation official (KIICG02):

"Most areas that are remaining [without access] are becoming or proving to be hard to reach, very difficult to assist. So, we are targeting such villages with reticulated systems from deep high yielding boreholes"

Apart from solving geographical, hydrogeological and salinity challenges, the study found that the key informants and focus groups believed that a shift from drilling handpump boreholes to groundwater reticulated systems would lead to bringing water closer to peoples' homes, thereby reducing distance and time taken to fetch water. From FGD03, it was said:

"Introduction of taps can also help reduce time spent on water collection; and even those that are far can receive their own tap. This system is much better than handpump boreholes because one borehole produces several water points which are also hygienic because they are not congested."

A Traditional Authority (KIITA03) also commented on the reduction of distance and time, saying:

"With these piped water systems, at least the water will be closer to everyone, and people will not be going far and hence they will be spending less time as you already stated."

By bringing water closer to the homes, some pointed to the fact that this could also be advantageous to the elderly and other physically challenged individuals in the community, as quoted from one member of FGD06 who said:

"We feel there is need for government to consider the disadvantaged like the elderly and the disabled, by bringing water to their homes because they cannot ably walk long distance to fetch water; government should consider them so that their lives can also be normal like everyone else. Taps could do better."

The study further found that even Government of Malawi through Ministry of Water and Sanitation had already taken the direction of promoting reticulated systems over handpump boreholes as a step towards attainment of safely managed service level of the Sustainable Development Goal 6.1. An official from the Ministry (KIICG01) reported:

"Reticulation of groundwater sources is already a government initiative that we would want to do; if we are to move from basic to safely managed [service levels], the way to go is to increase a lot of reticulations even in the rural areas. With this, we can even cover more population other than using a single borehole [point source]."

Another official from the Ministry of Water and Sanitation also commented that government was moving away from just looking at people getting water within 500m radius, rather water should be taken even closer to people. He said:

"…but we should now be talking of taking the water closer to the people instead of just focusing on having the source within 500m of people's reach and call that access."

Much as technological shift would solve a number of issues as discussed above, the study found that people were also of the view that the country must be moving with the advancement in technology as expressed by one Group Village Headman (KIIGVH02):

"The world is moving forward and we also need to move forward. We are now living a world full of technologies, and therefore provision of water should also use new technologies."

The community leaders believed that time had come to move up with technology, thus moving from handpump boreholes to tap water, as commented by one Traditional Authority (KIITA03):

"Things have changed over time. We need to go with technology. Our forefathers used to drink from unprotected water sources; then came handpump boreholes. We have now used these handpump boreholes for long and it's time to change; it is time to graduate; bring in taps now. If that happens, it means we are moving forward."

E. Financing for Infrastructural Projects

The study found that financing forms the back bone of universal access in the sense that it would require a considerable chunk of financial resources to have meaningful investments in technologically sound water supply projects that would solve the existing geographical, hydrogeological and water quality challenges, and boost the water access level to a magnitude that would overtake the prevailing high population growth. The available resources would determine the extent to which investments can be made as noted by key informant from Ministry of Water and Sanitation (KIICG01), who said:

"But the issue is on the resource envelope that we normally have; we use what we have, and that's the extent we can go."

This is an indication that if the resource envelope is small, nothing big can take place as also commented by an Area Development Committee chairperson (KIIADC01).

"This [universal access] can be possible if finances for projects are available; but if not, it means nothing can work."

The study, however, found that the current funding to the Water Sector was not enough to push water development to the level that could meaningful and lead to the attainment of universal access as expressed by a key informant from the local authority (KIILA01):

"The first challenge that I would say is that the resources that the sector [water sector] gets are very limited; they are not enough for the district be to achieve universality in water access."

The same concern was expressed by those from central government as quoted from KIICG01 who noted that even resources that go through central government were never enough to cover the districts well, which brought doubts as to whether SDG targets could be achieved:

"The resources [for projects] we get are not adequate enough for us to cover a greater distance in terms of a number of districts we are able to cover. Of course we prioritise most needy districts, but still, with the amount of money that we have, we may not even achieve 100% coverage in those [prioritised] districts.

F. Planning and Coordination of Developmental Projects

The study found that projects planning and coordination is another important factor for universal safe water access. The study noted that there were a number of interventions in the rural areas, yet no significant change was noticed because of lack or poor coordination. Some organisations or individuals would also go into villages without following the district plans and end up going into areas which are not the district's priority. As a result, there was duplication of efforts and no significant changes were noticed in the district. With proper planning and coordination, the projects would be going to areas where there was need only, and in a magnitude that meets the peoples' needs by the end of the day. This coordination is at all levels and among all players such as local leaders (chiefs, ADCs and VDCs), politicians (MPs and councillors), partner organisations and government officials (local authority and central government), as commented by the key informants:

"We only need good coordination from the leaders i.e., VDC, ADC, Councillors, MP, the government and the donors or NGOs; these people must work together, otherwise we will continue with the same trend of poor access to safe water. (KIIADC02)

"…especially for the rural areas there is need for a lot of coordination; because we pool our resources together as partners to have noticeable impact, other than the silo kind of working that we do." (KIICG01)

It was further pointed out that, although on-governmental organisations (NGOs) and other development partners (DPs) were investing in water supply projects, the impact was minimal because of uncoordinated and siloed approaches where each partner wants to do their own way, and sometimes duplicating the efforts. One key informant (KIICG01) said:

> *"…especially for the rural areas, there is need for a lot of coordination because, if we pull our resources together, other than the silo kind of working that we do, something great can be achieved. Unlike that somebody goes to Mangochi does their own thing; then another one goes there too and does something else; and in the end you [responsible office] don't even have a proper report of whatever is happening to be able to aggregate and see where the gaps are."*

G. Sustainability of Existing Water Sources

Another finding of the study is that the abandonment of water points is another factor derailing progress of access to safe water. The study noted that some water sources were being abandoned due to a number of reasons such as drying up or mechanical problems, according to key informants. The study further noted that some of the abandoned water sources were mainly linked to poor construction practices, poor O&M practices, irrelevant technology and old age.

According to a statement by one Area Development Committee chairperson (KIIADC03), he suspected that failure to uphold construction standards by contractors was leading to drying up of boreholes within a short period, as quoted:

> *"But other problems arise because some contractors drill boreholes that dry up within two to three months. Probably they are not given the standards for doing such work or they choose to do shortcuts. That is why you see that most of the non-functional boreholes are due to dryness."*

Choice of technology was also blamed as the cause of drying up of water points as quoted from one Group Village Headman (KIIGVH04) who said:

> *"The other problem is that we had shallow wells and most of these dried up just after two to three years."*

A VDC chairperson (KIIVDC04) echoed the sentiments by saying:

> *"We were provided with so many shallow wells and we were hopeful that water problems would be things of the past. Unfortunately, almost all these shallow wells dried up just after a short period and we are back to the old days."*

On water points being abandoned due to mechanical problems, key informants reported of boreholes having mechanical problems ranging from failed rising mains to worn-out pump housing. For instance, a Traditional Authority (KIITA04) cited a case or rising mains falling into the well, saying:

"Some boreholes have been abandoned due to risers that fell into the borehole and failed to be fished out."

Another key informant, a Village Development Committee chairperson (KIIVDC06) mentioned worn out pedestals due to old age as the cause for abandonment. He said:

"The biggest problem is that most of the old boreholes constructed in the early 2000s are now having their pedestals broken, and as such, the boreholes are being abandoned, thereby creating congestion at the other boreholes".

Apart from complete abandonment of some water sources due to drying up or water quality issues, some water sources were just unreliable as they were intermittent or seasonal in their supply due to low yielding or frequent mechanical failures. All these cases led to people having no proper access to safe water at all times. A participant from FGD04 complained of a low yielding problem especially in summer, as she said:

"When it is the peak of the dry season, from October, the water level goes exceedingly down such that the flow is so low, and it takes more time to fill a single pail leading longer queues and more time spent as people keep waiting".

Similarly, one GHV (KIIGVH02) alluded to the existence of some boreholes that completely dry up in the summer and resuscitate after rains:

"The other problem is that some boreholes dry up in the summer months, say from August, until the rain season".

4.5 Dynamics in Equitability of Access to Drinking Water

4.5.1 Spatial Disparities in Access to Drinking Water

The study found that there were inter-TA and intra-TA variations in both access to improved water sources as well as access to basic water services as shown Table 4.6 and Table 4.7 respectively. For instance, access to improved water sources across the TAs ranged between 76.9% and 100%, while access to basic water services ranged between 20% and 90.6%. On intra-TA variations, access to improved water sources ranged between 55% and100% while access to basic water services ranged between 18.2% and 21.2% across the sampled GVHs in TA Chilipa. Access to improved water sources in TA Katuli ranged between 76.5% and 100% while access to basic water services ranged from 0% to 100%. Similarly, TA Namavi had access to improved water sources at 100% across all GVHs and access to basic water services ranging between 50% and 100%, while TA Nankumba had access to improved water sources ranging from 75% to 100% and access to basic water services ranging from 0% to 100%.

The results of the analysis of inequality in water points distribution among the Traditional Authorities in the study area, using Gini index derived from Lorenz, as presented in Figure 4.20, and with reference to Table 4.8, showed a Gini coefficient of 0.3995, calculated as the ratio of area between line of perfect equality and the Lorenz curve (A) to the total area under the line of perfect equality (A+B) (Cole et al., 2018; Cullis and Van Koppen, 2009). The calculated area A was 0.19975, and the calculated area B 0.30025, while area A+B was 0.5. According to past studies, Gini index of less than 0.2 is classified as low inequality, 0.2 - 0.3 as moderate inequality, and greater than 0.3 as a high level of inequality (Cole et al., 2018; Dongzagla et al., 2022). The Gini index of 0.3995, therefore, shows that there was a high-level inequality among the four traditional authorities in the study area.

Table 4-6: Access to improved water sources

Location			Household water access			Access Rates
			Improved Source	Unimproved Source	Total	
Chilipa	GVH	Afiki	11	9	20	55.0%
		Kapire	19	0	19	100.0%
	Total		**30**	**9**	**39**	**76.9%**
Katuli	GVH	Chisuse	14	4	18	77.8%
		Chiwaula	9	0	9	100.0%
		Makande	13	4	17	76.5%
		Matola	15	3	18	83.3%
		Maundu	9	0	9	100.0%
	Total		**60**	**11**	**71**	**84.5%**
Namavi	GVH	Chapola	14	0	14	100.0%
		Kadango	16	0	16	100.0%
		Ng'ombe	2	0	2	100.0%
	Total		**32**	**0**	**32**	**100.0%**
Nankumba	GVH	Balamanja	18	0	18	100.0%
		Binali	18	0	18	100.0%
		Chigonere	18	0	18	100.0%
		Kaiche Anafi	18	1	19	94.7%
		Kasankha	1	0	1	100.0%
		Kasankha	18	0	18	100.0%
		Kholowele	6	2	8	75.0%
		Kholowere	1	0	1	100.0%
		Kholowere	9	0	9	100.0%
		Makunula	18	0	18	100.0%
		Maudzu	17	1	18	94.4%
	Total		**142**	**4**	**146**	**97.3%**
Total	**Total**		**264**	**24**	**288**	**91.7%**

Table 4-7: Access to basic water services

Traditional Authority			Number of HHs			Access to basic services
			0-30 minutes	Over 30 minutes	Total	
Chilipa	GVH	Afiki	2	9	11	18.2%
		Kapire	4	15	19	21.1%
	Total		**6**	**24**	**30**	**20.0%**
Katuli	GVH	Chisuse	4	10	14	28.6%
		Chiwaula	0	9	9	0.0%
		Makande	4	9	13	30.8%
		Matola	8	7	15	53.3%
		Maundu	9	0	9	100.0%
	Total		**25**	**35**	**60**	**41.7%**
Namavi	GVH	Chapola	12	2	14	85.7%
		Kadango	16	0	16	100.0%
		Ng'ombe	1	1	2	50.0%
	Total		**29**	**3**	**32**	**90.6%**
Nankumba	GVH	Balamanja	18	0	18	100.0%
		Binali	16	2	18	88.9%
		Chigonere	14	4	18	77.8%
		Kaiche Anafi	14	4	18	77.8%
		Kasankha	1	0	1	100.0%
		Kasankha	17	1	18	94.4%
		Kholowele	0	6	6	0.0%
		Kholowere	1	0	1	100.0%
		Kholowere	8	1	9	88.9%
		Makunula	4	14	18	22.2%
		Maudzu	11	6	17	64.7%
	Total		**104**	**38**	**142**	**73.2%**
	Total		**164**	**100**	**264**	**62.1%**

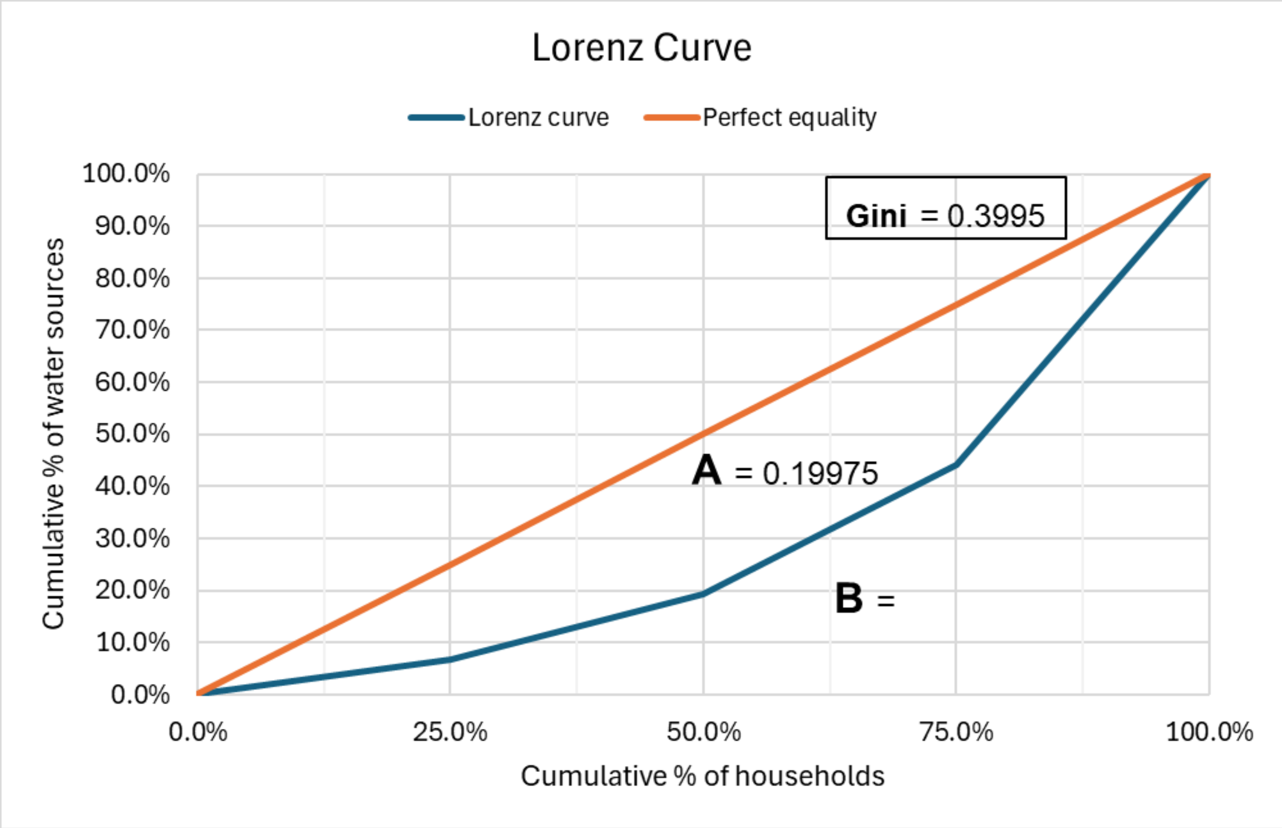


Figure 4-20: Lorenz curve for water points distribution in the study area

Table 4-8: Lorenz curve distribution matrix

Location	Number of Households	Percentage of households	Cumulative percentage of households	Number of water points	Percentage of water points	Cumulative percentage of water points	Perfect Equality	Area under Lorenz curve (B)	Area under line of perfect equality (A+B)	Area between perfect equality and Lorenz curve (A)	Gini Index (A/A+B)
	0	0.0%	0.0%	0	0.0%	0.0%	0%	0	**0.5**	**0.19975**	**0.3995**
Chilipa	1000	25.0%	25.0%	7	6.7%	6.7%	25%	0.008375			
Katuli	1000	25.0%	50.0%	13	12.5%	19.2%	50%	0.032375			
Nankumba	1000	25.0%	75.0%	26	25.0%	44.2%	75%	0.07925			
Namavi	1000	25.0%	100.0%	58	55.8%	100.0%	100%	0.18025			
Total	**4000**	**100.0%**		**104**	**100%**			**0.30025**			

4.5.3 The Political and Governance Dynamics

The study, through a thematic analysis, identified two main themes relating to dynamics in equitability of water access, and these are:

i. Institutional Arrangement
ii. Power Dynamics

The study first explored the institutional arrangement for development planning and implementation in the district and found that the district had all the development structures as stipulated by Government of Malawi (2013). The structures include Villages Development Committees (VDCs), Area Development Committees (ADCs), Area Executive Committees (AECs) and District Executive Committee (DEC). The arrangement is such that the VDC is responsible for all developments taking place at group village level while the ADC is responsible for TA level developments. AECs play a technical advisory role to the ADCs while DEC is the technical arm that handles all development issues in the district. All these structures have their own well-stipulated functions. In relation to community level developmental projects, which includes water supply, the study zeroed in on VDCs and ADCs as the day-to-day grassroots players in planning (including needs assessment), monitoring and supervision. Through the KIIs, the ADC and VDC chairpersons were assessed on their knowledge of the roles/functions of their respective committees. There were five functions for ADCs and six functions for VDCs that they were gauged against, as adapted from (Government of Malawi, 2013).

Results of a code-document analysis in ATLAS.ti 9, as presented by Figure 4.21, show that all the five functions were mentioned by at least one ADC chairperson. However, *"improving on and prioritising projects from the VDCs for submission to the DEC"* was the only function that was mentioned by all the ADC chairpersons (g=8), followed by *"supervising, monitoring and evaluating the implementation of projects at TA level"* which was mentioned by three chairpersons. One of the remaining functions was mentioned by two chairpersons while two functions were mentioned by only one person each. Contrary to the ADCs, the VDC chairpersons only mentioned three out six listed functions with *"identification and prioritisation of community needs"* topping the list (g=7), followed by *"communicating on community-based issues with the ADC"* (g=4). The last mention function (g=2) was *"supervising, monitoring and evaluating implementation of development activities in the villages"*.

		ADC 5 96	VDC 8 129	Totals
ADC_ addressing community needs at TA level	2	2		2
ADC_ bringing together community members and resources for self-help projects;	1	1		1
ADC_ improving on and prioritising project proposals from VDCs for submission to DEC	8	8		8
ADC_ organising monthly meetings together with VDCs from their area	1	1		1
ADC_ supervising, monitoring, and evaluating the implementation of projects at TA level	3	3		3
VDC_ communicating on community-based issues with the ADC	4		4	4
VDC_ encouraging and bringing together community resources for people's participation in self help activities	0			0
VDC_ initiating community self-help activities	0			0
VDC_ reporting to the relevant Group Village Headmen (GVH) on the discussions and activities of the committee	0			0
VDC_ supervising, monitoring and evaluating implementation of development activities in the villages	2		2	2
VDC_identifictaion and prioritisation of community needs	7		7	7
Totals		15	13	28

Figure 4-21: Analysis of knowledge of ADC and VDC functions

Secondly, as earlier presented, the study's thematic analysis identified power dynamics as one of the two main themes in relation to equitability of drinking water services. To better understand the power dynamics in the allocation of water sources, different forms of power were identified and classified as follows:

a. **Institutional Power:** This is the form power that institutionalised structures like ADCs and VDCs have in assessing community needs and deciding where to take development projects to.

b. **Traditional Power:** This is the power that is vested in traditional chiefs to look after the welfare of their subjects.

c. **Political Power**: According to the study, this power is possessed by politicians such as members of parliament (MPs) and ward councillors.

d. **Technical Power**: This is the form of power that technical arms and committees such as DEC and District Coordination Team (DCT) use to technically validate, vet or monitor projects. The committees can recommend acceptance or rejection of a project proposal on technical basis.

e. **Administrative Power:** This is the form of power that is bestowed on the office of the District Commissioner to formally authorise and guide implementation of projects by partners following technical advice.

f. **Capital Power:** Capital power, in this context, is defined as the inherent power that is possessed by the capital holder (the one with capital to invest). In this case, it can mean an organisation or individual that has the moneys to invest in community projects.

Through the key informant interviews, the study found that political power would sometimes override institutional power. Specifically, MPs would forego laid down procedures for the allocation of developmental projects, that is, allowing the ADCs and VDCs decide on where projects should go to. It was noted that in a number of circumstances, some MPs would bypass ADCs and decide on their own where to take borehole projects to, in disregard of area development plans. Usually, the political power would influence allocation of water projects to areas where the politician had high political following as expressed by one GVH (KIIGVH03):

"Sometimes it is the politicians, the MPs, who just take projects to an area where they feel they have supporters who voted for them".

It was also noted that those with institutional powers (ADCs) would not even have the courage to confront the one with political powers (the MP) for explanation why the project never went to ADC. One ADC chairperson (KIIADC03) said:

"It is because the ADC and chiefs have no power to control politicians, who seem to have more power to make their own decisions. In the end, as ADC we just back track".

The study also established that there was good harmonisation of the two powers. The traditional chiefs in the study area were respecting the institutional powers vested in the development committees (ADCs and VDCs). This was mostly the case because the traditional chiefs were also members of the said committees and therefore were already party to any decisions made by the committees. However, the study could not establish whether the participation by the chiefs was influencing the decision-making process in favour of the chiefs. The study further found that although the development committees had institutional powers to decide where to take the projects to, technical committees (DEC and DCT) used their technical powers to validate or appraise the submissions by the ADCs. In this case, technical powers would reign supreme over the institutional powers. This is evidenced by what one TA (KIITA01) said:

"It is the VDCs who outline the water needs in their area and these are taken to ADCs. The ADCs then submit the same to the Council (after prioritisation) where all necessary appraisals are done".

Another case was where capital power would override administrative powers. In this regard, a partner organisation feels like their operations in the district cannot be regulated by the council because they are the "capital holders" (they have the cash). On the other hand, the District Council, that has the administrative powers, shy away from regulating or disciplining the "capital holder", fearing that the organisation may leave for another district and lose project resources. This is evidenced by the sentiments provided key informants from both central government and local authority, who said:

"But the problem now comes, you know, when you are needy, to tell somebody to go away; so, because of the money (financial resources), most of the councils have yielded to things which probably in normal senses they would not have to." (KIICG01)

"...but right now, may be, we are not very strict as a district because sometimes we fear that we may lose support from these partners." (KIILA01)

Similarly, capital power was also seen to be overriding institutional power at local level. This was mostly common with religious based organisations who generally would not consult or inform the ADCs or VDCs on their plans to drill boreholes in the villages. The organisations had no regard for area development plans and could drill boreholes in areas of their choice since they had the funds to do so. One VDC chairperson, sitting as a key informant *(KIIVDC01)* complained about this malpractice by saying:

"There are also these… [people of some foreign race, belonging to a faith-based organisation] who just get into the villages and drill boreholes wherever they want without our [VDC] involvement. When you try to ask, they say that it is their money so they can do whatever they want with it. They don't mind whether there is another project in the area or not, they will just drill anywhere. They feel they have power because of their money."

CHAPTER FIVE: DISCUSSION

5.1 Drinking Water Safety Measured through Drinking Water Quality

5.1.1 Physio-Chemical Results

The study findings have indicated that, out of the two priority chemicals tested in this study, only arsenic was not detected in the water samples collected from water points in Mangochi District. This implies that there were either no arsenic presence or its concentrations in the water were below the detection limit of 5 mg/L, which is below both WHO (10 μg/L) and MS (50 μg/L) thresholds. This finding signifies that, although highlighted as a priority chemical under SDG 6.1 monitoring, arsenic may not be of serious concern. This is not surprising because past studies have suggested that most African countries are expected to have arsenic concentrations that are less than 10 mg/L (Ahoulé et al., 2015; Lapworth et al., 2020). Further, this finding agrees with findings of other studies conducted in different districts in Malawi (Balaka, Blantyre, Chikhwawa, Chiradzulu, Mulanje, Nkhatabay and Zomba), whose arsenic test results were also less than 10 mg/L (Kanyerere et al., 2012; Pritchard et al., 2008, 2007). Studies conducted in the neighbouring districts of Machinga and Balaka also found that arsenic concentrations in sampled water sources in the districts were below 10 μg/L (Pritchard et al., 2008; Rivett et al., 2019).

Contrary to the results of arsenic, fluoride was registered in the study area, especially in groundwater sources, even in values exceeding Malawi's standard value of 6mg/L. With mean value of 3.76mg/L, median of 3.16mg/L and SD value of 3.45, it signifies that there was skewed distribution of the fluoride data, with moderate variability and some dispersion around the central tendency. On the one hand, this finding contradicts with the findings of Addison et al. (2020), who in their study of groundwater vulnerability to geogenic fluoride, nation-wide in Malawi, predicted that the highest risk zone in Mangochi is 'elevated geological fluoride risk zone' where there is more than 60% likelihood of fluoride exceeding 1.5mg/L and 0%

likelihood of exceeding 4mg/L. This prediction implied that fluoride concentrations for groundwater sources (boreholes and shallow wells) in Mangochi District would not exceed 4mg/L. This contradiction could be attributed to the fact that the study by Addison et al. (2020) was based on statistical modelling, unlike this study which was based on actual observations and measurements. Generally, as argued by Xie (2011, p. 8), "all statistical models have limitations". St-Pierre (2016, p. 4918) further argues that "model predictions and observations differ more than what is practically acceptable in a portion of the prediction space". As such, it is expected that results of a prediction model may not produce the exact result as that from the actual measurement. A further argument to this contradiction is that prediction model suffered some serious limitation due to inadequacy of data, as alluded to by Addison et al. (2020, p. 20) that "this prediction may change with increased sampling and testing of the map". This shows that there is likelihood that some data values from fluoride testing results would still be outside the predicted ranges.

The finding of this study on fluoride concentration also agrees with past studies that found fluoride concentration levels above 4mg/L in some boreholes in Mangochi District. For instance, Chimphamba and Phiri (2014) analysed borehole water quality data collected by the Ministry responsible for Water Affairs in Malawi since 1980s, and established that, out of 5,324 boreholes assessed for the whole Malawi, 139 boreholes had fluoride concentrations exceeding WHO limit of 1.5mg/L, out of which 63 cases, representing 45%, were registered in Mangochi District with a maximum of 7mg/L. This study, however, did not indicate how many boreholes had values exceeding Malawi's standard maximum value of 6.0mg/L. A recent water quality analysis by Government of Malawi (2021), established fluoride concentrations ranging from 1.15mg/L to 14.5mg/L from 11 boreholes Mangochi District, out of which 64% had values above 6mg/L, with values ranging from 7.2mg/L to 14.5mg/L. The results of this nature would be expected in Mangochi District, being located within the alluvial plains, bearing in mind that

United Nations (1989) as cited in Mapoma and Xie (2014) reported fluoride concentrations between 2mg/L and 10mg/L from the alluvial regions in Malawi.

The results also showed that there was statistically insignificant variation in the fluoride concentrations between wet and dry seasons, which implies that the water users had almost constant level of exposure. However, there were higher values in the wet season than in the dry season as also confirmed by the wet season higher mean ranking during the Independent Sample Mann-Whitney U Test. One would expect to see higher concentrations in the dry season and low concentrations in the wet season because it is often attributed to the dilution effect of aquifer recharge from rain input (Dibal et al., 2017; Okoo, 2007; Satheeshkumar et al., 2017). However, this finding agrees with findings from other studies that also found higher fluoride concentrations in the wet season than the dry season (Battaleb-Looie and Moore, 2010; Ghahramani et al., 2020; Sreedevi et al., 2006). In the neighbouring district of Machinga, Sajidu et al. (2007) also found seasonal variations in groundwater fluoride concentrations with 26% of the water points under study having higher values in the wet season than in the dry season. Although no further probing was done, the scenario of higher fluoride concentrations in the wet season would either be related to fluoride bearing substances being found at shallower depths such that interaction between the water and the contaminants is more prominent in the wet season due to the rise in water levels; or contamination by rainwater infiltrate that interacts with the fluoride-bearing substances located at shallower depth and circulates further into the main aquifer. This is achieved through the process of leaching and dissolution of fluoride during circulation of water in fluoride-bearing rocks and soils, resulting into fluoride enrichment of the groundwater (Battaleb-Looie and Moore, 2010; Brunt et al., 2004). However, this suggested reason may still be challenged or confirmed through a further study that aims at identifying the fluoride sources.

Contrary to the insignificant seasonal variation, the results showed a significant spatial variation between TA Katuli, with the lowest mean ranking, and the rest of the TAs and insignificant differences among Chilipa, Namavi and Nankumba. The significant spatial variation could be as a result of differences in geochemical and environmental characteristics between Katuli and the rest of the TAs, while the insignificant variation could be attributed to homogenous geochemical and environmental characteristics across the three TAs (Nkemdirim et al., 2016).

Although this study did not look into the possible sources of groundwater fluoride in the study area, which in itself presents a gap for further investigation, other studies have shown that fluoride enrichment in groundwater is mainly a result of the interaction between water and fluoride-bearing minerals in the host rocks, such fluorspar (fluorite), apatite (fluorapatite) and phosphorite (Prajapati et al., 2017). Geological processes such weathering of the fluoride-bearing minerals and cation exchange, especially under high pH and low calcium conditions, are the common factors that influence fluoride concentration in ground water (Hao et al., 2021; Prajapati et al., 2017; Suneetha et al., 2018), which is in line with the present scenario where TA Katuli with the lowest fluoride mean rankings also registered lowest pH mean rankings. Any variations in the existence of fluoride-bearing minerals, geological and geochemical processes would therefore result in variations in fluoride concentrations in the groundwater. However, detailed analysis specific to the study area would be necessary.

Results of the turbidity test were relatively good, with 98% of the samples (n = 162) not exceeding 25 NTU, thus meeting the Malawi standard requirement for turbidity in drinking water from boreholes and shallow wells. The mean value of 3.17 NTU, median of less than 0.01 NTU and SD of 18.33 suggests a highly skewed distribution with most values concentrated near zero and with potential outliers. In terms of inter-TA comparisons, Katuli's highest mean rankings in the Kruskal-Wallis Test signify that it had the worst turbidity results, statistically, as compared to the rest of the TAs. This result is not surprising since three of the four samples that exceeded 25 NTU were registered in the TA. Although the results of the Independent Samples Mann-Whitney U Test showed no statical difference in the turbidity between the wet and dry seasons, the evidence that the three boreholes with turbidity exceeding 25 NTU had higher figures in the wet season than the dry season, points at some linkage with rainfall. Specifically, this could be attributed to ingress of silt-carrying rainwater, either as run-off or muddy infiltrate, into the boreholes as suggested by (Dzimbiri et al., 2021).

The ingress of dirty water from run-off is an indication that the faecal matter can easily find its way into the boreholes, thus compromising on the safety of the water. In additional, the turbid water may also act as breeding ground for microbes such as disease-causing bacteria (Boadi et al., 2020; Bwire et al., 2020). That is why high water turbidity is associated with higher levels of microbial water contamination (Shittu et al., 2008). This puts the water users at risk of contracting water-borne diseases such as diarrhoea. The situation signifies that the boreholes had infrastructural flaws such as absence of sanitary seal, poor well design or poor filter pack (Government of Malawi, 2016a; Mannix et al., 2018). This claim is enforced by the reports of borehole caretakers who confirmed that all the three boreholes were constructed without the knowledge and supervision by government representatives, usually the Water Monitoring Assistants; and as a result, no cement grouting (sanitary seal) was done. It is also possible that the well design might have been messed up, like having slotted casings close to the ground, since there was no technical supervision. According to key informants at the District Council, this is very common for boreholes constructed by some organisations and other individuals who usually have no regard for standardised procedures.

On pH, the SD of 0.41 shows that the data distribution was relatively consistent and symmetric around the median. The overall results depict that a good percentage (96%) of the water samples (n =162) conformed to the MS733:2005 and 4% fell below the lower limit of the acceptable range (pH = 6.0) with the lowest being pH = 5.5. The low pH values recorded in TA Katuli, which also showed significant statistical differences with the rest of the three TAs (Chilipa, Namavi and Nankumba) after a using Kruskal-Wallis Test, could be attributed to the geological formation of the area. According to (Moyo, 2013), such low pH values could, among others, be associated with rock formations like sandstone, that do not contain carbonates. The lithological map presented in (Addison et al., 2021) affirms this claim as it depicts presence of sandstones in the Katuli area. Although 4% of the samples fell below pH 6.0, there are no proven direct effects of the low pH to the consumers, rather, the indirect effects could be due to ingestion of toxic substances such as dissolved heavy metals (through corrosion) and other chemicals, since low pH increases their solubility in water (Gunarathna et al., 2016; Saalidong et al., 2022; WHO, 2007; WHO Working Group, 1986).

Moving to TDS/EC, the results in this study have also shown very high SD values, 345 for TDS and 582 for EC, suggesting that the TDS/EC data was skewed and that the mean may have been influenced by extreme values. The TDS/EC data reveal that there are some parts with high groundwater salinity within Mangochi District, since both parameters describe the salinity level of water, and one parameter may be used to predict the other because of their correlation, usually expressed by the equation TDS = kEC at 25ºC (Rusydi, 2018). The study registered some values that exceeded the Malawi standard values of 2000 mg/l for TDS and 3500 µS/cm for EC, specifically in TA Nankumba. The results of the Kruskal-Wallis Test also point at TA Nankumba as the TA with the worst TDS and EC results among the four study TAs, as it registered highest mean rankings which were also statistically different from the rest of the TAs. These results agree with other past studies that also found results exceeding the standard values in TA Nankumba. For instance, (Sajidu et al., 2008) recorded an EC value as high as 6800 µS/cm, also in TA Nankumba. The cases discussed above are an indication that TA Nankumba is more prone to high groundwater salinity than the rest of the study TAs.

The high TDS/EC values would be expected in groundwater in Mangochi District because of its alluvial aquifers which are generally characterised with higher mineralisation than basement aquifers (Harold W. T. Mapoma and Xie, 2014). However, the variations among the TAs are expected since TDS values would vary from one place to another due to factors such as rock type, thickness of soil cover, groundwater residence time, quantity of rainfall and weathering processes yet within the same climatic zone (Kumar et al., 2018). The TDS values are also expected to vary depth-wise due to varying depths of minerals and other soluble substances that interact with the aquifers, and such a relationship may vary from area to area, with some having a positive or negative correlation (Prakash Rai et al., 2023; Rehman et al., 2023; Sharma et al., 2022). As for the results of the Mann-Whitney U Test that showed higher TDS and EC mean rankings for the wet season that the dry season, it would be suggested that the salts and other minerals were lying in the shallow depth, such that, as the rain water infiltrates, and perhaps as the static water level rises, they get dissolved into the aquifer, thereby increasing the TDS values. This also agrees with the results of the one of the specific constituents, fluoride, which also had higher rankings for the wet season than the dry season, as discussed in section 5.2.1.2.

According to (WHO, 2017), the amount of dissolved solids may not necessarily have a direct health effect on consumers, rather it would depend on the toxicity of the specific constituent elements that are dissolved in the water (Sakizadeh, 2019). It is therefore understood that TDS is mostly linked to taste and palatability of the drinking water, and values beyond 1000 mg/l may result in the unpalatability of the water (WHO, 2017). Although the results indicate that only 1% (n = 162) of the samples were out of range in reference to MS733:2005, it is worth noting that 6% exceeded drinking water palatability threshold i.e., TDS >1000 mg/l. This implies that the Malawian standard for boreholes and shallow wells permit levels of TDS that are considered unpalatable, and as such, the boreholes may still be objectionable by the users even when the TDS values are within the Malawian standards. This would result in users shunning the boreholes for unsafe sources that are considered to produce palatable water like surface water or unprotected wells.

5.1.2 Microbial Results

The results of this study showed that some of the water samples registered presence of microbes associated with faecal contamination. Faecal streptococci were registered in 36% (n = 162) of the samples while faecal coliforms and E. coli were registered in 28% and 22% of the samples respectively. According to the results of the measure of central tendency, i.e the mean, the median and the SD, the data for all the three parameters (FS, FC and E. coli) were highly skewed, with most values concentrated near zero, and the mean heavily influenced by extreme values. However, it is worth noting that the nonconforming cases cut across 58 of the 82 (71%) water points in which at least one parameter was registered. This entails that the faecal matter was finding its way into the groundwater at the at the majority of the water points, thereby exposing the consumers to associated health risks such as diarrhoea infections (WHO, 2017). In terms of monitoring of the SDG 6.1 drinking water target, it is evident that these contaminated sources do not qualify as safely managed sources despite being in the class of improved water sources by virtue of their construction ((Bain et al., 2014).

The insignificant weak negative correlation between distance to potential sources of contamination (e.g., latrines) and faecal coliform counts is an indication that the contamination would not be conclusively linked to the latrines around. This can be proven by the fact that some the water sources that registered the highest degree of contamination are not the ones that were closest to latrines and the ones that were closest to the latrines (12m, 14m) showed better results. These results agree with the findings of (Kanyerere et al., 2012), on the one hand, as they also found an insignificant negative correlation between the distance from latrines and/or animal corrals and the degree of contamination, but differ with the same on the other hand as they found that the water source with the highest degree of contamination was also the water source that was nearest to a latrine (10m).

This observation above suggests that there were possibly other sources of contamination unlike the visibly available potential sources like latrines. The animal excreta observed around some of the water points, as evidence in Figure 4.12, could be one of the likely sources of the registered faecal contamination, as suggested by (Taonameso et al., 2019), who also attributed E. coli contamination to the animal faeces found around the water points. The animals usually follow the stagnant waters as observed in Figure 4-8 for drinking, which is consistent with the observation of (Taonameso et al., 2019). For instance, cattle excreta were observed around water points WP008 in TA Katuli and WP050 in TA Nankumba, while at the same time registering contamination by E. coli, FS and FC. Further analysis showed that these two specifically singled out points registered all the three parameters (E. coli, FS and FC) only in the dry season, except for a record of FS in the wet season for WP008 but in lower concentration than the dry season. This finding is consistent with findings of (Nayebare et al., 2022) who found higher E. coli counts in the dry season than the wet season, also attributing it to the greater accumulation of faecal matter at the land surface. Further probe indicated that there were maintenance works that took place in not more a month before the day of the study, but not followed by disinfection, thus, suggesting that the contamination might have resulted through contact with the internal handpump parts. It is worth mentioning that another contamination pathway could also be penetration of water carrying animal waste (Taonameso et al., 2019) through cracked headworks and poor or no sanitary sealing in some cases as observed in Figures 4-9 and 4-10.

5.1.3 Drinking Water Quality Conformity

Water quality assessment is essential in ensuring the suitability of drinking water. Water quality parameters are checked against the specified standard values to determine if the quality of the water conforms to the set standard (Roy, 2019), thereby ensuring drinking water safety to the consumers. In general, the findings of this study clearly show that 52.5% (n = 162) of the water samples did not conform with the Malawi standard (MS733:2005) and 88.3% did not conform with WHO drinking water guidelines (4th edition). The non-conformity was either microbial, physio-chemical or both. Specific to the water quality requirements for SDGs' safely managed water services. i.e., priority chemicals (arsenic and fluoride) and microbial contamination (thermotolerant coliforms), 88% and 28% (n = 162) did not conform to WHO guideline values and MS733:2005 respectively. This demonstrates, in agreement with WHO and UNICEF

(2023), that water quality poses as the most limiting factor for safely managed drinking water services.

The results are not very much surprising because drinking water services in Malawi has for a long time been hit by non-compliance with standards as observed from other past studies. The studies have touched on different types of drinking water sources that are thought to be safe for human consumption i.e., borehole water, piped water and bottled/sachet water. For instance, (Chidya et al., 2019) in their study "Standards Compliance and Health Implications of Bottled Water in Malawi" observed non-compliance with standards in some bottled water brands. Another study by (Ngumbira, 2020) found microbial water quality non-conformity for 72% of sachet water samples collected in Lilongwe. Further to this, (Government of Malawi, 2021) in assessment of water quality for boreholes and protected shallow wells in Mangochi District found a 74% (n = 11) non-conformity. Further, (Government of Malawi, 2020), during a drinking water quality audit in Malawi, observed a 4% (n=106) microbiological non-conformity with standards by water utility institutions, including the major water utility bodies (the Water Boards) which are expected to be on top of things when it comes to compliance with water quality standards.

The cases presented above expose serious lapses in enforcement of and compliance with drinking water standards in Malawi. As it can be observed, all the studies cited above were conducted in the SDGs era when water quality is of paramount importance in the progress monitoring for drinking water target, unlike in the MDGs era (Bain et al., 2018; WHO and UNICEF, 2017b, 2017a). In agreement with (Bain et al., 2014), this signifies that water sources may be called "improved", yet not guaranteeing safety in terms of human consumption. The compromised water quality in most of the improved water sources would therefore result in failure to attain of SDG target on drinking water (SDG 6.1) in its entirety. This is also a worrisome development considering that on daily basis, almost 4000 people (25% being children under five) die due to water, sanitation and hygiene (WASH) related issues globally (UNICEF, 2023).

5.2 Evaluation of Drinking Water Affordability

The results of the affordability ratio γ_1 as presented in section 4.3.7, on the one hand, reveal that the tariffs that were being paid towards operation and maintenance, which in this case are being referred to as water expenses, were affordable to 79% of the water user households. On the other hand, the results of γ_2 which was based on what would be an ideal tariff for cost recovery, would be affordable to only 47% of the HHs. This shows that the existing tariff was more affordable than what would be the ideal tariff for sustainability of the water sources. These results would be expected considering that most of the water point committee members had, during the FGDs, expressed that they set the water tariffs (contribution towards O&M) based on what was considered affordable by all in the community and not necessarily based on cost recovery. These results expose the need to carefully consider trade-offs between affordability and sustainability of the water supply services. For instance, setting a tariff for the sake of cost recovery, yet not affordable, may result in households losing access to drinking water on the one hand (Patterson et al., 2023); while on the other hand, setting a low tariff for water users to afford may result in insufficient water point financial resources (Jiang et al., 2019) that may lead to insufficient water point O&M (Truslove et al., 2020a), thus affecting its sustainability.

The SDGs were designed with an overarching ambition of "leaving no one behind" (WHO and UNICEF, 2017b) while recognising human rights as foundational to the 2030 agenda (Dattler et al., 2016). With that in mind, affordability was included as part of the normative human rights criteria applied in drinking water services alongside availability, quality, acceptability and accessibility (Bos, 2016). Unfortunately, monitoring practices always assume that people have access when water sources that produce good quality water are available within reach, yet without considering if they are be affordable (Brown and Heller, 2017). Studies have shown that affordability problems are prevalent in low income groups (Martins et al., 2016). The study population is one such low-income groups, with 52% having monthly income of not exceeding MWK7500 (US$10.14), which translates to a maximum of MWK90,000 (US$121.68) per year, of which only 27% were able to meet their basic household needs with that level of income while the other 25% needed more. This low level of income would most likely affect their willingness to pay for the water supply services as compared to buying food for the home. Although there is no clear way of measuring water services affordability in Malawi, adoption of any of the thresholds that are specified and used internationally by different governments and organisations, i.e., 2.5 - 5% (Fagundes and Malheiros, 2023; Goddard et al., 2021; Gutorova and Schellekens, 2018; WHO and UNICEF, 2021), would not translate to the reality on the ground. For example, the water services may be considered as affordable to a household that was paying for the water at MWK100 per month and with a monthly income of MWK 7500, which translates to an affordability ratio of only 1.3%, yet the same are not able to meet all their basic household needs, as the case is the preceding paragraph. This is a clear demonstration that, although by measurement affordability may be score well, the set tariffs may still be a hindrance to some individuals in the low-income groups, especially those leaving in extreme poverty. The findings of this study therefore lead to an argument that there ought to be a better way of measuring affordability of water services, bearing in mind the well-being of all.

5.3 Universality of Access to Drinking Water Services

5.3.1 Progress in Water Access

The study's findings show that there was considerable progress in the access to improved water sources, rated at 92%. However, the progress lowers when going up SDG drinking water access ladder. For instance, the study found that only 62% of the households were taking not more than 30 minutes of round trip to a water source including queueing while the remaining 30% were taking more than 30 minutes. This entails that, out of the 92% of access to improved sources, 62% were accessing basic water services which is second from the top most level of drinking water services ladder, while 30% were accessing limited water services. With basic services at 62%, it implies that access to safely managed drinking water services, the top most level on the drinking water services ladder, would not exceed 62 % as basic service services is the first prerequisite for safely managed services (WHO and UNICEF, 2017b). This finding agrees with the national trend where there is also a gap of more than 20% between access to improved water sources and access to improved water sources within 30 minutes, also referred to as basic services (WHO and UNICEF, 2023). Further to this, it is worth noting that the gap between the highest and lowest among the TAs in access to improved water sources was only 23%, whereas of access to basic services was 51%, signifying that the investments so far were just focussing on putting up the infrastructure with less focus on improving the service delivery. Low access to basic drinking water services provides a disadvantage to women and children, especially the girl child, in terms of trade-offs between fetching water and economic productivity or school time respectively, since women and children are mostly the ones that do the fetching of water in a Sub-Saharan Africa households including Malawi (Agesa and Agesa, 2019; WHO and UNICEF, 2023). Efforts to reduce the time spent by women and children in fetching of water would therefore create more time for household income generating activities and school time for the women and children respectively (Mosa et al., 2020).

The study's findings also show that, while the access to improved sources in Mangochi District was rated at 85% with 77% accessing water through boreholes (National Statistical Office, 2020), the study area had a higher access of 92%, with 89% accessing through boreholes. This finding would suggest that there was more investment in water sources development in the area. However, failure of the 52% and 88% of these improved sources to meet national water quality standards and WHO guidelines in drinking water quality respectively, raises questions on the way infrastructural investments were being implemented in the district. Perhaps, this could be due to the fact that most of the water sources were carried over from the MDGs era where focus had just been on increasing the water infrastructure in a bid to increase access to improved water sources without taking water quality into account (Satterthwaite, 2016; Weststrate et al., 2018). However, this argument cannot be fully supported because there were some water sources that were constructed in the SDGs era but still failed to meet water quality standards. In agreement with Holm et al. (2016), it shows that while there is progress in increasing improved water sources, safe drinking water is still limited despite being in the SDGs era.

Studies have shown that there is a negative relationship between access to basic water and sanitation services and under-five mortality (Gaffan et al., 2023). The high household access to improved sources, mostly from groundwater, is therefore a positive thing. However, the poor groundwater quality presents some health concerns since groundwater is oftentimes perceived to be clean and safe and usually consumed without any form of treatment (Mussa and Kamoto, 2023). For a healthy life, sufficient water quantity alone is not enough but it should be coupled with quality (Jepson et al., 2017; Miller et al., 2021). Poor access to good quality water, in sufficient quantity, would therefore lead to increased incidences of water related illnesses, thus impacting on the economic well-being of the households (Getts, 2018; Osiemo et al., 2019) The poor water quality situation unearthed in this study is therefore likely to affect the attainment of SDG drinking water target (SDG 6.1) in its entirety since water quality is of serious concern in the monitoring of the target (WHO and UNICEF, 2017b).

5.3.2 Factors Influencing Universality of Access to Drinking Water Services

Although the progress in access to improved sources was high, the results show that that are still gaps to be filled. Talking of access to basic drinking water services in the study area, the gap is even wider as we think of leaving no one behind (Ezbakhe et al., 2019; UNESCO, 2019). The study identified seven factors affecting the progress towards universal drinking water access, and these are: geographical and hydrogeological setting, groundwater quality, water supply technology, financing for infrastructural projects, planning and coordination of developmental projects, rapid population growth, and sustainability of existing water sources.

The study finds the groundwater quality, geographical and hydrogeological characteristics, which are all environmental factors, to have a serious bearing on the progress of access to improved water sources in Mangochi District. According to the study findings, some areas in the district have remained without access to improved water sources because they had been left out in several developmental projects due to their geographical setting, which had not been permitting for the mobilisation of equipment and materials. Some areas were only accessed by water transport (by boat) while some areas had poor terrain (hilly). Some of the people were moving up to the hills in search for land for settlement, farming and other economic activities, while some who were already living there could not move to a better landscape in respect of their ancestors who first habited there. This finding is consistent with Solo and Perez (1993) who outlined difficult sites and terrain, and complicated site layouts as some of the constraints in the provision of water and sanitation services to the urban poor who had settled in those undesirable pieces of land for economic reasons. Constructing new water supplies is such extreme geographical settings is often so difficult (Crichton-Smith, 2024).

Another environmental factor is the hydrogeological setting. There are other areas that have also been left out in terms of access to improved water sources because of poor ground water potential. It was found that some areas had either shallow, unreliable and usually contaminated aquifer, or an aquifer that was too deep and not suitable for a handpump, which is the most common technology in Malawi and the rest of the Sub-Saharan Africa (Danert, 2022; MacAllister et al., 2020; MacArthur, 2015). Some areas have complex hydrogeology such that groundwater is hard to find or too expensive to develop (Crichton-Smith, 2024). Some studies have revealed existence of aquifers which are too deep, extending beyond 1000m deep, which may not be practically possible to access even using motorised systems (Araffa et al., 2023). Areas with such deep aquifers are often declared as dry and not fit for a borehole construction project. The situation is even worsened by the climate change whose effects are resulting into further lowering of groundwater levels (Opoku et al., 2024). As such some studies have tried to map the groundwater potential zones, with classifications that would aid decision making for sustainable groundwater development and planning such as very high, high, moderate, low and very low potential (Dandapat et al., 2024).

Groundwater quality, especially groundwater salinity, is another environmental factor that is highlighted in this study. Barbieri (2023) describes groundwater salinity as an environmental issue in water resources that requires attention due to its impacts on the provision of potable water sources. Salinity is usually monitored using TDS and EC as indicators (Han et al., 2011; Moujabber et al., 2006; Stigter et al., 2006). The study found that some areas were either unserved in terms of provision of improved water sources, or the improved water sources are deserted because of high groundwater salinity. As a result, the households resorted to using unsafe water sources, thereby putting their lives at risk of contracting water related diseases (Aragaw et al., 2023; Mills and Cumming, 2016). This qualitative outcome of the study is consistent with the quantitative water quality test results of some areas with TDS values in excess of 1000 ppm, which is the drinking water palatability threshold (WHO, 2017). Generally, the high salinity levels are as a result of dissolved salts that originate from geologic processes and lithological and pedological factors, and turn to change the chemical constituent of the water (Abanyie et al., 2023; Musie and Gonfa, 2023).

Rapid population growth was also found to be another factor affecting the progress towards universal drinking water access in Mangochi District. The finding is consistent with Getts (2018) who highlighted population growth as one of the factors contributing to lack of access to water in rural Malawi. Mangochi's population stands out as the largest district population in the Southern Region, constituting 14.8%, and second largest the whole Malawi after Lilongwe Rural, constituting 6.5% of the national population. In terms of population growth rate, Mangochi has the second highest district level population growth rate of 3.6%, after

Machinga's 3.9% (National Statistical Office, 2019). The high population growth rate in Mangochi could be attributed to low literacy rate. According to National Statistical Office (2020), Mangochi had the lowest district literacy rate and the highest proportion of people who never attended school. National Statistical Office (2017) found that fertility decreased as the level of education goes up, such that those with no education had 3.2 more children than those women with secondary education, and those with no education had the highest proportion of teenage births. Murwirapachena (2022) found that municipal efforts to improve access to water services through capital expenditure were being offset by population growth. This shows that population growth could really be an issue in the district when it comes to distribution of resources. The findings from key informants showed that there were indeed some efforts being made in the district through capital investment in water sources development but the progress on the ground in terms of access was still far from reaching everyone. Unless the rate of investment is multiplied a couple of times, it is expected that the percentage of people without access to clean water will continue to increase as the population is increasing rapidly (Bensen, 2022). Otherwise, measures to control the rate of population growth need to be put in place in the district.

Another key factor to consider when thinking of universal access to safe drinking water was technology. The study's finding points at technology as not only the answer to the factors discussed above, viz. rapid population growth and unsuitable geological, hydrogeological and water quality conditions, but also for the improvement of service delivery. This finding is consistent with several other studies. For instance, Liedtke (2023) suggests the embracing of technology-driven solutions to address critical water accessibility issues. For communities facing water insecurity, Dugbazah et al. (2021) suggests the use of modern technologies such as solar powered piped water systems, which according to Ho et al. (2021), would be able to take water from a far source and bringing it closer to the communities, thereby not only making water available but also reducing water fetching time and extensive physical efforts. Andreah

(2022) observes that there is need to diversify the technology options to provide the best fit technologies for varying scenarios rather than using a ‘one size fits all’ approach. The argument in that paper was that, though handpump borehole had been the most reliable means of rural water provision in the Sub-Saharan Africa (MacArthur, 2015), the hand pumps were limited under certain environments. Technology is the only driving force that can address such limitations that lead to water crises in the developing countries (Gedeon, 2023). To achieve the SDG drinking water target (6.1), which aims at universal and equitable access to safe and affordable drinking water, there is, therefore, need to invest in new and innovative technologies that can improve access to water (GGI Insights, 2024), tailored to communities’ conditions and based on social context of each specific settlement (Angoua et al., 2018).

Financing for water supply infrastructural projects is another factor that was highlighted in the study findings. The observation was that there was need for more investment in water supply infrastructure if we are thinking of attaining universal water access amid challenges like rapid population growth and other environmental factors. Certain areas either remain unreached or have poor services because there are no financial resources to invest in a water supply project for new infrastructure or rehabilitation of existing old and dilapidated infrastructure. In agreement with this finding, Liedtke (2023) identified lack of infrastructure investment as one of the main challenges hindering accessibility to clean water in Africa. OECD (2022) also describes lack of financing as a major impeding factor leading to sluggish progress in access to water such that the world is said not to be track to meet the SDG 6. Tseole et al. (2022) also presents low investments in WASH infrastructure as one of the barriers to improved WASH practices. The rate of investment has not been matching with the rate of population growth (Armah et al., 2018) mainly due to a mismatch between the required investment to meet the demand and the available financial resources (OECD, 2022). Current estimates for attainment of the Sustainable Development Goal target of safe drinking water by 2030 requires the quadrupling of the current investment levels (World Health Organization et al., 2022) and this calls for a long-term sustained effort by all WASH players both local and international (Fuente et al., 2020). With this understanding, it is obvious that there is still a long way towards universal access to safe drinking water.

Another factor that was identified was planning and coordination for developmental projects. It was observed that proper development plans and coordination arrangements were necessary to guide implementation of water development projects in the district to avoid leaving out on needy areas, in contrast to the status quo where it was observed that some individuals and organisations were working in silos, and in disregard of district-based development structures, stakeholders and plans. Coordinated development planning is a tool for acceleration of developmental goals and seeks to come up with well prioritised and synchronised projects and activities that can be implemented using the available resources (Aipanda, 2017). Good development planning should ensure that the projects are well identified and prioritised based on need, through a participatory approach. Participatory project planning ensures that the voices of all relevant stakeholders are included to come up with a socially acceptable development projects that effectively deliver their intended outcomes, thus leaving no one behind (Dhakal, 2023). Stakeholders in this regard stand for all those people who may affect, be affected by, or have influence on a decision or process (Langsdale and Cardwell, 2022). Participatory approach in community water supply projects influences the projects sustainability (Diing et al., 2022). Stakeholder engagement in water supply decisions will therefore remain crucial at the grassroots because it is where the impacts are felt and therefore local voices need to be heard (Langsdale and Cardwell, 2022).

Development projects also require diverse stakeholder engagement and coordination to promote shared decision making and identification of common goals (Salamanca-Cano and Durán-Díaz, 2023). Poor coordination leads to fragmented service delivery, duplication of efforts, unnecessary competition among organisations and misalignment with government processes and agenda (Water Aid, 2011), such that little progress may be noticed despite huge investment. Local water challenges are addressed better when stakeholders collectively work together towards a common goal (Hove et al., 2021), in an evidence-based manner and supported by reliable population forecasts (Murwirapachena, 2022). When stakeholders come together, in a well-coordinated manner, they generate innovative approaches tailored to the social context and conditions of specific communities (Angoua et al., 2018). It is therefore expected that both private and nongovernmental sectors will have increased roles in the stakeholder engagement, in different capacities but with a focus on the local level (Langsdale and Cardwell, 2022).

Sustainability of water sources was found to be another factor affecting the attainment of universal safe water access in the study area. As already presented in the results chapter, some water sources were being abandoned due to different reasons, thus reading to reduction in number of usable water points. One of the reasons mentioned for abandonment was *poor O&M practices*. Liedtke (2023) also found poor maintenance to affect sustainability of water sources. Poor O&M practices was found to be the issue because the water point committees were not realising sufficient funds to be able offset O&M expenses as a result of low tariffs. The results of logistic regression carried out in this study, showed that the amount set as O&M tariff has a strong bearing on the sustainability of water points. This is consistent with Jiang et al. (2019) who also claimed that low tariffs contribute to the insufficiency of the financial resources for O&M. Lack of financial resources for O&M has an impact on the long-term functionality of water points, thus affecting the sustainability of the water points (Truslove et al., 2020a, 2020b). Another reason for poor sustainability was *poor construction practices*. The study found that there was a high number of abandoned water points that had either dried up or had serious mechanical or water yield problems because of poor construction and installation practices. This finding is consistent with Mannix et al. (2018) who found a 72% water points rate attributed to borehole construction and installation issues. They further claimed that the construction and installation issues were due to rushed drilling and installation, use of sub-standard drilling equipment, use of inappropriate drilling method and poor drilling supervision. *Irrelevant technology* was also seen to be a serious issue leading to high non-functionality and abandonment of water sources, hence affecting their sustainability. The observation was that, with the climate change, many protected shallow wells had dried due to lowering of the water table. The argument then was that shallow wells were no longer relevant in the prevailing circumstances of climate change. Kahn (2019) mentions that shallow wells may be affected by groundwater fluctuations between the rainy and dry seasons. Oregon State University (2020) further states that shallower wells are at great risk of water levels falling during dry conditions because shallow wells draw from shallow aquifers that are primarily recharged through precipitation. *Age of the water source* was another issue affecting functionality, thereby impacting negatively on the sustainability of the water sources. The study found that there were water sources that had outlived their lifespans and were abandoned because they could no longer function or were no longer economically viable as maintenance costs were too high due to frequent major breakdowns. This is consistent with past studies that found age of the water source as having a bearing on the functionality of the source. Fisher et al. (2015) found the source's age to be a determinant of functionality. Harvey (2004) also found that borehole failure increased with age, mostly from age five and above. Strong statistical evidence was also presented by other studies pointing at a strong negative relationship between age and functionality due to depreciation of the infrastructure over time (Foster, 2013; Truslove et al., 2019). However, it is worth noting that, in the case of a well constructed infrastructure, the influence of age would be more pronounced where there were poor O&M practices. Otherwise, it is expected for the water sources to still withstand the long-term operations where good O&M is practiced. In fact, the study established that O&M funds, which may translate into good O&M practices, had a stronger influence on functionality as compared to age.

5.4 Dynamics in Equitability of Access to Drinking Water Services

5.4.1 Spatial Dynamics of Drinking Water Access

The study's findings expose some spatial disparities in the water supply services in the study area. Service levels in terms proportion of households with access to improved sources varied across the TAs. For instance, the study revealed that there was a 23% gap between the TAs with the highest and lowest access to improved sources i.e. 100% being the highest and 77% being the lowest, and a 71% gap between the TAs with the highest and lowest access to basic water services i.e. 91% being the highest and 20% being the lowest. Apart from the inter-TA disparities, there were also disparities among villages within the TAs, signifying inequitable distribution of the improved water sources within and across the TAs. Existence of such disparities seem to have been a global challenge as revealed by other studies too. For instance, Fisher et al. (2015) reported on the existence of geographical variations and inequalities in access to improved drinking water and sanitation in Ethiopia while Wang et al. (2019) also reported to have found geographical disparities in access to improved water sources among developmental and ecological zones in Nepal.

The study also established that there was a high-level inequality among the four traditional authorities in the study area, following the calculated Gini index of 0.3995. According to past studies, Gini index of less than 0.2 is classified as low inequality, 0.2 - 0.3 as moderate inequality, and greater than 0.3 as a high level of inequality (Cole et al., 2018; Dongzagla et al., 2022). This high inequality exposes how disproportional the water points are distributed across the traditional authorities, which eventually leads to serious disparities in terms of access to improved water sources. Since equality is an important component of equity (Cullis and Van Koppen, 2009), the high inequality, therefore, also negatively affects the level of water access equitability. Inequalities in water supply, measured using Gini index has also been reported in many countries including Ghana, Brazil and Peru, (Azage et al., 2020; Dongzagla et al., 2022; Jesus et al., 2023). Deshpande et al. (2020) describes the geographical inequalities within countries as both vast and persistent, implying that they may be far from being over unless some drastic measures are taken in the allocation of resources towards water supply projects to overcome dynamics surrounding the allocation and financing of projects.

5.4.2 The Political and Governance Dynamics of Drinking Water Access

The Government of Malawi instituted local government structures with well-stipulated roles and functions, from the district level to the grassroots (or village) level, for the smooth implementation of decentralisation Government of Malawi (2013). The purpose of setting such development structures even at the grassroots level was to promote democratic and participatory decision making with those more concerned, who would in turn make decisions that concern them, resulting in more equitable and efficient service delivery (Hara, 2008). It is therefore imperative that these structures understand their roles and functions if they are to be effective and efficient, with less conflicts among them (Indeed Editorial Team, 2024). As such, the study's quest to understand some of the grassroots structures' level of knowledge of their functions found that the ADC chairpersons were more knowledgeable of their roles and functions than the VDC chairpersons. However, despite having some gaps in the knowledge of their functions, it is encouraging to note that almost all ADC and VDC chairpersons, except for one VDC chairperson, were knowledgeable of the key function that relates to prioritisation in the allocation of projects. This is a sign that, given an opportunity, they would be able to allocate the water projects equitably. The question then remains why there is still unequitable allocation of water sources in the study area. Perhaps, this signals that there were other forces and dynamics influencing the unequitable distribution of the water sources as discussed in section 5.5.1.

Dahl (1957) provided his most explicit definition of power as a relationship between people. This entails that power dynamics come into play in all relationships (Green et al., 2024). In agreement with this understanding, the study's findings can reveal that power displays are at the centre of water projects allocations. The exercise of power at different levels has either positively or negatively affected decision making on the allocation of water sources in the study area, resulting in inequitable water source distribution, consequently affecting the level of access to improved water sources in some areas. These powers have been abused to an extent that some who feel more superior show no respect for others' roles and have undermined the powers of other structures. These power displays defeat the whole purpose of the devolution of authority, which is expected to be the drive towards improvement of development delivery to the most vulnerable in the rural areas (Hara, 2008).

A good example of power displays as presented in Chapter 4 is the case of politicians, more specifically the MPs, using their political powers to override institutional powers of the ADCs and VDCs in deciding where to allocate water sources funded through constituency development fund (CDF) or water resources fund (WRF), a development that leaves a lot to be desired. The politicians' deliberate neglect of the role of the VDCs and ADCs, compromises the need to allocate projects following the prioritisation in the village and area development plans prepared by the development committees, thereby contributing towards unequitable access to improved water sources. For sure, the politicians feel that they are more superior such that they cannot consult the "inferior" structures like the VDCs and ADCs, thus agreeing with Green et al. (2024) who highlighted that those with more power are less likely to abide by rules, norms, and expectations. On the other hand, the ADCs and VDCs shy away from confronting the MPs in exercise of their institutional powers because themselves also feel so inferior to confront such a "superpower" as the MP. It is not clear why MPs behave like that, bearing in mind that they are members to the same Area Development Committees (Government of Malawi, 2013), which would have been easier for them to share their project plans to the ADCs. This problem of MPs feeling more superior has lived for ages and has also created power struggles even between the MPs and fellow politicians, the councillors, in which case the former wants to be the boss, and the later the servant, so as to be able to dictate issues rather than giving room for discussions (Chinsinga, 2008; Crawford and Christof Hartmann, 2008).

Despite this being the case, the citizens have more trust in the development committees than the elected politicians when it comes to development work (Maiden et al., 2021).

On the contrary, we see a good harmonisation of traditional and institutional powers between the chiefs and the development committees respectively. Just like MPs and Councillors, TAs have membership to the ADCs while GVHs to the VDCs, but on an advisory role (Government of Malawi, 2013). However, unlike with the MPs, the chiefs seem to work well with the ADCs, though it is not clear if the chiefs do not influence decision-making at the committee level. The good thing with projects that go through the Council, down to the development committees is that decisions or proposals are validated by technical staff who come to check the proposals against the guidelines, and thus, the decisions are checked even in the event of an attempted chief's influence. It is believed that the chiefs' contributions to the committees are developmental as they look at a wider spectrum because they have vested interests in the affairs of the people that they are looking after, hence spearheading development agenda in the communities (Mazibuko and Thebe, 2024).

Another angle in the power dynamics as revealed by the study is Capital Power versus Administrative Power as defined in section 5.5.1. The study's revelations that, on the one hand, some partners could dictate the councils on where to implement projects because they feel they have the capital power and can decide what to do with the money, and on the other hand, Councils also shying away from disciplining such organisations for fear of losing the funds, is a serious anomaly that is detrimental to the national as well as the global development agenda. Such partners may set their own guidelines that may contradict with government laid down procedure and not be confronted just because of the capital, in agreement with Green et al. (2024, p. 4) who said "people with more power have the ability to set and alter rules and norms". The capital power in this case also seems to override the institutional power such that the organisations with funds to invest in development may pay no attention to area development plans but defend their own reasons for choosing to implement in a particular area. Cepeda

(2021) also observes a power asymmetry, between money holder and the recipient, in which case the former may dictate the latter, in the end affecting the alignment of development priorities and visions, leading to failure to address the actual needs of the target communities. This may compromise on the equality and equitability of access to safe water in the district.

5.5 Progress on Simultaneity in Safety, Affordability, Universality, Equitability

The SDG target 6.1 states: *"By 2030, achieve **universal** and **equitable access** to **safe** and **affordable** drinking water **for all**"* (WHO and UNICEF, 2017b, p. 7). *According to* WHO and UNICEF (2017a, p. 11), the attainment of this target implies that:

i. There is ***universal*** access, which means that all exposures and settings have access to water
ii. There is ***equitable*** access, which means there are no inequalities between population subgroups.
iii. The drinking water is ***safe,*** which means that the water is free from pathogens and elevated levels of toxic substances at all times.
iv. The water service is ***affordable***, which means that the payment for the service does not present a barrier to access or prevent people from meeting other basic human needs.

This represents a simultaneous attainment of the elements above *(universality, equitability, safety and affordability)*, else, with one element lagging behind, the attainment of the target will be a flop. The study's findings depict serious gaps in the progress on the target, and raises doubts on the simultaneity of the elements. From Figure 5-1, it can be depicted that, although no element had reached 100%, the variances were at different levels, with safety (water quality) being the worst. Much as access to improved water sources is at 92%, only 48% of the sources was meeting the MS733:2005 and 12% was meeting the WHO guidelines for drinking water. Using the best case of measuring the progress (where lean parameters are used), the variance for access to improved water sources is only 8%, while the variance for affordability (actual) is 21 % and that of safety (water quality using MS) is at 52%. If the stricter parameters are used, the variance on access to basic services is at 38%, while that of affordability (ideal) is at 53% and for safety (water quality using WHO) is at 88%.

In terms of equitable access, it is worth mentioning that there is already a huge gap of almost 71% in terms of access to basic water services, between the highest TA (at 91%) and the lowest TA (at 20%), which is worse when compared to the gap of 23%, (100% for the highest TA and 77% for the lowest TA) in terms of access to improved water sources. In addition, the summary statistic, the Gini Index of 0.3995, revealed high level of inequality in the distribution of water sources across the four TAs in the study area.

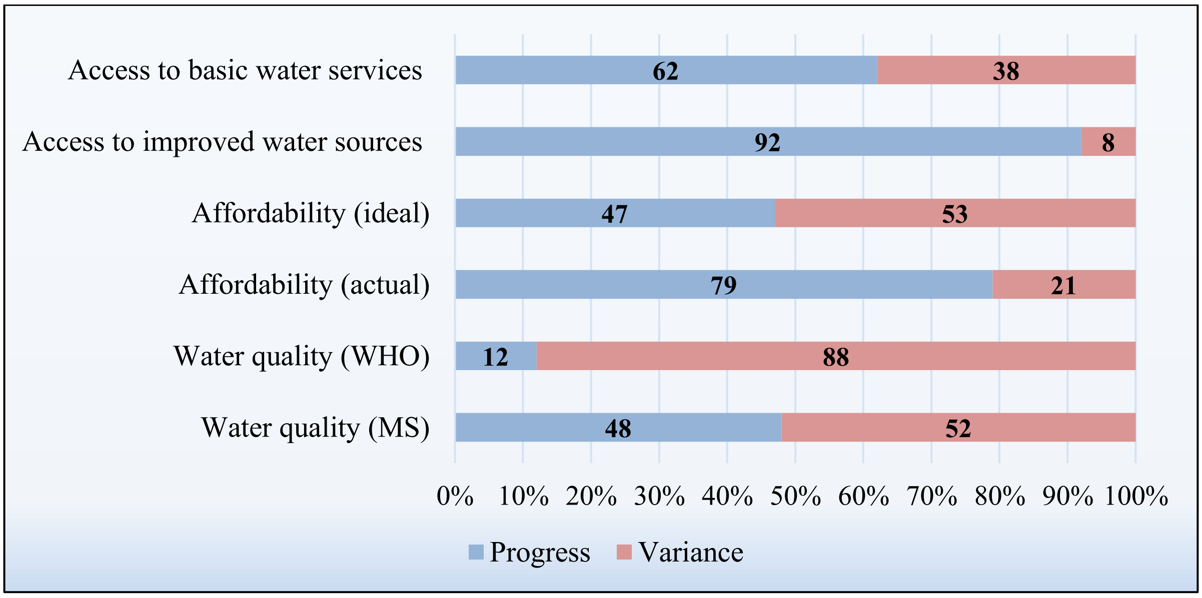


Figure 5-1: Progress in drinking water services

This staggered progress of the elements of SDG target 6.1 is a demonstration of a failed simultaneous progress for the key elements discussed above. This has serious implications on the attainability of the drinking water target, SDG 6.1, which according to Evaristo et al. (2023), requires on-the-ground solutions that address the foundational challenges. In support of the factors highlighted by this study, Vyas-Doorgapersad (2023) also mentions migration, climate change, high population growth, deteriorated infrastructure, water scarcity, poverty, a lack of financial and human resources, and poor maintenance of water infrastructure as some of the challenges hampering the progress in water supply services. Each of these challenges relate to one or more of the elements of the SDG 6.1 target, and careful consideration is required, otherwise with the current progress, it is very unlikely to achieve the target. So far, other studies have already started concluding that universal water targets may not be achieved 2030 (Tumwebaze et al., 2023). Even by looking at the current rates of global progress towards SDG 6.1 target, it is predicted that, by 2030, around two billion people will still not have safe water at home (Crichton-Smith, 2024).

With the high non-conformity rate of the water quality standards, it is obvious that corrective measures are required to the specific water points, some of which may require decommissioning, to remain with only the usable safe water points, thus lowering the number of available water points and subsequently lowering the access rate to improved water sources. This water target will also depend on the progress in other goals like the *Goal 1 - No poverty* and *Goal 10 – Reduced inequalities,* which, according to the recent UN Report on SDGs, the progress is slow, and in some cases retrogressing (United Nations, 2024). The realisation of this target in its entirety would also depend on the adoption of human rights-based approaches to ensure services are safe, available, accessible, affordable, and acceptable (Paul, 2022).

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Research Overview

The research was conducted on the basis that there was a knowledge gap on simultaneity of safety, affordability, universality and equitability of drinking water services since it had not been explored in Malawi or elsewhere. The main objective of the study was therefore to explore the simultaneity of safety, affordability, universality and equitability in drinking water services in Mangochi District in Malawi. Specifically, the study assessed safety of drinking water services, evaluated affordability of drinking water services, investigated factors that influence universality of access to drinking water services and analysed dynamics in equitability of access to drinking water services in Mangochi District. The study collected quantitative data using a household survey, water quality testing and market prices survey, while key informant interviews, focus group discussions, observations were used to collect qualitative data. Data were analysed in line with the specific objectives but in general perspective, descriptive statistics, non-parametric tests using Kruskal Wallis T-test and Mann-Whitney U-test, correlation tests, logistic regression, Gini index and thematic analysis were applied. SPSS v20 and ATLAS.ti 9 were used as the main data management and analysis software for quantitative and qualitative data respectively. However, Microsoft Excel was also used in water tariff and inequality analyses. The study has come up with a number of fundings which are summarised in the next section.

6.2 Summary of Key Findings

6.2.1 Safety of Drinking Water Services

Poor water quality is a serious concern in the study area, with a compliance rate of only 48% according to the Malawian standard MS733:2005, and 12% according to the WHO guidelines, thus compromising on the safety of the drinking water services. Despite this being the case, arsenic is not a threat in the study area as it was below the detection limit. However, fluoride and microbial contamination may pose serious health risks in the study area after being found in concentrations exceeding the standard values. TA Katuli was the worst in terms of pH, turbidity and faecal contamination, but the best in the fluoride results. TA Nankumba was the worst in EC, TDS and fluoride results. TA Chilipa was the best on faecal contamination while TA Namavi was just moderate almost in all the parameters. In conclusion, the water quality concerns described above are not only a hindrance to the attainment of safe drinking services, vis a vis, the SDG 6.1 target, but also pose health concerns to the users.

6.2.2 Affordability of Drinking Water Services

The study established that the current water payments were theoretically affordable to 79% of the households, with the majority (62%) households paying up to US$1.46 per annum, which is lower than what would have been the ideal sustainable tariff of US$3.45 per annum. If the ideal tariff was to be applied, it would be theoretically affordable to only 47% of the households. The study has further observed that the theoretical affordability, defined as the ratio of water expenditure to disposable income, may not necessarily represent the real affordability by the households considering that 51% of the households in the study area were failing to meet all their household basic needs using their monthly income, yet theoretically, water costs were not affordable to only 21% of the households. These theoretical estimations, though internationally accepted, would result in national, regional or global celebrations on having an affordable drinking water service, yet with so many left behind because they cannot practically afford the services.

6.2.3 Universality of Drinking Water Services

Although there was remarkable progress in terms of access to improved water sources in the study area, at 92%, the progress towards access to basic water services was slower, at only 62%. The poor water quality registered in the study area makes matters worse as it lowers the gains made in the increase in number of accessible water sources. Rapid population growth is also another factor impeding the progress towards universal access to safe drinking water, as it also offsets the investment gains in form of increase in the number of water sources. This is an indication of a slow progress towards universal access to safe drinking water. Additionally, the study observes that geophysical and groundwater quality factors had an upper hand in most of the areas that remain without proper access to safe drinking water, and these can only be offset with heavy and strategic investments in relevant technologies that can deal with the specified issues. A good example of such technologies is the use of solar powered reticulated water systems, as opposed to the usual point water sources such as handpump boreholes. Such investments will only be effective if there is good planning and coordination among all the stakeholders.

Another important factor to look for is the sustainability of the existing water systems as it also has the potential to offset any gains made in the investments for new water sources. The study established that the amount of contribution towards O&M, also referred to as the water tariff in this case, has more influence on the functionality vis a vis the sustainability of the water sources, and therefore more attention needs to be made in the setting and collection of the tariff. As for the study area, the sustainability of the water sources may have been compromised due to low and unsustainable tariffs which subsequently affected the amount of O&M funds collected. The study also unearthed a serious conflict between financial sustainability and affordability of the drinking water services, requiring carefully considered trade-offs between the two.

6.2.4 Dynamics in Equitability of Drinking Water Services

The study established that there was a high-level inequality in the distribution of water sources among the four traditional authorities in the study area, following the calculated Gini index of 0.3995. This is an indicator of compromised equitable access to the human right of safe and clean water. These inequalities are a result of power displays in the allocation of water projects as established by the study. The study revealed that the exercise of power at different levels has affected decision making on the allocation of water sources in the study area, resulting in inequitable water sources distribution, consequently affecting the level of access to improved water sources in some areas. As observed by the study, some stakeholders feel more superior and show no respect for others' roles and have undermined the powers of other stakeholders and structures.

The study, for example, observed that politicians used their political powers to override the institutional powers of the ADCs and VDCs in deciding where to allocate water projects in the communities, which mostly was being done with a political eye. This includes projects funded by Government of Malawi through constituency development fund (CDF) or water resources fund (WRF), which were seen to be more controlled by Members of Parliament (MPs) other than the District Council structures. There was also no equitability in the allocation of these resources from the Central Government as it neither considered the level of need nor the size of the constituency. Other dynamics involved the presence of organisations with capital power (funds to spend), especially faith-based, who were also seen to be overriding on the powers of the ADCs and VDCs. These faith-based organisations just decide on their own where to put up water infrastructure following their faith followers, in disregard of area development plans. Such deliberate neglect of the roles of the VDCs and ADCs, compromises the need to allocate projects following the prioritisation in the village and area development plans prepared by the development committees, thereby contributing towards unequitable access to improved water sources.

6.3 Study Conclusion

6.3.1 Safety of Drinking Water Services

Drinking water safety is compromised due poor water quality in the study area, leaving a strong negative bearing on the SDG 6.1 attainability.

6.3.2 Affordability of Drinking Water Services

Water was theoretically affordable to the majority (79%) of the households in the study area. However, the current payments are not sufficient for operation and maintenance cost recovery.

In addition, the study concludes that the theoretical affordability, defined as the ratio of water expenditure to disposable income, may not necessarily represent the real affordability especially in a rural household setting where income may not even be enough to cater for all the basics needs.

6.3.3 Universality of Drinking Water Services

The study establishes that water supply technology, financing for projects, project planning and coordination, rapid population growth, sustainability of water infrastructure, groundwater quality, and geophysical and hydrogeological setting are the key factors influencing progress of universal water access in Mangochi District.

6.3.4 Dynamics in Equitability of Drinking Water Services

There is high water access inequality in Mangochi District which is being fuelled by, among other factors, unhealthy power dynamics among development stakeholders, such as abuse of political and capital power.

6.3.5 Overall Study Conclusion

In conclusion, the study did not find any simultaneity in the progress of the four elements of safety, affordability, universality and equitability in drinking water services as serious disparities among them were found. In agreement with other scholars, as earlier discussed, the study has shown that the road to universal and equitable access to safe and affordable drinking water services is not an easy one, but requires a multifaceted approach accompanied by a huge investment in effective and efficient technologies to be able to suppress and overcome the retarding forces.

As a thesis statement, it is almost impossible to achieve simultaneity of safety, affordability, universality and equitability of access to drinking water services, reading from the results of the study. This is because one element influences another element, either positively or negatively, and as such, trade-offs among these elements are inevitable. For example, equitable distribution of projects may be a plus to universality of access and the vice versa, where a bid to have universal access may result in elimination of disparities. Similarly, the bid to have high quality water by introducing high-tech equipment or system expansion may result in increased costs which could eventually compromise on affordability.

6.4 Contribution to Knowledge

This research explored simultaneity in the attainment of safety, affordability, universality and equitability in drinking water services in relation to the Sustainable Development Goal target 6.1, using integrated methods. The novelty of the research is that the literature shows that no similar study has been conducted in Malawi, or perhaps, elsewhere in the world.

6.4.1 Safety of Drinking Water Services

The study is the first to test and provide a general outlook for arsenic in groundwater in Mangochi District. The study has also come up with a record-breaking groundwater fluoride concentration in Mangochi District and Malawi at large. The study has further unearthed scenarios of higher concentrations in certain seasons against the norm i.e. higher TDS and fluoride values in the wet season as compared to dry season. This has also opened an opportunity for further research to validity the possibility of salts in the shallower depth being the cause for this scenario.

This knowledge contribution is instrumental to policy and practice towards the promotion of groundwater reticulations in alignment with the Malawi 2063 Vision that seeks to achieve reliable and available clean piped water.

6.4.2 Affordability of Drinking Water Services

The study has also challenged the theoretical affordability calculations (ratio of water expense to income) against the real affordability on the ground. It was demonstrated that the theoretical affordability is not a true reflection of the affordability situation on the ground, especially in poor households who fail to meet their basic needs using their monthly income. Affordability measure should go beyond just looking at the ratio, and consider that the household first meets its basic needs, then thereafter apply the ratio. Failure of which one may not be willing to pay because they will first consider meeting other the basic needs. This knowledge contribution aligns with SDG 6.1 as it promotes equitable access to drinking water services. It also aligns with the Human Rights-Based Approach (HRBA) to Water and Sanitation and Willingness-to-Pay Theory (Economic Theory of Demand and Pricing).

6.4.3 Factors that Influence Universality of Access to Drinking Water Services

The study established that sustainability of existing water sources was one of the factors influencing universality. The study further established that O&M funds had more influence on the functionality of a hand pump as compared to age of the hand pump. Another contribution is that the study has provided proof or reasons behind handpump failures within the first 3 to 5 years, by analysing the effectiveness of cumulative tariff over a period. Ideally, literature was only providing factual underpinning that more hand pumps may fail in the first 3 to 5 years without clearly showing the background cause. The revelation by this study is that the most common tariff being used at a hand pump fitted water source, which utmost was US$1.46 per household per year, had the capacity to sustain the hand pump only up to 3 years. To ensure lifetime sustainability of hand pump fitted water sources, the study established the minimum tariff of US$3.45 per household per annum, as ideal. However, the implementation of the said ideal tariff needs to synchronise with affordability principles, which may include subsidies to allow for effective synergies and trade-off between the two.

The outline above contributes new knowledge to policy and practice on water point sustainability and aligns with SDG 6.1. It also contributes knowledge to the IWRM theory and ETDP, specifically on sustainable management, and cost recovery model and water tariff structure respectively, as discussed in Chapter 2.

6.4.4 Dynamics in Equitability of access to Drinking Water Services

The study contributes to the body of knowledge by providing a measure of inequality in the distribution of water sources in the study area. This study is the first to measure inequality in the distribution of water sources using the Lorenz Curve and Gini Index in Mangochi District, and perhaps Malawi. The high inequality as provided by the Gini Index of 0.3995 signifies serious implementation gaps in as far as water development is concerned in the area. The knowledge is very instrumental in the development of implementation plans towards the SDG6.1 and Malawi 2063 Vision aspirations. The inequality also signifies that some people are being deprived of their human right to safe water access, thus making a knowledge contribution towards the HRBA to water and sanitation.

6.4.5 Conceptual Model

As stated in the study conclusion, the road to universal and equitable access to safe and affordable drinking water services requires a multifaceted approach. The conceptual model presented in Figure 6-1 summarises the study outputs. The model is divided into six major categories namely: inputs, processes, enablers, outputs, outcome and challenges or threats.

The major input in this model are financial resources. A significant volume of financial resources is required to produce outputs which are water infrastructure, both new and old. The financial resources need to go through processes that will translate finances into outputs. The processes include investment in new (new constructions) and old (rehabilitation and maintenance) infrastructure. The output should in turn translate into an outcome which is universal and equitable access to safe and affordable drinking water services. The threats/challenges are at different levels: (a) threat to the processes e.g. partiality of leaders is a threat to a fair decision making on where to allocate water sources; (b) threat to output e.g. geological, hydrogeological and poor water quality may affect the quality of the output – the water source being or to be constructed (c) threat to the outcome e.g. rapid population growth is a threat to water access such that the rate of population growth is overtaking the rate of infrastructure development to such an extent that there is no significant move in the outcome. Lastly, the enablers on the one hand provide a platform from effective processes e.g. availability of development plans, while on the other hand provide solutions to the challenges/threats e.g. technology choice/shift.

The conceptual model introduces a comprehensive framework for advancing existing theories like the IWRM through its emphasis on multifaceted and systemic approach to achieving universal and equitable access to safe and affordable drinking water services. The model extends the discourse of IWRM's discourse by explicitly delineating the flow from financial inputs to tangible outputs, outcomes, and the challenges that may impede progress. The model further offers a detailed, systemic, and adaptable framework that explicitly links financial inputs, infrastructural outputs, and societal outcomes while accounting for potential threats. Its emphasis on enablers and challenges provides a pragmatic approach that complements and enhances the principles of IWRM, ultimately contributing to more effective strategies for achieving equitable water access globally.

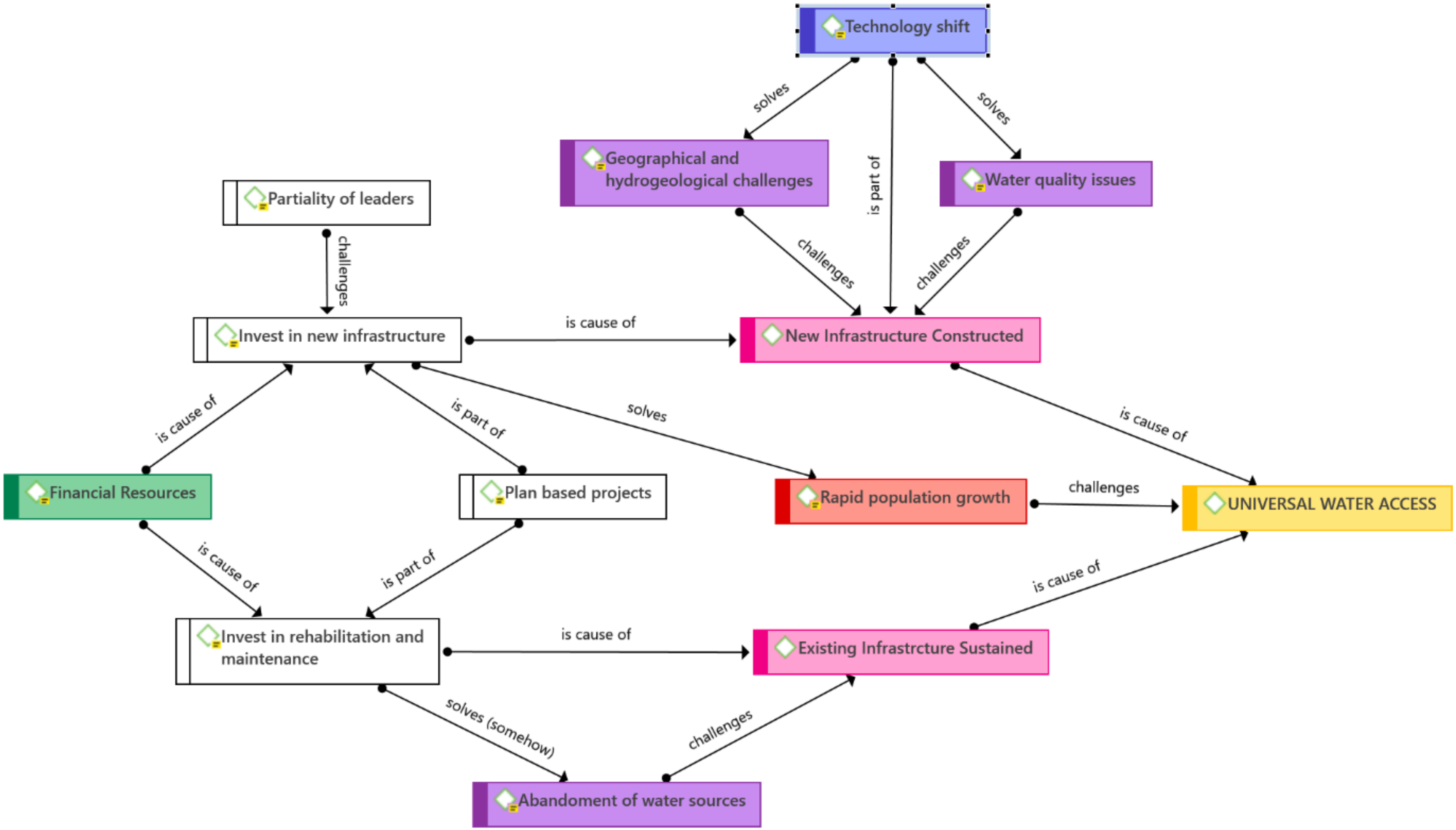


Figure 6-1: Conceptual model for universal water access

6.5 Study Recommendations

Following the findings of this study, the following recommendations are made:

Key Finding#1: Poor Water Quality in the Study Area

The poor water quality registered is most of the boreholes, especially physio-chemical parameters, date back to as early as the commissioning dates due to lack of enforcement of water quality as well as construction standards. Both National Water Resources Authority and Government of Malawi (through Mangochi District Council) should enhance monitoring and enforcement to ensure that only water sources with acceptable water quality are being commissioned in the district. Penal policies need to be introduced, or if any, enforced to ensure that any organisation or individual found on the wrong side by developing water sources with poor quality is punished accordingly.

Another recommendation is to eliminate all sources and pathways of microbial contamination by: disinfecting and demolishing all latrines close to the water sources; providing fences to the water points to deter animals; providing for livestock watering troughs away from the water points; and reworking on the sanitary sealing for the water sources with no or poor sanitary seals. As for the water sources with serious chemical contamination that cannot be remedied, it is recommended that they should be decommissioned, with an alternative source in place, to reduce the exposure of the water users to harmful substances.

Key Finding#2: Theoretical affordability not a true reflection of real affordability by the households (theoretically 21% cannot afford Vs 51% not able to meet all their monthly basic needs)

The study recommends that the responsible international bodies should consider reviewing the method of measuring affordability in water supply services in order to accommodate the real economic situations for the poor.

Key Finding#3: Poor groundwater quality and poor hydrogeological potential rendering other areas not fit for groundwater development

Mangochi District Council should implement a district-wide approach (DWA) in water supply investments by pooling funds from all partners towards some strategic investments. While implementing the DWA, focus should be on the construction of reticulated water supply systems as opposed to hand pump water sources in order to respond to some of the challenges registered in some parts, such as poor groundwater quality and poor hydrogeological potential, at the same time aligning the Council's aspirations with the Malawi 2063 Vision on access to clean piped water.

Key Finding#4: High inequality in the distribution of water sources influenced by a number of factors including politicisation of projects

The Mangochi District should establish by-laws that probit stakeholders from carrying out water development activities in the district without the Authority's knowledge and approval to ensure equitable distribution of water sources. In addition, Government of Malawi should review guidelines for allocation and utilisation of special development funds that go to the District Councils, to reflect the different needs and sizes of the constituencies, other than the one size fits all approach currently taking place, to ensure that those that are far much behind in terms of water supply can quickly catchup.

6.6 Future Research Directions

The study established that some water sources registered higher TDS and fluoride in the wet season, a phenomenon that is not common considering the dilution effect of precipitation. This study hypothesised that the higher wet season values are as a result of salts being in the shallower depth and leaching into the ground after precipitation. Further study is therefore recommended to establish the real cause, leading to either acceptance or rejection of this hypothesis. Of special interest is the borehole at Kwipulumbu John Village that registered the highest TDS and groundwater fluoride values in both seasons, but with higher values in the wet season. A longitudinal study, collecting water level and corresponding TDS and fluoride data on a monthly basis for a period of not less than 12 months may be conducted to establish seasonal trends of the TDS and fluoride concentrations, as well as depth-concentration relationship. Another study should carry out an economic analysis on what it would take to achieve the universal and equitable access to safe and affordable drinking water services in the district.

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APPENDIX A: HOUSEHOLD SURVEY QUESTIONNAIRE

HOUSEHOLD LEVEL SURVEY

Name of Investigator: ______________________ Starting Time: ______________________

Date: ___________________________________ Ending Time: _______________________

LOCATION

Village Name:…………….............. GVH:…………. .ADC: ……………….

TA:……………

Household code ………………….

Please record the GPS location of the household

PRELIMINARY

Age of respond *(   ) **Hint:** ensure that respondent is at least 18years old*

Sex of Respondent *(Male / Female)*

Size of household *(   )*

Sex of household head (*Male / Female)*

No	QUESTION IN ENGLISH	FUNSO MUCHICHEWA	MAUSYO GA MCHIYAWO
1	**As a household, what is your main source of drinking water?** ◯ Tap from Piped supply ◯ Borehole or tube-well ◯ Protected dug well ◯ Protected spring ◯ Unprotected dug well ◯ Unprotected spring ◯ Surface water	**Pakhomo panu pano madzi akumwa mumakatunga kuti?** ◯ Mpopi ◯ Mjigo ◯ Chitsime chokumba koma chotetezedwa ◯ Kasupe otetezedwa ◯ Chitsime chokumba chosatetezedwa	**Ana pamlango pano mesi gakumwa asateka kwapi?** ◯ Mpope ◯Mjigo ◯ Chisima chakukula nambo kutetelwa ◯ Kasupe ja kutetelwa ◯ Chisima ◯ Kasupe ja nga tetelwa ◯ Ku lusulyo, ku nyasa, ku damu

		◯ Kasupe osatetezedwa ◯ Madzi apamtunda	
2	**If drinking from improved source, where is the water source located?** ◯ On premises *(In own dwelling or yard or plot)* ◯ Elsewhere within the village ◯ In another village	**Ngati ndi mpopi/ mjigo/ chitsime chotetezedwa/ kasupe otetezedwa; malo amenewa ali kuti?** ◯ Panyumba pompano ◯ M'mudzi mommuno ◯ Ku mudzi wina	**Naga akusateka ku mpopi, pa mjigo, pa chisima kapena pa kasupe; malo gakwe gali kwapi?** ◯ Panyumba pano pano ◯ M'musi muno muno ◯ Musi wine.
3	**If elsewhere, are there any physical challenges faced when going to collect the water?** ◯Yes *(long distance)* ◯Yes *(Hilly)* ◯Yes *(no bridge on river)* ◯Yes (*other*………………….......) ◯No	**Mukamakatunga madzi, mumakumana ndi vuto liri lonse madzi kumbali ya mayendedwe?** ◯Eya *(mtunda kutalika)* ◯Eya *(Ndikumapiri)* ◯Eya *(kusowa wa mulatho)* ◯Eya (*china*………………….....) ◯No	**Naga akusateka mesi kwine pana isausyo yakusimana nayo pakajende kuti akateche ka mesi?** ◯ Elo (Lutando lwelewu) ◯ Elo (Kwitumbi) ◯ Elo (Kusowa kwa mlato) ◯ Elo (*Yine*………………….....) ◯Iyayi
4	**How much round-trip time (in minutes), including queuing, does a household member take to collect water?** ◯ 0-30 minutes	**Ndimphindi zochuluka bwanji zomwe mumatenga kuti mudzafike kunyumba mukapita kotunga madzi?** ◯ 0-30	**Akusajigala ndawi je lewu mnope uli kwala ni kuudya kuteka mesi?** ◯ Ngapunda mbindi 30 ◯ Kupunda mbindi30 ◯ Ngangumanyilila

	◯ Over 30 minutes ◯ Don't know	◯ kudutsa mphindi 30 ◯ Sindikudziwa	
5	**How many 20 litre buckets do you need to draw to meet your daily household needs?** **_________ (*insert number)***	**Ndindowa zingati zamadzi zomwe zimafunikira patsiku limodzi pakhomo pano?** **_________ (*lembani nambala)***	**Akusakamulisya idebe ilingwa ya mesi pa mlango pano pali siku?** **_________ (*insert number)***
6	**Does the water source provide sufficiently for your daily household needs?** ◯ Yes ◯ No	**Kodi mumakwanitsa kupeza madzi okwanira pakhomo panu tsiku ndi tsiku?** ◯ Eya ◯ Ayi	**Mesi ga kusatekago ga kusakwanila pa mlango pano?** ◯ Elo ◯ Iyayi
7	**If no (on 6), why?** ◯ Low yielding ◯ Mechanical problems ◯ Many users ◯ Very far ◯ Other _________________	**Ngati ayi (pa 6), ndichifukwa chani?** ◯ Madzi alipo ochepa ◯ Kuonongeka ◯ Ogwiritsa ntchito ndi ambiri ◯ Ndikutali ◯ Zifukwa zina ____________	**Naga iyayi ligongo?** ◯ Mesi gakusakopoka panondi ◯ Ipangiso ye jonasiche ◯ Kutupa kwa wandu ◯ Kutali mnope ◯ Magongo gane ________________
8	**Are you able to draw water any time, both day and night?** ◯ Yes ◯ No	**Zimatheka kutunga madzi nthawi inali iliyonse?** ◯ Eya ◯ Ayi	**Ana akusakombola kuteka mesi ndawi jili jose?** ◯ Elo ◯ Iyayi

9	**If no (on 8), why?** ◯ The water source is closed/locked by committee during some hours ◯ It is not safe at night ◯ Water source dries up during some hours ◯ Other ____________________	**Ngati ayi (pa 8), ndichifukwa chani?** ◯ Nthawi ina pamakhomedwa ◯ Usiku kumaopsa ◯ Madzi samatuluka ma ola ena ena ◯ Other ____________________	**Naga iyayi (pa 8) ligongo chichi?** ◯ Ndawi sine pakusawaga pewugale ni amchilongowa wa mjigo ◯ Chilo kusajogoya kwenda ◯ Chisime chikusajumula ndawi sine ◯ Yine ____________________
10	**Does the source supply water all year round?** ◯ Yes ◯ No ◯ Don't know	**Kodi madziwo amatuluka mwezi ulionse pachaka?** ◯ Eya ◯ Ayi ◯ Sindikudziwa	**Ana mesi gakusapatikana chaka chosope?** ◯ Elo ◯ Iyayi ◯ Ngangumanyilila
11	**If no (on 10) which months does the water source not supply water?** *Hint: Select all that apply.* ◯ January ◯ February ◯ March ◯ April ◯ May ◯ June	**Ngati ayi (pa 10), ndimiyezi iti yomwe madzi amavuta** ***(Chongani miyezi yonse yomwe yatchulidwa)*** ◯ January ◯ February ◯ March ◯ April ◯ May ◯ June	**Naga iyayi , miyesi jakwe japi mesi gangakopoka ?** ***(Achonje pasasyile)*** ◯ January ◯ February ◯ March ◯ April ◯ May ◯ June ◯ July

	◯ July ◯ August ◯ September ◯ October ◯ November ◯ December ◯ Don't Know	◯ July ◯ August ◯ September ◯ October ◯ November ◯ December ◯ Sindikudziwa	◯ August ◯ September ◯ October ◯ November ◯ December ◯ Ngangumanyilila
12	**How many improved water sources, in total, do you have in the village?** _________ ***(insert number)*** ◯ Don't Know	**Kuphatikiza mijigo, mipopi, zitsime zotetezedwa ndi kasupe otetezedwa, zonse zilipo zingati mmudzi muno?** _________ ***(insert number)*** ◯ Sindikudziwa	**Akwete isima ilingwa yakutetelwa m'musi muno?** _________ ***(insert number)*** ◯ Ngangumanyilila
13	**Are you able to draw water from other improved sources when your usual source is not functioning?** ◯ Yes ◯ No	**Kodi zimatheka kukatunga madzi kuchokera ku mjigo kapena mpopi wina inu wanu ukaonongeka?** ◯ Yes ◯ No	**Akusakombola kuteka mesi kwisima ine chawo chilli chijonasiche?** Elo Iyayi
14	**If no (on 13), why?** ◯ Other sources are very far ◯ Barred by the other community	**Ngati ayi (pa 13), ndichifukwa chani?** ◯ Kotunga madzi kwinako ndikutali ◯ Timakanizidwa ndi eni ake	**Naga iyayi (on 13), ligongo?** ◯ Yisima ine, ilikwakutalika ◯ Achimisyene akusatikanya

15	**Is everyone in the community able to access the water point?** *Hint: Is access to this water point inclusive, or are some community members excluded due to disability, lack of money, or culture and beliefs?* ◯ Yes ◯ No ◯ Don't know	**Kodi wina aliyense kuno amakwanitsa kugwiritsa ntchito malo wotungapo madzi?** *Kodi kupeza madzi pamalowa kumathekera aliyense kapena ena amasalidwa chifukwa cha ulumali, chikhalidwe komanso zikhulupiriro?* ◯ Eya ◯ Ayi ◯ Sindikudziwa	**Ana waliwose akusakwanisa kuteka mesi pa chisima, ?** *Ana kusimaniga kwa mesi kusapatikina kwa wandu wosope m'musi kapena pana wane wakusasagulidwa m'magongo ga ulumali, kusowa makobili kapena miyambo jine?* ◯ Elo ◯ Iyayi ◯ Ngangumanyilila.
16	**If no (on 15), why doesn't everyone have access to the improved water source?** ◯ Community conflicts ◯ Disability ◯ Old age ◯ Barred due to failure to contribute towards cost of operation and maintenance	**Ngati ayi (pa 15), ndichifukwa chiyani ena sakwanitsa kugwiritsa ntchito malo otungapo madziwa?** ◯ Mikangano ya m'mudzi ◯ Ulumali ◯ Ukalamba ◯ Kuletsedwa kamba kolephera kulipira ndalama	**Naga iyayi, ligongo chichi wane wangakola lusa lakuteka mesi gakutetelwa?** ◯ Maukangani ga m'musi ◯ Ulumali ◯ Kalambala ◯ Kulepela kusonga mbiya ◯ Kulekasidwa ligongo la chikulupi

	◯ Barred due to certain beliefs ◯ Long distance ◯ Other ___________________	ya chitukuko cha pamalo otungira madzi ◯ Kuletsedwa kamba ka zikhulupiriro zina zammudzi ◯ Kutalika kwa mtunda ◯ Zina ________________	◯ Lutando lelyewu ◯ Yine ___________________
17	**As a household, do you contribute towards operation and maintenance of the water source you use??*Hint:*** *If yes, proceed to question 19.. If no, ask 18 then jump to 26.* ◯ Yes ◯ No	**Kodi mumapereka nawo ndalama zothandizira chitukuko chpamalo otungira madzi? *(Ngati ayankha eya, pitirizani pa 19. Ngati ati ayi, funsani 18 kenaka pitani pa 26)*** ◯ Eya ◯ Ayi	**Ana pewasya pawo akusajigala nawo mbali pakusonga nawo mbiya sya pa mjigo?** ◯ Elo ◯ Iyayi
18	**If no (on 17), why?** ◯ Not aware about such contributions ◯ Don't have money ◯ I don't see the need for making such contributions ◯ Funds are mismanaged by committee ◯ Village chief abuses the funds	**Ngati ayi (pa 17), ndichifukwa chani?** ◯ Sindikudziwa chilichonse chokhuza zimenezo ◯ Ndilibe ndalama ◯ Sindiona kufunikira kwake ◯ Ndalamazo sizigwiritsidwa ntchito bwino ndi akomiti ◯ Amfumu amazionongo ndalamazo	**Naga iyayi, ligongo chichi?** ◯ Ngani mbinganeje ya nsonje sonje ◯ Ngakola makobili ◯ Pangali chifukwa chakusonjela mbiyasyo ◯ Amchilongola akusadyonanga makobili ◯ Mwenye akusadyonanga mbiya

19	**How are the contributions done** ◯ Monthly ◯ Yearly ◯ After break-down ◯ Don't know	**Kodi maperekedwe andalama amayenda motani?** ◯ Pamwezi ◯ Pachaka ◯ Chikaonongeka ◯ Sindikudziwa	**Msonjesonje ukasawaga uli?** ◯ Pamwesi ◯ Pachaka ◯ Kusonga pa udyonasiche mjigo ◯ Ngangumanyilila
20	**If monthly or yearly (in 19), how much do you pay as monthly contribution?** ***Hint: if yearly, devide by 12*** ◯ >0-100 - MWK ◯ >100-200 - MWK ◯ >200-300 - MWK ◯ >300-400 - MWK ◯ >400-500 - MWK ◯ >500 - MWK	**Potsatira funso la pa 19, kodi mumapereka ndalama zingati pamwezi?** ***(gawani ndalama ya pachaka ndi 12)*** ◯ 0 ◯ >0-100 - MWK ◯ >100-200 - MWK ◯ >200-300 - MWK ◯ >300-400 - MWK ◯ >400-500 - MWK ◯ >500 – MWK	**Akusapeleka mbiya silingwa pa mwesi sa pa mjigo?** ◯ 0 ◯ >0-100 - MWK ◯ >100-200 - MWK ◯ >200-300 - MWK ◯ >300-400 - MWK ◯ >400-500 - MWK ◯ >500 - MWK
21	**If after break down (in 19), what is the highest amount you have contributed at once?** ◯ >0-100 - MWK ◯ >100-200 - MWK ◯ >200-300 - MWK ◯ >300-400 - MWK ◯ >400-500 - MWK	**Ngati mumapereka chikaonongeka, ndalama yaikulu kwambiri yomwe munaperekako pakamodzi ndi zingati?** ◯ >0-100 - MWK ◯ >100-200 - MWK ◯ >200-300 - MWK ◯ >300-400 - MWK	**Naga akusapeleka chilli chipaswiche (in 19), akusapeleka mbiya silingwa?** ◯ >0-100 - MWK ◯ >100-200 - MWK ◯ >200-300 - MWK ◯ >300-400 - MWK ◯ >400-500 - MWK

	◯ >500 - 1000MWK ◯ >1000MWK	◯ >400-500 - MWK ◯ >500 - 1000MWK ◯ >1000MWK	◯ >500 - 1000MWK ◯ >1000MWK
22	**Do you contribute willingly?** ◯ Yes ◯ No	**Kodi mumapereka ndi mtima onse popanda kuwiringula?** ◯ Eya ◯ Ayi	**Ana mbiya akusapeleka mwakusaka kwao?** ◯ Elo ◯ Iyayi
23	**If no (on 22), why?** ◯ I don't see the need for making such contributions ◯ Money isn't enough ◯ Contributions are mismanaged by committee ◯ Village chief abuses the contributions	**Ngati ayi (pa 22), ndichifukwa chani?** ◯ Sindimaona kufunikira kwake ◯ Ndimakhala ndindalama zochepa ◯ Ndalamazo sizigwiritsidwa ntchito bwino ndi akomiti ◯ Amfumu amazionongа ndalamazo	**Naga iyayi, (on 22), ligongo chichi?** ◯ Ngikusalola ligongo la msonjesonje ◯ Magobili ngusakola gakunondipa ◯ Achimlongola akusajonanga mbiya ◯ Mwenye konanga mbiya
24	**Suppose maintenance costs have gone higher, would you be willing to pay more?** ◯ Yes ◯ No	**Inu muli okonzera kupereka ndalama yochulukirapo malingana ndikuti zinthu zikukwera mtengo tsiku ndi tsiku** ◯ Eya ◯ Ayi	**Naga msonjesonje wa pa mjigo ukwesile takomboleje kupeleka mwakusaka kwao?** ◯ Elo ◯ Iyayi

25	**If yes (on 24), how much would you be willing to pay per year?** ◯ >0 - 100 - MWK ◯ >100-250 - MWK ◯ >250-500 - MWK ◯ >500-750 - MWK ◯ >750-1000 - MWK ◯ >1000 - MWK	Ngati eya (pa 24), mukhoza kuwanitsa kumapereka zingati? ◯ >0 - 100 - MWK ◯ >100-250 - MWK ◯ >250-500 - MWK ◯ >500-750 - MWK ◯ >750-1000 - MWK ◯ >1000 - MWK	**Naga elo (on 24), nkusapeleka silingwa mwakusaka kwenu pa chaka?** ◯ >0 - 100 - MWK ◯ >100-250 - MWK ◯ >250-500 - MWK ◯ >500-750 - MWK ◯ >750-1000 - MWK ◯ >1000 - MWK
26	**What is the main source of your household income?** ◯ Employment ◯ Piece work *(Ganyu)* ◯ Petty trading ◯ Fishing ◯ Farming ◯ Social cash transfer ◯ Begging ◯ Other (specify) __	**Kodi ndalama yothandizikira tsiku nditsiku mumaipeza bwanji?** ◯ Ndimagwira ntchito ◯ Ganyu ◯ Bizinezi yaing'ono ◯ Usodzi ◯ Ulimi ◯ Mtukula pa Khomo ◯ Kupemphetsa ◯ Zina ___________________	**Ana litala lyachi lekulungwa lakupatila mbiya pa mlango pano?** ◯ Masengo ◯ Ganyu ◯ Geni ja mwana mwana ◯ Kulaga nsomba ◯ Kulima ◯ Mtukula pa mlango ◯ Kuwenda ◯ Matala gane (specify) __
27	**On average, how much do you earn per month?** ◯ >0 - 7500 MWK ◯ >7500 -15,000 MWK	**Pamwezi mumapeza ndalama zingati** ◯ >0 - 7500 MWK ◯ >7500 -15,000 MWK	**Akusapata mbiya silingwa pa mwesi?** ◯ >0 - 7500 MWK ◯ >7500 -15,000 MWK

	◯ >15000-28,000 MWK ◯ >28,000-35,000MWK ◯ >35,000 MWK	◯ >15000-28,000 MWK ◯ >28,000-35,000MWK ◯ >35,000 MWK	◯ >15000-28,000 MWK ◯ >28,000-35,000MWK ◯ >35,000 MWK
28	**How much do need to support your monthly basic needs?** ◯ >0 – 7,500 MWK ◯ >7,500 -15,000 MWK ◯ >15000 -22,500 MWK ◯ >22,500-30,000MWK ◯ >30,000 – 37,500MWK ◯ >37,500MWK ◯ Don't know	**Panyumba pano mumafuna ndalama zochuluka bwanji kuti mukwaniritsa zofunika zoyambirira za pakhomo** ◯ >0 – 7,500 MWK ◯ >7,500 -15,000 MWK ◯ >15000 -22,500 MWK ◯ >22,500-30,000MWK ◯ >30,000 – 37,500MWK ◯ >37,500MWK ◯ Don't know	**Akusasosya mbiya silingwa pa mwesi kuti apate yakusosegwa pa mlango?** ◯ >0 – 7,500 MWK ◯ >7,500 -15,000 MWK ◯ >15000 -22,500 MWK ◯ >22,500-30,000MWK ◯ >30,000 – 37,500MWK ◯ >37,500MWK ◯ Ngangumanyilila
	THANK YOU VERY MUCH FOR TAKING PART IN THIS SURVEY	**ZIKOMO KWAMBIRI PAKUTENGA NAWO MBALI PAKAFUKUFUKUYU**	**SIKOMO KWEDYINJI**

APPENDIX B: INTERVIEW GUIDE FOR GOVERNMENT OFFICIALS

1. Briefly explain what your general roles are your position as……….
2. What are your specific roles when it comes to water development issues, especially in community water supply?
3. How are decisions on where to implement water supply projects arrived at? What does the policy say? Is this working properly or not?
4. As you are aware, SDG6.1 says *"By 2030, achieve universal and equitable access to safe and affordable drinking water services".* How is government approaching this? Are there any strategies that have been put in place to achieve this? Do you think Malawi is on track in terms of progress?
5. Has the government taken deliberate efforts to check the safety (water quality) of the water that communities are drinking? Or should we assume that all is well with all improved water sources?
6. Development Partners and other NGOs play a big role in community water supply. However, not all organisations follow guidelines, and this can affect government's approach. What measures are/can be put in place to ensure compliance when it comes to provision of water?
7. What are some of the challenges that can affect progress of SDG6.1? What should be done to address these challenges?
8. Your final thoughts

APPENDIX C: INTERVIEW GUIDE FOR LOCAL LEADERS

MAFUNSO KWA ATSOGOLERI AKUMUDZI

9. Mwachidule, tilongosolereni kuti pa udindo wanu mumagwira ntchito zotani.

   Atusalire masengo gakusakamula pa udindo wawo

10. Kodi pa udindo wanu, ntchito zachitikuko cha madzi zimakukhudzani motani?

    Mmachili ga ulongolowa genu, chitukuko cha mesi ukusiwawandika mwa ntiuli

11. Mudera lanu mukamabwera chitukuko chamadzi, chimagawidwa motani? Amapanga chiganizo choti chitukuko chipite mbali iyi ndi iyo ndinani?

    Mdela mwawo chitukuko cha mesi chilli chiyiche, wakusawa pasogolo mukugawanya ga madela gakwala chitukuko wani.

12. Mukuona ngati chitukuko cha mmadzi chikuyenda bwino mudera lanu?

    Mwakuionela mdela muno, ngani ja chitukuko cha mesi jokwenda?

13. Ndimavuto anji okhudzana ndichituko chamadzi omwe mukuwaona?

    Ana pana masyausyo ga mtiuli gakusimana nago mwakulingana ni chitukuko cha mesi.

14. Tikamayenda timaona madera ena kuli mijigo/zitsime/mipopi yambiri kuposa madera ena. Chimapangitsa ndichani?

    Mmadela mwine mwana mijigo, mipope, isima yejinji kuposa madela gane; ana akuganisya kuti chikusatendekasya chichi?

15. Panopa kuli ndondomeko zoonetsetsa kuti munthu aliyense azitha kupeza madzi abwino, komaso pa mpindi zosapyolera 30 kupita ndikubwera. Inu mukuona ngati ndizotheka? Tingapange bwanji kuti zitheke? Ngati ndizosatheka, ndizinthu ziti zolepheretsa zomwe mukuziona?

    Apano pana chilinganisyo chakuti mundu jwine jilijose jukoleje likuga lakupata mesi ngambone, ndawi jangapunda 30 minisi kwala ni kudya. Ana yeleyi yakomboleka?Mpaka tutende uli kuti yeleyi ikomboleche? Naga yangakomboleka yindu yapi yati mpaka yilepelekasye yakuiona?

16. Malingaliro anu omaliza

Malowe gawo gakumalichisya

APPENDIX D: FOCUS GROUP DISCUSSION GUIDE

ZOKAMBIRANA ZAMACHEZA NDI KOMITI YAPAMADZI

1. Tiuzeni dzina la Komiti yanu

   Atusalire lyina la komiti

2. Tiuzeni ntchito yomwe mumagwira ngati komiti

   Atusalire masengo ga kusakamula mpela a mchilongowa wa pa mjigo

3. Udindo wanu unali otani pamene malo otungira madziwa anamangidwa?

   Udindo wawo walidyi wa mtiulimu ndawi jiwawugulaga chisima

4. Pankhani zotolera ndalama zothandizira ntchito zina monga kukonza chikaonongeka zimayenda bwanji?

   Mungani jakulokotera mbiya, syakamusila masengo chisima chili chijonasiche sikusadyenda uli

5. Kumbali yammene madzi amatulukira pamalopa, munenapo kuti chani? Ndinu okhutitsidwa?

   Kumbali ja kakopwoche ka mesi pawele mjigowu tatusalire ilingwa?

6. Ilipo nthawi yomwe munatha kukhala kwa sabata yathunthu madzi asakutuluka? Chimachitika kuti zitero? Nanga inu munapangapo chani?

   Ana pana katema kiwatemi mlungu wamtundu mesi ngagakukopoka?chatendekaga chichi?

7. Kodi pali anthu ena mmudzi muno omwe samakwanitsa kudzatunga madzi pamalopa? Ngati alipo zifukwa zake ndichani? Nanga tingatani kuti ayambe kukwanitsa.

   Ana pana wandu wane ,wakusakanigaka kuteka mesi pa malo pano? Naga apali magongo gakwe chichi? Mpaka tutende chichi kuti dyemanjajo akwanilise.

8. Ubale wanu ndiotani ndi amfumu, a VDC ndi anthu ammudzi muno omwe amawa pamalopa?

Ulongo wawo ni achimwenye, achimlongowa wa chitukuko ni wandu wa mmusi wakusamwa mesi ukuwaga uli pa malo pano.

9. Ndimavuto anji omwe mumakumana nawo mukamagwira ntchito yanu?

   Ana nimasausyo gakusasimangana nago mundawi jakukamula masyengo

10. Mau ena omaliza

   Akwete malowe gakumalisya?

APPENDIX E: OBSERVATION CHECHLIST

Water Quality Observation Checklist **Date……………………………**

1. Name _____________Village :______________________GVH:_________________

   ADC_______________________ TA: ____________________________

2. Water point code number _____________________

3. Capture location details _______________________ ,_______________________

4. Is the surrounding clean? *(Yes/No)*

   a. Take pictures

5. Does the water source have a complete apron and drainage? *(Yes/No*

   a. If yes, what is the general condition?

      A. *Complete;* ***B.*** *Partially worn-out,* ***C.*** *Completely worn-out)*

6. Does the water source have a soak-away pit? *(Yes/No).*

   a. If yes, is the soak-away pit function properly i.e. no stagnant water? *(Yes/No)*

7. Mention any potential source of contamination within 50m from the water source

   (none; waste disposal pit; graveyard; pit latrine; damping site; other………………….)

   at _____m

8. Any evidence of animal trespass or droppings around the water source? *(Yes/No)*

APPENDIX F: MARKET PRICES SURVEY CHECKLIST

Name of Supplier (Optional):	Date:
Description of spare part	**Unit Cost (MWK)**
Fulcrum pin assembly	
Hanger pin assembly	
Rodhanger assembly	
Bearing bush	
Top rod assembly	
Pump rod assembly	
Rod centraliser	
Riser pipe assembly	
Top sleeve	
Flapper	
Centraliser	
Cylinder assembly	
Valve body assembly (plunger & foot valve)	
Bobbin	
Cup-seal	
O-ring	
Gasket	
Compression cone	
Double end socket	
Solvent cement	
Labour (Area Mechanic)	

APPENDIX G: NCST APPROVAL LETTER

NATIONAL COMMISSION FOR SCIENCE & TECHNOLOGY

Lingadzi House
Robert Mugabe Crescent
P/Bag B303
City Centre
Lilongwe

Tel: +265 1 771 550
+265 1 774 189
+265 1 774 869
Fax: +265 1772 431
Email:directorgeneral@ncst.mw
Website:http://www.ncst.mw

NATIONAL COMMITTEE ON RESEARCH IN THE SOCIAL SCIENCES AND HUMANITIES

Ref No: NCST/RTT/2/6 **5th May 2020**

Mr Kondwani Andreah,

District Water Development Office,

P.O. Box 325,

Mangochi.

Email: koandreah@gmail.com

Dear Mr Andreah,

RESEARCH ETHICS AND REGULATORY APPROVAL AND PERMIT FOR PROTOCOL NO. P.04/20/475: ASSESSMENT OF SIMULTANEOUS ATTAINMENT OF UNIVERSALITY, EQUITABILITY, SAFETY AND AFFORDABILITY IN DRINKING WATER ACCESS IN MANGOCHI DISTRICT, MALAWI

Having satisfied all the relevant ethical and regulatory requirements, I am pleased to inform you that the above referred research protocol has officially been approved. You are now permitted to proceed with its implementation. Should there be any amendments to the approved protocol in the course of implementing it, you shall be required to seek approval of such amendments before implementation of the same.

This approval is valid for one year from the date of issuance of this approval. If the study goes beyond one year, an annual approval for continuation shall be required to be sought from the National Committee on Research in the Social Sciences and Humanities (NCRSH) in a format that is available at the Secretariat. Once the study is finalised, you are required to furnish the Committee and the

Committee Address:
Secretariat, National Committee on Research in the Social Sciences and Humanities, National Commission for Science and Technology, Lingadzi House, City Centre, P/Bag B303, Capital City, Lilongwe3, Malawi. Telephone Nos: +265 771 550/774 869; E-mail address: ncrsh@ncst.mw

Commission with a final report of the study. The committee reserves the right to carry out compliance inspection of this approved protocol at any time as may be deemed by it. As such, you are expected to properly maintain all study documents including consent forms.

Wishing you a successful implementation of your study.

Yours Sincerely,

Yalonda .I. Mwanza
NCRSH ADMINISTRATOR
HEALTH, SOCIAL SCIENCES AND HUMANITIES DIVISION

For: CHAIRMAN OF NCRSH

Committee Address:
Secretariat, National Committee on Research in the Social Sciences and Humanities, National Commission for Science and Technology, Lingadzi House, City Centre, P/Bag B303, Capital City, Lilongwe3, Malawi. Telephone Nos: +265 771 550/774 869; E-mail address: ncrsh@ncst.mw

APPENDIX H: PERMISSION FROM MANGOCHI DISTRICT COMMISSIONER

C/O Mzuzu University
P/Bag 201
Luwinga,
Mzuzu 2

28th May, 2020

The District Commissioner
Mangochi District council
P.O. Box 138
Mangochi

Dear Sir,

SEEKING PERMISSION TO CONDUCT A STUDY ON SIMULTANEOUS ATTAINMENT OF UNIVERSALITY, EQUITABILITY, SAFETY AND AFFORDABILITY IN DRINKING WATER ACCESS IN MANGOCHI DISTRICT.

I write to request for a permission from your office to conduct a study on simultaneous attainment of universality, equitability, safety and affordability in drinking water access In Mangochi District, Malawi. I am a PhD student at Mzuzu University.

Sustainable Development Goal Target 6.1 states that "By 2030, achieve universal and equitable access to safe and affordable drinking water services". This entails that provision of water should stay focused on key words such as universal, equitable, safe and affordable. The study therefore aims at understanding how these can simultaneously be achieved.

The study will be conducted in TAs Nakumba, Chilipa, Katuli and Namavi and will use Household Survey, Water Quality Analysis, Focus Group Discussions and Key Informant Interview.

Your consideration will be greatly appreciated.

Approved

Yours faithfully,

Kondwani Andreah

Principal Investigator

APPENDIX I: INFORMED CONSENT FORM – ENGLISH VERSION

Study Name: Exploration of the Simultaneity of Safety, Affordability, Universality and Equitability in Drinking Water Services in Mangochi District in Malawi

Principal Investigator: Kondwani Andreah, BSc, MSc, PhD Student (Mzuzu University).

Introduction

Hello, my name is *(Name of Enumerator)* ______________________________. We, led by Mr Kondwani Andreah as Principal Investigator, are conducting a study on water access. The study aims at understanding how Mangochi District can attain universal and equitable access to safe and affordable drinking water. I would like to invite you to participate in the study. This consent form has been prepared to provide you with information that can make you understand all what this research is about so that you can ably decide whether to participate or not. I am requesting you to read this document if you are comfortable to read; but if you cannot read on your own, I can read it to you. Please if there is anything that you are not sure of its meaning and seek for clarification about this study, feel free to ask me any question. After you have read this document and you have made a decision to willingly participate in this study, I will ask you to sign two copies of this consent form indicating that you have read and understood the information in this document. You will be asked to have one copy of this document (if you wish to have it) for your own record. The other copy will be kept in a confidential, safe and secure place for our records.

Are you able and willing to read this document on your own?

Yes, I will read the document on my own ____

No, read the document to me ________

Why have you been chosen to take part in this study?

You have been chosen to take part in this study because the study believes that you can provide useful information that will that assist us to achieve the objectives of the study

How long is it going to take for you to participate in this study?

I have a set of questions that I want to ask you that will take us about 45 minutes.

What will happen to you if you take part in this study?

Once we are done with this interview, you will no longer be required to provide further information later after this**.**

What are the risks of participation?

Your participation in this study will not have any risk to your physical or mental well-being because the study will not use any invasive measures on you and that the study assures you of confidentiality of all the information that you are going to provide in the course of our interview. The information will be used for academic purposes.

What will you get or benefit by participating in this study?

There is no direct benefit in participating in the study as your participation is voluntary. However, the information you provide will go a long way to help not only those who are still not accessing safe water, but you also, since the study findings will help improve service delivery in community water supply. Let me also assure you that there is going to be no any repercussions from the study if you decide to participate or not participate in this study.

Who can you contact if you will have problems or questions?

If you have issues regarding the way we are conducting the study, I will encourage you to contact the following: Principal Investigator, Mr. **Kondwani Andreah** on phone number 0999932603, or **Assoc. Pro Mtafu Manda** on 01320722/575.

Informed Consent – Agreement to Participate in Study

If you have heard or read this consent form and all your questions have been answered and you agree to take part in this study, please write down your name and sign or make your mark below:

I, *(name of study participant)* …………………………………………… hereby voluntarily agree to take part in the study entitled ***"Assessment of Simultaneous Attainment of***

Universality, Equitability, Safety and Affordability in Drinking Water Access in Mangochi District, Malawi"

The procedure of my participation has been well explained including the voluntary nature of my participation. All of my questions and concerns about the study have also been adequately answered.

Participant's Signature/ Thumb ……………………………………..

Date: …………………………….

Study Participant Code Number:

Person Obtaining Consent

I have explained to the participant the objectives, procedure of participation, and any related risks and their management in this study:

Name…………………………………….. Signature: ……………………..…

Date: …………………………………

APPENDIX J: INFORMED CONSENT FORM – CHICHEWA VERSION

Mutu wakafukufuku: Kuunika momwe boma la Mangochi lingakwanitsire kuti aliyesense athe kukhala ndi kuthekera komwa madzi abwino popanda kusalana komaso pamtengo wabwino

Otsogolera kafukukufuku: Kondwani Andreah, BSc, MSc, PhD Student (Mzuzu University).

Mau Oyamba/Mlondola Njira

Dzina langa ndine *(Dzina la ofunsa mafunso)* ______________________________________.

Motsogozedwa ndi Mr Kondwani Andreah ngati wamkulu wathu, tikupanga kafukufuku okhudzana ndi madzi omwe timamwa. Cholinga chakafukufukuyu ndichofuna kuona momwe boma la Mangochi lingakwanitsire kuti aliyesense athe kukhala ndi kuthekera komwa madzi abwino popanda kusalana komaso pamtengo wabwino. Chomcho, ndikukumemani kuti muthe kutenga nawo mbali pa kafukufuku ameneyu.

Muloledwa kukhala ndi imodzi mwa makalatawa (ngati mungafune kukhalanayo) kuti muzitha kukumbukira. Kalata ya ndondomeko inayi izatengedwa ndikusungidwa mmalo abwino, otetezedwa ndipo mwa chinsinsi mmene timasungira zinthu zathu.

Kodi mumatha ndipo mukufuna kuwerenga kalatayi panokha?

Inde, ndiwerenga pa ndekha ____

Ayi, ndiwerengeleni ________

Chifukwa chiyani mwasankhidwa kutengapo nawo gawo pa kafukufuku ameneyu?

Mwasankhidwa kuti mutenge nawo mbali chifukwa kafukufukuyu akukhulupilira kuti mupeleka maganizo ofunikira amene atathandize kuti zolinga za kafukufukuyu zikwaniritsidwe.

Kodi kafukufuku ameneyu akutengelani nthawi yayitali bwanji?

Ndili ndi kagulu ka mafunso oti ndikufunseni komwe katatitengele mphindi 45

Chitakuchitikileni ndi chani mukatenga nawo gawo mu kafukufuku ameneyu?

Tikangomaliza ndi mafunso amenewa, simukuyeneranso kupeleka maganizo anu ndipo simudzafunidwanso mtsogolomu kupeleka maganizo ena a kafukufuku ameneyu.

Kodi pali ziophyezo zanji?

Kutengapo nao mbali kwanu kulibe chiophyezo chilichonse pa moyo wanu chifukwa kafukufukuyu sagwiritsa ntchito njira zina zili zonse zosakhala bwino pa inu ndipo kafukufukuyu awonetsetsa kuti maganizo amene mutapeleke azasungidwe mwachinsinsi.

Kodi mupindula chiyani potengapo gawo mu kafukufuku ameneyu?

Palibe phindu lowoneka lomwe mutapeze chifukwa chakutengapo gawo kwanu. Komabe, maganizo anu adzathandiza kwambiri anthu ena omwe pakadali pano akanalibe mwayi omwa madzi abwino, komaso athandiza ndi inu nomwe pamene tikuunikira zopititsa patsogolo ntchito za chitukuko chamadzi. Ndikutsimikizireniso mwachimvekere kuti sipadzakhala zovuta zina zili zonse kuchoka kukafukufuku ameneyu kapena wogwira ntchito ya za umoyo ngati mwasankha kutengapo mbali kapena ayi mu kafukufuku ameneyu.

Kodi mungalankhule ndi ndani ngati muli ndi vuto kapena mafunso okhudza kafukufuku ameneyu?

Ngati muli ndi zina zokhudzana ndi mmene tikupangira ka fukufukuyi, ndikulimbikitsani kuti muyimbe lamya kwa: **Otsogolera kafukufukuyu**, Mr. **Kondwani Andreah** panambala iyi 0999932603, kapena M'phunzitsi wa ku sukulu ya ukachenjede ya Mzuzu University yemweso akuthandiza nawo pa kafukufuku ameneyu a **Mtafu Manda** pa nambala izi 01320722 kapena 01320575.

CHIBVOMELEZO – MGWIRIZANO WOTENGA MBALI MU KAFUKUFUKU

Ngati mwawerenga kapena kuyimva kalata ya chibvomelezoyi, ndipo mafunso anu onse ayankhidwa komaso mukubvomeleza ketenga nawo mbali mu kafukufukuyu, chonde Lembani dzina lanu ndi kutikitila kapena kuyika chidindo cha chala munsimu.

Ine, *(dzina la otengapo mbali),*………..……………………………mwandekha ndikuvomera kutengapo gawo mu kafukufuku amene mutu wake uli **"**Kuunika momwe boma la Mangochi lingakwanitsire kuti aliyesense athe kukhala ndi kuthekera komwa madzi abwino popanda kusalana komaso pamtengo wabwino**".** Ndondomeko ya kutangapo gawo kwanga komanso kutengapo gawo mwakufuna kwanga zalongosoledwa bwino lomwe. Mafunso ndi nkhawa zanga zonse zayankhidwa mokwanira.

Otenga nawo mbali pa kafukufuku……………………………………….

Potikitila/podinda ……………………………………………….

Tsiku …………………………………………..

Nambala ya ya chizindikiro ya munthu otenga nawo mbali:

Wotenga chilolezo

Ndafotokoza bwino lomwe za kafukufuku uyu kwa munthu otenga mbali mukafukufuku uyu ndi zonse zimene zingayembekezedwe mu mkafukufuku ameneyu

Dzina………………………………………… Tikitilani: ……………………………..…

Tsiku ………………………………….

APPENDIX K: INFORMED CONSENT FORM – CHIYAO VERSION

Mtwee wa kafukufuku: Kumulika kuti boma ja Mangochi jikwanilisye kuti jwalijose atameje ni kukomboleka kwa kumwa mesi gambone mwangasagulana soniso pa mtengo wambome

Wakulongolera kafukufuku: Kondwani Andreah, BSc, MSc, PhD Student (Mzuzu University).

Ndandilo

Une lina langu *(Name of Enumerator)* ______________________________. Uwe, mwakulongoleledwa ni Mr Kondwani Andreah wali wa kulungwa jwa kafukufuku, tukutenda kafukufuku jwa kapatikane ka mesi. Chakulinga cha kafukufukuju ni kusaka kupikanichisya matala ga m'boma ja Mangochi mwa mpaka atendelele kuti mundu julijose jupate mesi gakumwa gambone ni ga kutetelwa. Mulyele ligongo lyali tukwawenda kuti awe nawo munkutula wajwele kafukufuku (chiwungunya). Yosope yayilembedwe amu yawichidwe mwitala mwakapa likuga lakupikanichisya kuti ajigale nawo mbali. Achi chibaluwa chilinganyidwe kuti jamanja achipikaninichisye nikuti chakamuchisye kutenda chisagula chakuti ana najigale nawo mbali kapena iyayi mukafukufukuju (chiwungunya). Mwamyoyo ngwawenda kuti achiwalanje chenene chibaluwachi kuti achipikanichisye nambo soni naga ngakombola kuwalanga komboleka kusala kuti nawalanjile kuti achipikanichisye chenene. Naga pana pangakupikanichisya muyayilembedwe muchibaluwachi chonde awe wagopoka kuwusya kuti twalongosolele kuti apikanichisye chenene yakafukufuku (chiwungunya) chelechi. Naga achipikanichisye chenene chibaluwachi nambo soni najitikene nayo yakujigala nawo mbali pakafukufukuju chonde tinawende kuti asayine ikalakala iwili yakwayana niyakafukufukuju pakwitichisya yakuti apikanichisye nambo soni akamulene nayo yajwele kafukufukuju. Nambo soni naga yanonyele yakuti akole chikalata chawo titwape chimo kuti chimo chinecho tuchisunje uwwe mwakuchisamalila sawu chindu chakutukamuchisya kukuyichisya yajwele kafukufukuju.

Ana mpakana apakombole kuwalanga chikalatachi mwajikape?

Elo mpakana napakombole______

Iyayi nganimba napakombwele_____

Ana ligongo chichi alakwe asagwile kujigala nawo mbali paju kafukufukuju?

Asagwile kujigala nawo mbali paju kafukufukuju ligongo lyakuti mwaju kafukufukuju alakwejo akwete ukombosi wakupeleka utenga wakusosegwa umpakana utukamuchisye kupata yisyesyene yayikusosegwa mujwele kafukufukuju.

Ana mpakana yajigalile ndawi jajilewu uli kutenda nawo kafukufukuju?

Tuwisile ndawi jajilewu mbindi sakwana 45.

Ana pambesi pakujigala nawo mbali pakafukufukuju pana soni yatuli?

Naga ali apeleche yakusosedwa yosope nikuti pele amalene nayo basi pangali soni yine yakuti apelechele soni.

Ana pana chakogoya chine chilichose mujwele kafukufukuju?

Kujigala mbali kwawo mujwele kafukufukuju kwangali chakogoya chine chilichosecho pawumi wawo nambo soni atamose nganisyo syawo ligongo lyakuti mwelemu mwangali yakusawusya yine yayiliyoseyo mwakuti aju kafukufukuju jukwasimichisya alakwe kuti yosope yatapeleche pepano ili yakusunjidwa mwakwasunjila insinsi yawo yosope.

Yeleyi ili yakuti ikamuchisye pangani jamajiganyo basi.

Ana alakwejo tapindulepo chichi pajwele kafukufukuju?

Paju kafukufukuju alakwejo pangalipo chatapate ligongo lyakuti kujigala mbali kwawoku kuli sawu gamba kulipeleka pakusaka kamuchisya chabe.

Nambo soni ine yaliyose yampakana apeleche paju kafukufukuju ngawa kuti tiyigambe kwakamuchisya wanganakola ukoto wamesi gambone pewo iyayi nambo soni mpakana alakwejo ligongo lyakuti yeleyi tiyikamuchisye mawumi gawandu wajinji mmisi mwetumu mmadela getu gosope.

Nambo soni ngusaka kwasalichisya kuti pangali vuto jine jalijose jampakana japate naga ali ajigele nawo mbali payeleyi yakafukufukuyi nata kuwa kuti mwine asagwile ngasaka kujigala nawo mbali payeleyi.

Ana mpakana wayichile wani naga ali akwete chakusawusya kapena chiwusyo pangani jajwele kafukufukuju?

Naga ali akwete vuto kapena chiwusyo mkatikati mwakutenda nawo aju kafukufukuju, nditu wapate awa wanduwa pakwimba telefoni syawo sawu : Wwungunya jwamkulungwa baba **Kondwani Andreah** pa **0999932603** nambo soni Nakanga jwamkulungwa **Pro Mtafu Manda** pa **01320722/575.**

Yakamulana pakujigala nawo mbali pakafukufukuju.

Naga apikanichisye nikuwalanga chenene jakwayana kafukufukuju nambo soni iwusyo yosope ipikaniche chenene nikuti soni alakwewo ajitichisye yakujigala nawo mbali pakafukufukuju tukwawenda kuti alembe lina lyawo nikusayinila pasipo pakwitikana niyakujigala nawo mbali mukafukufukuju.

Une (lina lwawo) …………………………………………………. ngwitikana nayo yakujigala mbali pakafukufukuju jwali mtwe wakwe **"Matala gambone gampaka gakuyidwe pakusaka kuti tupakombole kwanilisya kwikasya mesi gakumwa gambone kwa wandu wosope m'boma ja Mangochi chilambo cha Malawi".**

Matala gosope gakujigala mbali kwangu mujwele kafukufukuju galongosoledwe chenene nambo soni kulipeleka kwanamsyene pajwele kafukufukuju. Nambo soni yiwusyo niyine yosope yijanjidwe chenenepe .

Kusayinila kwa jwakujigala nawo mbali/kapena chala……………………………………

Lisiku/Lyuwa…………………………………………………………………………

Jamundu jwakujigala nawo mbali

Mundu nkujigala ukoto

Longoswele yakulinga, matala niyine yosope yakwayana nimwampakana tutendele jwele kafukufukuju(chiwungunyachi):

Lina………………………………………… Kusayina/kudinda chala………………………...

Lisiku/Lyuwa…………………………………………..

APPENDIX L: WATER QUALITY ANALYSIS RESULTS

Water point ID	Longitude	Latitude	Name	Village	GVH	ADC	TA
WP001	34.996071160	-14.76944090	Kapire Mosque	Kapire	Kapire	Chilipa	Chilipa
WP002	34.997319058	-14.77615009	Malinda	Kapire	Kapire	Chilipa	Chilipa
WP003	34.998791255	-14.78314239	Kapire Market	Kapire	Kapire	Chilipa	Chilipa
WP004	34.998520352	-14.78437492	Kapire CDSS	Kapire	Kapire	Chilipa	Chilipa
WP005	34.997678138	-14.78701272	Kapire Primary School	Kapire	Kapire	Chilipa	Chilipa
WP006	35.056978092	-14.74717803	Nansongole School	Afiki	Afiki	Chilipa	Chilipa
WP007	35.055757351	-14.75592919	Afiki	Afiki	Afiki	Chilipa	Chilipa
WP008	35.404258780	-14.30163689	Chilungo Mosque	Chilungo	Maundu	Katuli	Katuli
WP009	35.405814797	-14.30177789	Nambalale School	Chilungo	Maundu	Katuli	Katuli
WP010	35.402862690	-14.29994813	Chisanje	Chilungo	Maundu	Katuli	Katuli
WP011	35.402726233	-14.30199264	Tiyanjane	Chilungo	Maundu	Katuli	Katuli
WP012	35.427703299	-14.29393632	Inaki	Inaki	Chiwaula	Katuli	Katuli
WP013	35.484671071	-14.26089744	Mizinga	Mizinga	Makande	Katuli	Katuli
WP014	35.488955565	-14.23958918	Chikoja	Chikoja	Makande	Katuli	Katuli
WP015	35.424089357	-14.10877824	Mponda 1	Mponda	Matola	Mpita	Katuli
WP016	35.423105992	-14.13072824	Mponda 2	Mponda	Matola	Mpita	Katuli
WP017	35.371628702	-14.09934996	Mkumula	Mkumula	Chisuse	Mpita	Katuli

WP018	35.371814109	-14.10148603	Kalenjere	Chisuse	Chisuse	Mpita	Katuli
WP019	35.395930856	-14.11631895	Matola	Matola	Matola	Mpita	Katuli
WP020	35.388974212	-14.11588130	Mtalika	Mtalika	Matola	Mpita	Katuli
WP021	35.195235237	-14.06570251	Ng'ombe 2 Mosque	Ng'ombe 2	Kadango	Namavi	Namavi
WP022	35.191780552	-14.06646028	Mtondo	Ng'ombe 2	Kadango	Namavi	Namavi
WP023	35.190025046	-14.06581373	Lilembwe	Ng'ombe 2	Kadango	Namavi	Namavi
WP024	35.188573971	-14.06718780	Lilembwe School	Ng'ombe 2	Kadango	Namavi	Namavi
WP025	35.186380595	-14.06888220	Lupeta	Ng'ombe 2	Kadango	Namavi	Namavi
WP026	35.184875540	-14.06970728	Ng'ombe 2	Ng'ombe 2	Kadango	Namavi	Namavi
WP027	35.202777609	-14.09894706	Chilawi 2	Chilawi	Kadango	Namavi	Namavi
WP028	35.202594548	-14.10528304	Chilawi Nseu	Chilawi	Kadango	Namavi	Namavi
WP029	35.198579952	-14.10372451	Chikwewo	Chilawi	Kadango	Namavi	Namavi
WP030	35.196180716	-14.10451109	Tambala	Chilawi	Kadango	Namavi	Namavi
WP031	35.193851888	-14.10491495	Usipa	Chilawi	Kadango	Namavi	Namavi
WP032	35.191698410	-14.10668646	Chitola	Chilawi	Kadango	Namavi	Namavi
WP033	35.189380981	-14.10599255	Chilawi Mzikiti	Chilawi	Kadango	Namavi	Namavi
WP034	35.188524351	-14.10564332	Chitola 2	Chilawi	Kadango	Namavi	Namavi
WP035	35.199877471	-14.11085732	Maugula	Chilawi	Kadango	Namavi	Namavi
WP036	35.201790556	-14.10987241	Mateule	Chilawi	Kadango	Namavi	Namavi
WP037	35.242468603	-14.23001164	Chilonga Centre	Chilonga	Chapola	Namavi	Namavi
WP038	35.232833438	-14.23457899	Kapangula	Chilonga	Chapola	Namavi	Namavi

WP039	35.273376033	-14.21560606	Kwilasya Kuphiri	Kwilasya	Chapola	Namavi	Namavi
WP040	35.271359347	-14.21889708	Usi	Kwilasya	Chapola	Namavi	Namavi
WP041	35.269322880	-14.22325828	Mwamadi	Kwilasya	Chapola	Namavi	Namavi
WP042	34.952747114	-14.37708568	Pamboni	Anafi	Kaiche Anafi	Malembo	Nankumba
WP043	34.949946888	-14.37816718	Kaiche Mzikiti	Anafi	Kaiche Anafi	Malembo	Nankumba
WP044	34.947255962	-14.36900900	Gotapiri	Anafi	Kaiche Anafi	Malembo	Nankumba
WP045	34.940074012	-14.36464998	Zonda	Anafi	Kaiche Anafi	Malembo	Nankumba
WP046	34.936103672	-14.35448206	Ntongola	Mchisa	Kaiche Anafi	Malembo	Nankumba
WP047	34.946337305	-14.38024540	Chimvuwu	Anafi	Kaiche Anafi	Malembo	Nankumba
WP048	34.936771877	-14.39130879	Kandaya	Anafi	Kaiche Anafi	Malembo	Nankumba
WP049	34.927087761	-14.40068136	Mpandamoyo	Anafi	Kaiche Anafi	Malembo	Nankumba
WP050	34.821456000	-14.18225958	Domwe	Domwe	Kholowere	Malembo	Nankumba
WP051	34.824302495	-14.17272122	Kholowere Centre	Kholowere	Kholowere	Malembo	Nankumba
WP052	34.824433923	-14.17186368	Kholowere pa trading	Kholowere	Kholowere	Malembo	Nankumba
WP053	34.822904393	-14.17598491	Nkhunda	Kholowere	Kholowere	Malembo	Nankumba
WP054	34.931306541	-14.13839406	Galankhanga	Balamanja	Balamanja	Mbwadzulu	Nankumba
WP055	34.927200414	-14.13931057	Mulopa	Balamanja	Balamanja	Mbwadzulu	Nankumba
WP056	34.925559908	-14.14210137	Balamanja Mosque	Balamanja	Balamanja	Mbwadzulu	Nankumba
WP057	34.931232780	-14.13782217	Mfula	Balamanja	Balamanja	Mbwadzulu	Nankumba
WP058	34.933080487	-14.14387291	Kachere	Mankhambira	Balamanja	Mbwadzulu	Nankumba
WP059	34.932391159	-14.14173497	Chilongozi	Mankhambira	Balamanja	Mbwadzulu	Nankumba

WP060	34.861303568	-14.11970733	Kasankha Mosque	Kasankha	Kasankha	Mbwadzulu	Nankumba
WP061	34.859581590	-14.12160456	Pamfumu	Kasankha	Kasankha	Mbwadzulu	Nankumba
WP062	34.858213328	-14.12212804	Kamphata	Kasankha	Kasankha	Mbwadzulu	Nankumba
WP063	34.856752530	-14.12244635	Kasankha	Kasankha	Kasankha	Mbwadzulu	Nankumba
WP064	34.861545973	-14.12105929	Six	Kasankha	Kasankha	Mbwadzulu	Nankumba
WP065	34.845117442	-14.13745348	Chanza	Mwenda	Kasankha	Mbwadzulu	Nankumba
WP066	34.848555364	-14.13935153	Mwenda Kuseli	Mwenda	Kasankha	Mbwadzulu	Nankumba
WP067	34.807017669	-14.48549070	Binali Center	Binali	Binali	Mvumba	Nankumba
WP068	34.811395369	-14.48651909	Binali Market	Binali	Binali	Mvumba	Nankumba
WP069	34.808654152	-14.49406759	Thwethwe	Kanyama	Binali	Mvumba	Nankumba
WP070	34.862853549	-14.53219896	Waye	Chilimba	Makunula	Mvumba	Nankumba
WP071	34.883105569	-14.53000499	Masubi Trust	Chilimba	Makunula	Mvumba	Nankumba
WP072	34.858205952	-14.51988586	Chikopa	Makunula	Makunula	Mvumba	Nankumba
WP073	34.844742604	-14.50951827	Makunula Primary School	Makunula	Makunula	Mvumba	Nankumba
WP074	34.851868562	-14.51872974	Makunula centre	Makunula	Makunula	Mvumba	Nankumba
WP075	34.912036881	-14.21628370	Manzy	Chigonere	Chigonere	Nkope	Nankumba
WP076	34.914829731	-14.21815217	Kasupe	Chigonere	Chigonere	Nkope	Nankumba
WP077	34.918734357	-14.23369569	Chibwerera	Chigonere	Chigonere	Nkope	Nankumba
WP078	34.933107644	-14.22986020	Mchenga Trust	Ng'ombe	Chigonere	Nkope	Nankumba
WP079	34.934534915	-14.22440259	Mteterezi	Ng'ombe	Chigonere	Nkope	Nankumba

WP080	34.985167310	-14.31770288	Kambuzi	Kwipulumbu	Maudzu	Nkope	Nankumba
WP081	34.979796521	-14.32139751	John	Kwipulumbu	Maudzu	Nkope	Nankumba
WP082	35.103556663	-14.29029648	Maudzu	Maudzu	Maudzu	Nkope	Nankumba

Water point ID	Type of Source	Potential source of contamination with 50m (W)	Potential source of contamination with 50m (D)	Distance from potential contamination source(m) (W)	Distance from potential contamination source(m) (D)	pH (W)	pH (D)	TDS (ppm) (W)
WP001	Borehole	None				6.9		194
WP002	Borehole	None	None	NA	NA	7.2	6.6	228
WP003	Borehole	Pit latrine	Pit latrine	48	48	7.1	6.9	385
WP004	Borehole	Pit latrine	Pit latrine	28	28	6.8	6.9	440
WP005	Borehole	Pit latrine	Pit latine	45	45	7.0		320
WP006	Borehole	Pit latrine	Pit latrine	29	29	7.1	6.8	526
WP007	Borehole	None	None	NA	NA	6.9	6.7	333
WP008	Borehole	Pit latrine	Pit latrine	19	19	5.8	5.5	36
WP009	Borehole	None	None	NA	NA	6.5	6.1	54
WP010	Borehole	Pit latrine	Pit latrine	38	38	5.9	5.5	47
WP011	Borehole (vonder)	Pit latrine	Pit latrine	23	23	5.7	5.6	37
WP012	Borehole	Pit latrine	Pit latrine	29	29	6.1	5.9	75
WP013	Borehole	Pit latrine	Pit latrine	23	23	6.0	6.1	47

WP014	Borehole	Pit latrine	Pit latrine	27	27	6.2	6.2	82
WP015	Borehole	Pit latrine	Pit latrine	37	37	6.6	6.5	138
WP016	Borehole	Pit latrine	Pit latrine	24	24	6.3	6.2	52
WP017	Borehole	None	None	NA	NA	6.1	6.5	145
WP018	Borehole	Pit latrine	Pit latrine	27	27	6.1	6.4	126
WP019	Borehole	Pit latrine	Pit latrine	27	27	6.4	6.6	167
WP020	Borehole	None	None	NA	NA	6.2	6.5	73
WP021	Borehole	Pit latrine	Pit latrine	30	30	7.0	6.7	456
WP022	Borehole	None	Pit latrine	NA	NA	7.1	6.9	409
WP023	Borehole (vonder)	None	None	NA	NA	6.7	6.3	156
WP024	Borehole	None	Pit latrine	NA	NA	7.1	6.9	353
WP025	Borehole	Pit latrine	Pit latrine	32	32	7.1	7.0	287
WP026	Borehole (vonder)	Pit latrine	Pit latrine	32	32	6.8	6.6	137
WP027	Borehole (vonder)	Pit latrine	Pit latrine	48	48	7.2	7.0	427
WP028	Borehole	Pit latrine	Pit latrine	39	39	7.0	6.7	342
WP029	Borehole	Pit latrine	Pit latrine	12	12	6.8	6.6	320
WP030	Borehole (vonder)	Pit latrine	Pit latrine	26	26	6.7	6.6	305
WP031	Borehole	Pit latrine	Pit latrine	28	28	6.9	6.9	288
WP032	Borehole	Pit latrine	Pit latrine	35	35	6.7	6.6	411
WP033	Borehole (vonder)	Pit latrine	Pit latrine	21	21	7.0	6.8	325
WP034	Borehole	Pit latrine	Pit latrine	20	20	6.9	6.8	300

WP035	Borehole (vonder)	Pit latrine	Pit latrine	35	35	7.0	6.8	311
WP036	Borehole	Pit latrine	Pit latrine	17	17	7.2	6.8	373
WP037	Borehole	Pit latrine	Pit latrine	42	42	7.1	6.9	678
WP038	Borehole	Pit latrine	Pit latrine	49	49	7.3	7.2	458
WP039	Borehole	Pit latrine	Pit latrine	30	30	6.9	6.9	576
WP040	Borehole	Pit latrine	Pit latrine	27	27	7.1	7.0	558
WP041	Borehole	Pit latrine	Pit latrine	29	29	7.2	7.0	530
WP042	Borehole	Pit latrine	Pit latrine	26	26	7.2	7.0	894
WP043	Borehole	Pit latrine	Pit latrine	24	24	7.5	7.3	421
WP044	Borehole	None	None	NA	NA	7.3	7.0	524
WP045	Borehole	None	None	NA	NA	7.1	7.0	618
WP046	Borehole	None	None	NA	NA	7.1	6.8	839
WP047	Borehole	Pit latrine	Pit latrine	33	33	7.0	6.8	672
WP048	Borehole	None	None	NA	NA	7.1	6.8	522
WP049	Borehole	None	None	NA	NA	6.6	6.5	257
WP050	Borehole	None	None	NA	NA	7.1	6.9	455
WP051	Borehole	None	None	NA	NA	7.2	7.1	671
WP052	Borehole	Pit latrine	Pit latrine	43	43	7.4	7.2	491
WP053	Borehole	None	None	NA	NA	7.6	7.4	638
WP054	Borehole	Pit latrine	Pit latrine	24	24	7.3	7.2	563
WP055	Borehole	Pit latrine	Pit latrine	22	22	7.2	7.0	610

WP056	Borehole	Pit latrine	Pit latrine	26	26	7.2	7.0	686
WP057	Borehole	Pit latrine	Pit latrine	24	24	7.2	7.1	585
WP058	Borehole	Pit latrine	Pit latrine	25	25	7.7	7.7	1193
WP059	Borehole	Pit latrine	Pit latrine	20	20	7.3	7.2	727
WP060	Borehole	Pit latrine	Pit latrine	14	14	7.3	7.2	445
WP061	Borehole	Pit latrine	Pit latrine	22	22	7.1	7.1	540
WP062	Borehole	Pit latrine	Pit latrine	17	17	7.2	7.2	387
WP063	Borehole	Pit latrine	Pit latrine	25	25	7.2	7.0	665
WP064	Borehole	Pit latrine	Pit latrine	14	14	7.1	7.1	729
WP065	Borehole	None	None	NA	NA	7.1	7.1	581
WP066	Borehole	None	None	NA	NA	7.2	7.2	642
WP067	Borehole	Pit latrine	Pit latrine	44	44	7.1	6.9	403
WP068	Borehole	Pit latrine	Pit latrine	21	21	7.2	6.8	434
WP069	Borehole	None	Pit latrine	NA	NA	7.0	6.8	758
WP070	Borehole	Pit latrine	Pit latrine	26	26	7.0	6.7	535
WP071	Borehole	None	None	NA	NA	6.9	6.8	509
WP072	Borehole	None	None	NA	NA	7.2	6.8	841
WP073	Borehole	None	None	NA	NA	7.2	7.0	574
WP074	Borehole	None	None	NA	NA	7.0	6.8	901
WP075	Borehole	None	None	NA	NA	7.2	7.1	1098
WP076	Borehole	None	None	NA	NA	7.2	7.0	684

WP077	Borehole	None	None	NA	NA	6.9	6.8	377
WP078	Borehole	None	None	NA	NA	7.1	6.9	985
WP079	Borehole	None	None	NA	NA	7.0	6.9	1066
WP080	Borehole	None	None	NA	NA	7.1	7.0	421
WP081	Borehole	None	None	NA	NA	7.3	7.1	2477
WP082	Borehole	Pit latrine	Pit latrine	27	27	7.2	7.0	984

Water point ID	**TDS (ppm) (D)**	**EC (µS/cm) (W)**	**EC (µS/cm) (D)**	**Turbidity (NTU) (W)**	**Turbidity (NTU) (D)**	**Faecal Streptococci (counts/100 ml) (W)**	**Faecal Streptococci (counts/100 ml) (D)**	**Faecal Coliforms(counts/100 ml) (W)**	**Faecal Coliforms(counts/100 ml) (D)**
WP001		329		<0.01		4		0	
WP002	271	381	453	4.00	<0.01	0	0	0	0
WP003	510	641	866	<0.01	<0.01	0	2	0	0
WP004	424	725	707	2.00	<0.01	0	0	0	0
WP005		533		<0.01		101		0	
WP006	526	881	882	<0.01	<0.01	0	0	0	0
WP007	417	551	695	<0.01	<0.01	0	0	0	0
WP008	14	61	24	3.00	0.90	273	61	14	12
WP009	31	91	53	<0.01	<0.01	28	7	12	16
WP010	37	79	62	165.00	42.00	25	18	21	14

WP011	20	62	34	7.00	<0.01	31	99	0	73
WP012	47	125	80	<0.01	3.40	31	9	0	0
WP013	41	80	71	43.00	<0.01	0	0	0	0
WP014	64	137	107	<0.01	20.70	12	3	0	0
WP015	102	230	171	8.00	<0.01	0	0	0	0
WP016	43	89	72	7.00	<0.01	35	6	7	0
WP017	157	241	262	<0.01	<0.01	24	12	0	11
WP018	99	210	170	<0.01	<0.01	0	0	0	19
WP019	128	285	214	<0.01	<0.01	280	33	0	0
WP020	86	122	131	<0.01	<0.01	21	6	3	0
WP021	434	770	723	<0.01	<0.01	0	1	0	0
WP022	400	680	707	<0.01	<0.01	0	0	0	0
WP023	132	260	238	<0.01	<0.01	0	0	0	4
WP024	342	590	572	<0.01	<0.01	0	0	0	17
WP025	295	480	492	<0.01	<0.01	0	0	0	0
WP026	149	230	253	155.00	4.20	59	16	77	36
WP027	427	711	764	<0.01	<0.01	0	0	0	2
WP028	307	570	512	<0.01	<0.01	0	0	0	0
WP029	344	531	577	<0.01	<0.01	0	1	0	1
WP030	290	510	484	<0.01	<0.01	36	25	0	2
WP031	302	480	521	4.00	<0.01	0	0	0	0

WP032	421	680	703	<0.01	<0.01	43	11	0	0
WP033	348	540	593	2.00	<0.01	0	0	0	0
WP034	312	499	520	<0.01	<0.01	0	1	0	0
WP035	305	518	512	<0.01	<0.01	0	0	0	4
WP036	350	620	595	<0.01	<0.01	20	9	0	0
WP037	599	1130	1034	<0.01	<0.01	0	0	0	0
WP038	504	760	840	<0.01	<0.01	0	20	0	0
WP039	596	960	1012	<0.01	<0.01	0	3	0	0
WP040	575	930	958	<0.01	<0.01	0	1	0	0
WP041	533	870	936	<0.01	2.40	0	1	0	40
WP042	894	1490	1574	<0.01	2.90	0	2	32	31
WP043	404	702	722	<0.01	<0.01	0	0	72	10
WP044	545	861	942	<0.01	<0.01	0	2	0	0
WP045	573	1029	1024	<0.01	<0.01	0	0	4	0
WP046	750	1401	1253	2.00	<0.01	0	0	0	0
WP047	758	1111	1284	<0.01	<0.01	17	1	0	0
WP048	554	869	934	<0.01	<0.01	0	0	0	4
WP049	347	429	521	<0.01	<0.01	0	1	3	0
WP050	528	760	802	<0.01	0.88	0	6	0	113
WP051	693	1120	1162	<0.01	<0.01	21	0	0	0
WP052	541	821	901	<0.01	<0.01	0	0	3	0

WP053	677	1063	1130	<0.01	<0.01	0	0	49	10
WP054	555	930	940	<0.01	<0.01	0	0	0	0
WP055	633	1010	1092	<0.01	<0.01	8	114	4	0
WP056	674	1140	1110	2.00	<0.01	17	0	0	0
WP057	630	972	1052	7.00	<0.01	0	34	0	0
WP058	985	1990	1672	<0.01	<0.01	49	0	0	0
WP059	686	1210	1143	<0.01	<0.01	0	0	0	0
WP060	419	741	751	<0.01	<0.01	0	2	7	0
WP061	609	899	1022	<0.01	<0.01	0	0	128	98
WP062	354	642	634	<0.01	<0.01	0	0	28	12
WP063	869	1110	1424	<0.01	<0.01	0	0	0	0
WP064	691	1210	1212	7.00	<0.01	3	0	0	0
WP065	631	970	1133	<0.01	<0.01	0	3	4	0
WP066	648	1070	1103	<0.01	<0.01	0	0	0	0
WP067	418	671	734	<0.01	2.10	0	0	0	0
WP068	415	722	742	<0.01	0.90	4	0	0	0
WP069	845	1264	1515	<0.01	0.20	0	0	0	1
WP070	510	893	913	6.00	<0.01	69	16	8	0
WP071	502	848	836	<0.01	0.60	0	0	0	0
WP072	931	1388	1552	<0.01	<0.01	0	0	0	0
WP073	533	951	953	4.00	<0.01	0	0	9	0

WP074	841	1479	1508	<0.01	<0.01	0	0	8	0
WP075	1553	1830	2683	<0.01	<0.01	0	0	0	0
WP076	817	1141	1361	<0.01	0.60	33	4	0	4
WP077	336	618	561	4.00	<0.01	0	0	9	0
WP078	1122	1642	1840	<0.01	<0.01	0	0	0	0
WP079	1104	1752	1872	<0.01	<0.01	0	0	4	0
WP080	421	701	701	<0.01	0.40	0	0	0	1
WP081	2072	4122	3574	<0.01	0.20	0	0	0	0
WP082	1021	1644	1731	<0.01	<0.01	0	0	0	0

Water point ID	**E-coli (counts/100ml) (W)**	**E-coli (counts/100ml) (D)**	**Arsenic (mg/L) (W)**	**Arsenic (mg/L) (D)**	**Fluoride (mg/L) (W)**	**Fluoride (mg/L) (D)**
WP001	0		<0.001		2.8	
WP002	0	0	<0.001	<0.001	3.4	2.3
WP003	0	0	<0.001	<0.001	4.2	4.4
WP004	0	0	<0.001	<0.001	5.7	2.9
WP005	0		<0.001		2.1	
WP006	0	0	<0.001	<0.001	5.8	5.0
WP007	0	0	<0.001	<0.001	2.9	3.1

WP008	9	7	<0.001	<0.001	0.5	0.2
WP009	8	8	<0.001	<0.001	4.1	0.8
WP010	5	7	<0.001	<0.001	0.4	0.3
WP011	0	40	<0.001	<0.001	0.2	0.4
WP012	0	0	<0.001	<0.001	0.6	0.2
WP013	0	0	<0.001	<0.001	0.5	0.3
WP014	0	0	<0.001	<0.001	0.6	0.5
WP015	0	0	<0.001	<0.001	1.0	0.9
WP016	0	0	<0.001	<0.001	0.4	0.5
WP017	0	3	<0.001	<0.001	1.3	1.6
WP018	0	9	<0.001	<0.001	1.4	1.6
WP019	0	0	<0.001	<0.001	1.6	1.6
WP020	0	0	<0.001	<0.001	0.6	1.1
WP021	0	0	<0.001	<0.001	5.5	5.4
WP022	0	0	<0.001	<0.001	4.5	4.4
WP023	0	0	<0.001	<0.001	1.2	1.7
WP024	0	8	<0.001	<0.001	1.6	1.6
WP025	0	0	<0.001	<0.001	2.6	2.3
WP026	64	21	<0.001	<0.001	0.9	0.7
WP027	0	0	<0.001	<0.001	4.7	3.8
WP028	0	0	<0.001	<0.001	2.6	2.7

WP029	0	0	<0.001	<0.001	2.1	2.0
WP030	0	0	<0.001	<0.001	3.3	3.4
WP031	0	0	<0.001	<0.001	2.2	1.9
WP032	0	0	<0.001	<0.001	2.2	2.3
WP033	0	0	<0.001	<0.001	2.1	2.3
WP034	0	0	<0.001	<0.001	2.5	2.0
WP035	0	0	<0.001	<0.001	3.6	3.1
WP036	0	0	<0.001	<0.001	2.9	2.4
WP037	0	0	<0.001	<0.001	3.0	2.6
WP038	0	0	<0.001	<0.001	4.3	3.9
WP039	0	0	<0.001	<0.001	5.2	4.7
WP040	0	0	<0.001	<0.001	4.5	4.6
WP041	0	24	<0.001	<0.001	3.9	4.0
WP042	21	19	<0.001	<0.001	5.1	4.1
WP043	40	4	<0.001	<0.001	4.3	3.9
WP044	0	0	<0.001	<0.001	3.7	3.8
WP045	0	0	<0.001	<0.001	4.3	4.4
WP046	0	0	<0.001	<0.001	4.6	4.0
WP047	0	0	<0.001	<0.001	5.9	5.4
WP048	0	1	<0.001	<0.001	2.3	2.1
WP049	0	0	<0.001	<0.001	0.6	0.3

WP050	0	77	<0.001	<0.001	5.9	5.3
WP051	0	0	<0.001	<0.001	7.5	6.9
WP052	0	0	<0.001	<0.001	5.8	5.7
WP053	13	6	<0.001	<0.001	6.6	6.4
WP054	0	0	<0.001	<0.001	7.4	6.2
WP055	0	0	<0.001	<0.001	19.2	17.2
WP056	0	0	<0.001	<0.001	6.4	9.2
WP057	0	0	<0.001	<0.001	8.5	6.4
WP058	0	0	<0.001	<0.001	7.1	5.4
WP059	0	0	<0.001	<0.001	6.0	5.2
WP060	3	0	<0.001	<0.001	0.6	4.4
WP061	92	59	<0.001	<0.001	0.5	1.5
WP062	4	7	<0.001	<0.001	1.1	3.9
WP063	0	0	<0.001	<0.001	0.9	3.2
WP064	0	0	<0.001	<0.001	0.6	0.8
WP065	0	0	<0.001	<0.001	3.4	3.4
WP066	0	0	<0.001	<0.001	4.3	3.7
WP067	0	0	<0.001	<0.001	2.7	2.2
WP068	0	0	<0.001	<0.001	2.2	2.2
WP069	0	0	<0.001	<0.001	3.1	3.1
WP070	7	0	<0.001	<0.001	1.1	1.2

WP071	0	0	<0.001	<0.001	2.1	2.1
WP072	0	0	<0.001	<0.001	2.3	1.9
WP073	4	0	<0.001	<0.001	5.4	4.9
WP074	3	0	<0.001	<0.001	2.9	1.9
WP075	0	0	<0.001	<0.001	8.1	7.6
WP076	0	1	<0.001	<0.001	5.4	5.4
WP077	8	0	<0.001	<0.001	3.0	2.9
WP078	0	0	<0.001	<0.001	4.8	5.1
WP079	0	0	<0.001	<0.001	4.1	3.9
WP080	0	0	<0.001	<0.001	5.9	5.3
WP081	0	0	<0.001	<0.001	27.2	19.8
WP082	0	0	<0.001	<0.001	3.9	3.4

APPENDIX M: DETAILED HOUSEHOLD SURVEY RESULTS

Household Code	Village	GVH	ADC	TA	Age of respondent	Sex of respondent	Sex of Household Head_	Household size	Source of drinking water
HH001	Afiki	Afiki	Chilipa	Chilipa	18	F	F	7	Borehole
HH002	Afiki	Afiki	Chilipa	Chilipa	24	F	M	3	Borehole
HH003	Afiki	Afiki	Chilipa	Chilipa	34	F	M	8	Borehole
HH004	Afiki	Afiki	Chilipa	Chilipa	23	F	M	13	Borehole
HH005	Afiki	Afiki	Chilipa	Chilipa	40	F	M	4	Borehole
HH006	Afiki	Afiki	Chilipa	Chilipa	27	F	M	6	Borehole
HH007	Afiki	Afiki	Chilipa	Chilipa	26	F	M	8	Borehole
HH008	Afiki	Afiki	Chilipa	Chilipa	27	F	F	7	Borehole
HH009	Afiki	Afiki	Chilipa	Chilipa	32	F	M	6	Borehole
HH010	Afiki	Afiki	Chilipa	Chilipa	24	F	M	4	Borehole
HH011	Gwaza	Afiki	Chilipa	Chilipa	50	F	M	6	Unprotected dug well
HH012	Gwaza	Afiki	Chilipa	Chilipa	29	M	M	4	Unprotected dug well
HH013	Gwaza	Afiki	Chilipa	Chilipa	88	M	M	2	Surface water
HH014	Gwaza	Afiki	Chilipa	Chilipa	41	M	M	8	Surface water
HH015	Gwaza	Afiki	Chilipa	Chilipa	31	F	M	3	Surface water

HH016	Gwaza	Afiki	Chilipa	Chilipa	26	F	M	7	Surface water
HH017	Gwaza	Afiki	Chilipa	Chilipa	50	F	M	13	Surface water
HH018	Gwaza	Afiki	Chilipa	Chilipa	37	M	M	6	Surface water
HH019	Gwaza	Afiki	Chilipa	Chilipa	24	F	M	3	Unprotected dug well
HH020	Gwaza	Afiki	Chilipa	Chilipa	31	F	M	8	Borehole
HH021	Kapire	Kapire	Chilipa	Chilipa	20	M	M	6	Borehole
HH022	Kapire	Kapire	Chilipa	Chilipa	37	F	M	5	Borehole
HH023	Kapire	Kapire	Chilipa	Chilipa	28	F	M	5	Borehole
HH024	Kapire	Kapire	Chilipa	Chilipa	25	F	M	5	Borehole
HH025	Kapire	Kapire	Chilipa	Chilipa	18	F	M	4	Borehole
HH026	Kapire	Kapire	Chilipa	Chilipa	30	F	M	8	Borehole
HH027	Kapire	Kapire	Chilipa	Chilipa	26	F	M	6	Borehole
HH028	Kapire	Kapire	Chilipa	Chilipa	32	F	M	7	Borehole
HH029	Kapire	Kapire	Chilipa	Chilipa	49	F	M	11	Borehole
HH030	Kapire	Kapire	Chilipa	Chilipa	18	F	M	10	Borehole
HH031	Nkaombe	Kapire	Chilipa	Chilipa	55	F	M	8	Borehole
HH032	Nkaombe	Kapire	Chilipa	Chilipa	24	F	M	5	Borehole
HH033	Nkaombe	Kapire	Chilipa	Chilipa	42	F	M	8	Borehole
HH034	Nkaombe	Kapire	Chilipa	Chilipa	31	F	M	5	Borehole
HH035	Nkaombe	Kapire	Chilipa	Chilipa	69	F	F	7	Borehole

HH036	Nkaombe	Kapire	Chilipa	Chilipa	23	F	M	3	Borehole
HH037	Nkaombe	Kapire	Chilipa	Chilipa	41	F	F	9	Borehole
HH038	Nkaombe	Kapire	Chilipa	Chilipa	20	F	M	8	Borehole
HH039	Nkaombe	Kapire	Chilipa	Chilipa	40	F	M	7	Borehole
HH040	Chilungo	Maundu	Katuli	Katuli	37	F	M	9	Borehole
HH041	Chilungo	Maundu	Katuli	Katuli	21	F	F	3	Borehole
HH042	Chilungo	Maundu	Katuli	Katuli	20	F	M	5	Borehole
HH043	Chilungo	Maundu	Katuli	Katuli	32	F	M	4	Borehole
HH044	Chilungo	Maundu	katuli	Katuli	40	F	M	4	Borehole
HH045	Chilungo	Maundu	Katuli	Katuli	46	F	F	7	Borehole
HH046	Chilungo	Maundu	Katuli	Katuli	30	F	M	6	Borehole
HH047	Chilungo	Maundu	Katuli	Katuli	36	F	M	3	Protected dug well
HH048	Chilungo	Maundu	Katuli	Katuli	32	F	M	5	Protected dug well
HH049	Inaki	Chiwaula	Katuli	Katuli	18	M	M	3	Borehole
HH050	Inaki	Chiwaula	Katuli	Katuli	66	F	F	6	Borehole
HH051	Inaki	Chiwaula	Katuli	Katuli	75	F	F	3	Borehole
HH052	Inaki	Chiwaula	Katuli	Katuli	19	F	F	6	Borehole
HH053	Inaki	Chiwaula	Katuli	Katuli	40	F	M	6	Borehole
HH054	Inaki	Chiwaula	Katuli	Katuli	30	F	M	2	Borehole

HH055	Inaki	Chiwaula	Katuli	Katuli	42	M	M	8	Borehole
HH056	Inaki	Chiwaula	Katuli	Katuli	36	F	F	3	Borehole
HH057	Inaki	Chiwaula	Katuli	Katuli	23	F	F	2	Borehole
HH058	Chikoja	Makande	Katuli	Katuli	56	M	M	10	Borehole
HH059	Chikoja	Makande	Katuli	Katuli	24	F	F	6	Borehole
HH060	Chikoja	Makande	Katuli	Katuli	42	F	M	9	Borehole
HH061	Chikoja	Makande	Katuli	Katuli	46	F	M	8	Borehole
HH062	Chikoja	Makande	Katuli	Katuli	57	F	M	7	Unprotected dug well
HH063	Chikoja	Makande	Katuli	Katuli	65	F	M	3	Unprotected dug well
HH064	Chikoja	Makande	Katuli	Katuli	60	F	M	5	unprotected dug well
HH065	Chikoja	Makande	Katuli	Katuli	76	F	F	1	unprotected dug well
HH066	Mizinga	Makande	Katuli	Katuli	36	M	M	6	Borehole
HH067	Mizinga	Makande	Katuli	Katuli	67	M	M	5	Borehole
HH068	Mizinga	Makande	Katuli	Katuli	30	F	F	7	Borehole
HH069	Mizinga	Makande	Katuli	Katuli	67	F	M	5	Borehole
HH070	Mizinga	Makande	Katuli	Katuli	36	F	M	10	Borehole
HH071	Mizinga	Makande	Katuli	Katuli	68	M	M	2	Borehole

HH072	Mizinga	Makande	Katuli	Katuli	65	M	M	5	Borehole
HH073	Mizinga	Makande	Katuli	Katuli	53	F	M	4	Borehole
HH074	Mizinga	Makande	Katuli	Katuli	80	F	F	3	Borehole
HH075	Chisuse	Chisuse	Mpita	Katuli	71	M	M	4	Borehole
HH076	Chisuse	Chisuse	Mpita	Katuli	32	F	M	5	Borehole
HH077	Chisuse	Chisuse	Mpita	Katuli	29	F	M	5	Borehole
HH078	Chisuse	Chisuse	Mpita	Katuli	19	F	M	3	Borehole
HH079	Chisuse	Chisuse	Mpita	Katuli	24	M	M	5	Borehole
HH080	Chisuse	Chisuse	Mpita	Katuli	55	F	M	4	Borehole
HH081	Chisuse	Chisuse	Mpita	Katuli	40	F	F	4	Borehole
HH082	Chisuse	Chisuse	Mpita	Katuli	24	F	M	2	Borehole
HH083	Chisuse	Chisuse	Mpita	Katuli	35	M	M	3	Borehole
HH084	Mkumula	Chisuse	Mpita	Katuli	34	F	M	7	Unprotected dug well
HH085	Mkumula	Chisuse	Mpita	Katuli	46	F	F	6	Unprotected dug well
HH086	Mkumula	Chisuse	Mpita	Katuli	33	F	M	5	Borehole
HH087	Mkumula	Chisuse	Mpita	Katuli	69	F	M	3	Unprotected dug well
HH088	Mkumula	Chisuse	Mpita	Katuli	20	F	M	4	Borehole

HH089	Mkumula	Chisuse	Mpita	Katuli	21	F	M	3	Unprotected dug well
HH090	Mkumula	Chisuse	Mpita	Katuli	42	M	M	8	Borehole
HH091	Mkumula	Chisuse	Mpita	Katuli	21	M	M	6	Borehole
HH092	Mkumula	Chisuse	Mpita	Katuli	19	F	M	5	Borehole
HH093	Matola	Matola	Mpita	Katuli	42	F	M	5	Borehole
HH094	Matola	Matola	Mpita	Katuli	18	F	M	2	Borehole
HH095	Matola	Matola	Mpita	Katuli	66	F	F	5	Borehole
HH096	Matola	Matola	Mpita	Katuli	39	F	M	6	Borehole
HH097	Matola	Matola	Mpita	Katuli	23	F	M	6	Unprotected spring
HH098	Matola	Matola	Mpita	Katuli	43	F	M	4	Borehole
HH099	Matola	Matola	Mpita	Katuli	20	M	M	3	Borehole
HH100	Matola	Matola	Mpita	Katuli	20	M	M	3	Borehole
HH101	Matola	Matola	Mpita	Katuli	34	F	M	7	Borehole
HH102	Mponda	Matola	Mpita	Katuli	27	F	M	3	Borehole
HH103	Mponda	Matola	Mpita	Katuli	20	F	M	5	Borehole
HH104	Mponda	Matola	Mpita	Katuli	38	M	M	7	Borehole
HH105	Mponda	Matola	Mpita	Katuli	26	M	M	4	Borehole
HH106	Mponda	Matola	Mpita	Katuli	51	M	M	3	Borehole

HH107	Mponda	Matola	Katuli	Katuli	43	F	M	8	Unprotected dug well
HH108	Mponda	Matola	Mpita	Katuli	25	F	M	5	Unprotected dug well
HH109	Mponda	Matola	Mpita	Katuli	49	F	M	5	Borehole
HH110	Mponda	Matola	Mpita	Katuli	36	F	M	7	Borehole
HH111	Chilonga	Chapola	Namabvi	Namabvi	25	F	F	7	Borehole
HH112	Chilonga	Chapola	Namabvi	Namabvi	59	F	F	8	Borehole
HH113	Chilonga	Chapola	Namabvi	Namabvi	25	F	M	4	Borehole
HH114	Chilonga	Chapola	Namabvi	Namabvi	50	F	F	6	Borehole
HH115	Chilonga	Chapola	Namabvi	Namabvi	29	F	M	4	Borehole
HH116	Chilonga	Chapola	Namabvi	Namabvi	38	F	M	6	Borehole
HH117	Chilonga	Ng'ombe	Namabvi	Namabvi	26	M	M	4	Borehole
HH118	Chilonga	Ng'ombe	Namabvi	Namabvi	33	M	M	4	Borehole
HH119	Kwilasya	Chapola	Namabvi	Namabvi	52	F	M	4	Borehole
HH120	Kwilasya	Chapola	Namabvi	Namabvi	35	F	M	2	Borehole
HH121	Kwilasya	Chapola	Namabvi	Namabvi	26	F	M	7	Borehole
HH122	Kwilasya	Chapola	Namabvi	Namabvi	37	F	M	7	Borehole
HH123	Kwilasya	Chapola	Namabvi	Namabvi	47	F	F	7	Borehole
HH124	Kwilasya	Chapola	Namabvi	Namabvi	27	F	F	5	Borehole
HH125	Kwilasya	Chapola	Namabvi	Namabvi	45	F	M	6	Borehole

HH126	Kwilasya	Chapola	Namabvi	Namabvi	28	F	M	5	Borehole
HH127	Chilawi	Kadango	Namabvi	Namabvi	63	F	M	7	Borehole
HH128	Chilawi	Kadango	Namabvi	Namabvi	50	F	F	7	Borehole
HH129	Chilawi	Kadango	Namabvi	Namabvi	45	F	F	5	Borehole
HH130	Chilawi	Kadango	Namabvi	Namabvi	33	F	F	8	Borehole
HH131	Chilawi	Kadango	Namabvi	Namabvi	47	F	M	7	Borehole
HH132	Chilawi	Kadango	Namabvi	Namabvi	35	F	M	5	Borehole
HH133	Chilawi	Kadango	Namabvi	Namabvi	18	F	M	3	Borehole
HH134	Chilawi	Kadango	Namabvi	Namabvi	53	F	M	8	Borehole
HH135	Ng'ombe 2	Kadango	Namabvi	Namabvi	31	F	M	4	Borehole
HH136	Ng'ombe 2	Kadango	Namabvi	Namabvi	35	F	M	8	Borehole
HH137	Ng'ombe 2	Kadango	Namabvi	Namabvi	22	F	M	4	Borehole
HH138	Ng'ombe 2	Kadango	Namabvi	Namabvi	42	F	M	7	Borehole
HH139	Ng'ombe 2	Kadango	Namabvi	Namabvi	46	F	M	9	Borehole
HH140	Ng'ombe 2	Kadango	Namabvi	Namabvi	60	F	F	4	Borehole
HH141	Ng'ombe 2	Kadango	Namabvi	Namabvi	65	F	F	2	Borehole
HH142	Ng'ombe 2	Kadango	Namabvi	Namabvi	70	M	M	5	Borehole
HH143	Kaiche Anafi	Anafi	Malembo	Nankumba	43	F	M	5	Borehole
HH144	Kaiche Anafi	Anafi	Malembo	Nankumba	54	F	M	6	Borehole
HH145	Kaiche Anafi	Anafi	Malembo	Nankumba	30	F	M	5	Borehole
HH146	Kaiche Anafi	Anafi	Malembo	Nankumba	56	F	M	8	Borehole

HH147	Kaiche Anafi	Anafi	Malembo	Nankumba	40	F	M	8	Borehole
HH148	Kaiche Anafi	Anafi	Malembo	Nankumba	35	F	M	6	Borehole
HH149	Kaiche Anafi	Anafi	Malembo	Nankumba	30	F	M	8	Borehole
HH150	Kaiche Anafi	Anafi	Malembo	Nankumba	29	M	M	4	Borehole
HH151	Kaiche Anafi	Anafi	Malembo	Nankumba	37	F	M	7	Borehole
HH152	Kaiche Anafi	Anafi	Malembo	Nankumba	35	M	M	5	Borehole
HH153	Kunchisa	Anafi	Malembo	Nankumba	42	M	M	10	Borehole
HH154	Kunchisa	Anafi	Malembo	Nankumba	55	M	M	10	Borehole
HH155	Kunchisa	Anafi	Malembo	Nankumba	25	F	M	6	Borehole
HH156	Kunchisa	Anafi	Malembo	Nankumba	24	F	F	6	Unprotected dug well
HH157	Kunchisa	Anafi	Malembo	Nankumba	61	M	M	8	Borehore
HH158	Kunchisa	Anafi	Malembo	Nankumba	25	F	M	4	Borehole
HH159	Kunchisa	Anafi	Malembo	Nankumba	30	F	F	2	Borehole
HH160	Kunchisa	Anafi	Malembo	Nankumba	27	F	F	4	Borehole
HH161	Kunchisa	Anafi	Malambo	Nankumba	33	F	M	4	Borehole
HH162	Domwe	Kholowele	Malembo	Nankumba	40	M	M	8	Borehole
HH163	Domwe	Kholowele	Malembo	Nankumba	43	F	M	8	Borehole
HH164	Domwe	Kholowele	Malembo	Nankumba	35	F	M	12	Borehole
HH165	Domwe	Kholowele	Malembo	Nankumba	41	M	M	8	Borehole
HH166	Domwe	Kholowere	Malembo	Nankumba	21	F	M	3	Borehole

HH167	Domwe	Kholowere	Malembo	Nankumba	35	F	M	7	Borehole
HH168	Domwe	Kholowere	Malembo	Nankumba	38	F	M	7	Borehole
HH169	Domwe	Kholowere	Malembo	Nankumba	28	F	M	6	Borehole
HH170	Domwe	Kholowere	Malembo	Nankumba	25	F	M	5	Borehole
HH171	Kholowele	Kholowere	Malembo	Nankumba	66	F	M	6	Borehole
HH172	Kholowele	Kholowele	Malembo	Nankumba	21	F	M	7	Surface Water
HH173	Kholowele	Kholowele	Malembo	Nankumba	42	F	M	7	Surface Water
HH174	Kholowele	Kholowele	Malembo	Nankumba	66	F	M	6	Borehole
HH175	Kholowere	Kholowere	Malembo	Nankumba	30	F	M	8	Borehole
HH176	Domwe	Kholowere	Malembo	Nankumba	25	F	M	4	Borehole
HH177	Kholowere	Kholowere	Malembo	Nankumba	33	F	M	8	Borehole
HH178	Kholowele	Kholowele	Malembo	Nankumba	20	F	M	7	Borehole
HH179	Kholowere	kholowere	Malembo	Nankumba	45	F	M	8	Borehole
HH180	Balamanja	Balamanja	Mbwadzulu	Nankumba	37	F	M	5	Borehole
HH181	Balamanja	Balamanja	Mbwadzulu	Nankumba	50	F	F	5	Borehole
HH182	Balamanja	Balamanja	Mbwadzulu	Nankumba	32	F	M	4	Borehole
HH183	Balamanja	Balamanja	Mbwadzulu	Nankumba	25	F	M	5	Borehole
HH184	Balamanja	Balamanja	Mbwadzulu	Nankumba	30	F	M	6	Borehole
HH185	Balamanja	Balamanja	Mbwadzulu	Nankumba	20	F	F	2	Borehole
HH186	Balamanja	Balamanja	Mbwadzulu	Nankumba	32	F	F	4	Protected dug well

HH187	Balamanja	Balamanja	Mbwadzulu	Nankumba	76	F	M	1	Protected dug well
HH188	Balamanja	Balamanja	Mbwadzulu	Nankumba	53	F	M	5	Borehole
HH189	Mankhambila	Balamanja	Mbwadzulu	Nankumba	20	F	M	4	Borehole
HH190	Mankhambila	Balamanja	Mbwadzulu	Nankumba	21	F	M	4	Protected dug well
HH191	Mankhambila	Balamanja	Mbwadzulu	Nankumba	24	F	M	2	Protected dug well
HH192	Mankhambila	Balamanja	Mbwadzulu	Nankumba	46	F	F	5	Protected dug well
HH193	Mankhambila	Balamanja	Mbwadzulu	Nankumba	30	F	M	5	Protected dug well
HH194	Mankhambila	Balamanja	Mbwadzulu	Nankumba	40	F	M	5	Borehole
HH195	Mankhambila	Balamanja	Mbwadzulu	Nankumba	26	F	F	4	Borehole
HH196	Mankhambila	Balamanja	Mbwadzulu	Nankumba	30	F	M	4	Borehole
HH197	Mankhambila	Balamanja	Mbwadzulu	Nankumba	27	F	M	6	Borehole
HH198	Kasankha	kasankha	Mbwadzulu	Nankumba	48	F	M	4	Borehole
HH199	Kasankha	Kasankha	Mbwadzulu	Nankumba	32	F	M	5	Borehole
HH200	Kasankha	Kasankha	Mbwadzulu	Nankumba	48	F	F	10	Borehole
HH201	Kasankha	Kasankha	Mbwadzulu	Nankumba	45	F	M	6	Borehole
HH202	Kasankha	Kasankha	Mbwadzulu	Nankumba	30	F	M	7	Borehole

HH203	Kasankha	Kasankha	Mbwadzulu	Nankumba	26	M	M	6	Borehole
HH204	Kasankha	Kasankha	Mbwadzulu	Nankumba	32	F	F	7	Borehole
HH205	Kasankha	Kasankha	Mbwadzulu	Nankumba	28	F	M	8	Borehole
HH206	Kasankha	Kasankha	Mbwadzulu	Nankumba	30	F	F	4	Borehole
HH207	Kasankha	Kasankha	Mbwadzulu	Nankumba	20	F	F	3	Borehole
HH208	Mwenda	Kasankha	Mbwadzulu	Nankumba	45	M	M	8	Borehole
HH209	Mwenda	Kasankha	Mbwadzulu	Nankumba	53	F	M	6	Borehole
HH210	Mwenda	Kasankha	Mbwadzulu	Nankumba	20	F	M	2	Borehole
HH211	Mwenda	Kasankha	Mbwadzulu	Nankumba	63	F	M	15	Borehole
HH212	Mwenda	Kasankha	Mbwadzulu	Nankumba	48	F	F	6	Borehole
HH213	Mwenda	Kasankha	Mbwadzulu	Nankumba	56	F	M	5	Borehole
HH214	Mwenda	Kasankha	Mbwadzulu	Nankumba	40	F	M	3	Borehole
HH215	Mwenda	Kasankha	Mbwadzulu	Nankumba	30	F	M	10	Borehole
HH216	Mwenda	Kasankha	Mbwadzulu	Nankumba	40	F	M	4	Borehole
HH217	Binali	Binali	Mvumba	Nankumba	26	M	M	4	Borehole
HH218	Binali	Binali	Mvumba	Nankumba	20	F	M	3	Borehole
HH219	Binali	Binali	Mvumba	Nankumba	25	F	M	7	Borehole
HH220	Binali	Binali	Mvumba	Nankumba	19	F	M	5	Borehole
HH221	Binali	Binali	Mvumba	Nankumba	46	F	F	4	Borehole
HH222	Binali	Binali	Mvumba	Nankumba	32	F	M	8	Borehole
HH223	Binali	Binali	Mvumba	Nankumba	29	F	M	5	Borehole

HH224	Binali	Binali	Mvumba	Nankumba	30	F	M	7	Borehole
HH225	Binali	Binali	Mvumba	Nankumba	30	F	M	4	Borehole
HH226	Kanyama	Binali	Mvumba	Nankumba	20	F	F	3	Borehole
HH227	Kanyama	Binali	Mvumba	Nankumba	26	F	M	4	Borehole
HH228	Kanyama	Binali	Mvumba	Nankumba	25	F	M	5	Borehole
HH229	Kanyama	Binali	Mvumba	Nankumba	19	F	M	3	Borehole
HH230	Kanyama	Binali	Mvumba	Nankumba	25	F	M	5	Borehole
HH231	Kanyama	Binali	Mvumba	Nankumba	71	F	M	4	Borehole
HH232	Kanyama	Binali	Mvumba	Nankumba	32	F	M	4	Borehole
HH233	Kanyama	Binali	Mvumba	Nankumba	29	F	M	5	Borehole
HH234	Kanyama	Binali	Mvumba	Nankumba	22	F	F	3	Borehole
HH235	Chilimba	Makunula	Mvumba	Nankumba	53	M	M	7	Borehole
HH236	Chilimba	Makunula	Mvumba	Nankumba	28	F	F	3	Borehole
HH237	Chilimba	Makunula	Mvumba	Nankumba	77	F	M	8	Borehole
HH238	Chilimba	Makunula	Mvumba	Nankumba	44	F	M	7	Borehole
HH239	Chilimba	Makunula	Mvumba	Nankumba	80	F	F	4	Borehole
HH240	Chilimba	Makunula	Mvumba	Nankumba	39	F	M	3	Borehole
HH241	Chilimba	Makunula	Mvumba	Nankumba	20	F	F	3	Borehole
HH242	Chilimba	Makunula	Mvumba	Nankumba	25	F	M	4	Borehole
HH243	Chilimba	Makunula	Mvumba	Nankumba	19	F	F	3	Borehole
HH244	Makunula	Makunula	Mvumba	Nankumba	79	F	M	6	Borehole

HH245	Makunula	Makunula	Mvumba	Nankumba	21	F	M	4	Borehole
HH246	Makunula	Makunula	Mvumba	Nankumba	42	F	F	5	Borehole
HH247	Makunula	Makunula	Mvumba	Nankumba	18	F	M	3	Borehole
HH248	Makunula	Makunula	Mvumba	Nankumba	57	F	M	9	Borehole
HH249	Makunula	Makunula	Mvumba	Nankumba	30	F	M	5	Borehole
HH250	Makunula	Makunula	Mvumba	Nankumba	32	F	M	7	Borehole
HH251	Makunula	Makunula	Mvumba	Nankumba	31	F	M	7	Borehole
HH252	Makunula	Makunula	Mvumba	Nankumba	20	F	M	3	Borehole
HH253	Chigonere	Chigonere	Nkope	Nankumba	49	F	M	5	Borehole
HH254	Chigonere	Chigonere	Nkope	Nankumba	49	F	M	2	Borehole
HH255	Chigonere	Chigonere	Nkope	Nankumba	25	M	F	7	Borehole
HH256	Chigonere	Chigonere	Nkope	Nankumba	20	M	M	4	Borehole
HH257	Chigonere	Chigonere	Nkope	Nankumba	30	F	M	5	Borehole
HH258	Chigonere	Chigonere	Nkope	Nankumba	46	M	M	7	Borehole
HH259	Chigonere	Chigonere	Nkope	Nankumba	30	M	M	6	Borehole
HH260	Chigonere	Chigonere	Nkope	Nankumba	44	M	F	8	Borehole
HH261	Chigonere	Chigonere	Nkope	Nankumba	23	F	M	6	Borehole
HH262	Ng'ombe	Chigonere	Nkope	Nankumba	25	F	M	5	Borehole
HH263	Ng'ombe	Chigonere	Nkope	Nankumba	29	F	M	5	Borehole
HH264	Ng'ombe	Chigonere	Nkope	Nankumba	19	F	M	3	Borehole
HH265	Ng'ombe	Chigonere	Nkope	Nankumba	47	F	F	6	Borehole

HH266	Ng'ombe	Chigonere	Nkope	Nankumba	26	F	M	6	Borehole
HH267	Ng'ombe	Chigonere	Nkope	Nankumba	54	F	M	5	Borehole
HH268	Ng'ombe	Chigonere	Nkope	Nankumba	44	F	M	5	Borehole
HH269	Ng'ombe	Chigonere	Nkope	Nankumba	20	F	M	7	Borehole
HH270	Ng'ombe	Chigonere	Nkope	Nankumba	60	F	M	6	Borehole
HH271	Kwiipulumbu	Maudzu	Nkope	Nankumba	48	F	M	8	Borehole
HH272	Kwiipulumbu	Maudzu	Nkope	Nankumba	45	F	M	6	Borehole
HH273	kwiipulumbu	Maudzu	Nkope	Nankumba	45	F	M	5	Borehole
HH274	Kwiipulumbu	Maudzu	Nkope	Nankumba	24	M	M	6	Borehole
HH275	Kwipulumbu	Maudzu	Nkope	Nankumba	30	F	M	7	Borehole
HH276	Kwipulumbu	Maudzu	Nkope	Nankumba	27	F	F	13	Borehole
HH277	Kwipulumbu	Maudzu	Nkope	Nankumba	32	F	M	7	Borehole
HH278	Kwiipulumbu	Maudzu	Nkope	Nankumba	58	M	M	11	Borehole
HH279	Kwipulumbu	Maudzu	Nkope	Nankumba	20	F	M	3	Borehole
HH280	Maudzu	Maudzu	Nkope	Nankumba	27	F	M	5	Borehole
HH281	Maudzu	Maudzu	Nkope	Nankumba	28	M	M	4	Borehole
HH282	Maudzu	Maudzu	Nkope	Nankumba	20	F	M	2	Borehole
HH283	Maudzu	Maudzu	Nkope	Nankumba	36	F	F	6	Borehole
HH284	Maudzu	Maudzu	Nkope	Nankumba	40	F	M	7	Borehole
HH285	Maudzu	Maudzu	Nkope	Nankumba	45	F	M	4	Borehole
HH286	Maudzu	Maudzu	Nkope	Nankumba	78	F	M	4	Borehole

HH287	Maudzu	Maudzu	Nkope	Nankumba	25	F	M	4	Surface water
HH288	Maudzu	Maudzu	Nkope	Nankumba	19	M	M	9	Tap

Household Code	**Category of Source**	**Why drinking from unimproved source**	**Locality of improved source**	**Physical challenges to water sources**	**Round trip time (min)**	**Daily HH water demand (20L pails)**	**Water source meets HH demand**
HH001	Improved		Elsewhere within the village	Yes (long distance)	>30	3	Yes
HH002	Improved		Elsewhere within the village	No	≤30	3	Yes
HH003	Improved		Elsewhere within the village	No	≤30	8	Yes
HH004	Improved		Elsewhere within the village	Yes (long distance)	>30	25	No
HH005	Improved		Elsewhere within the village	Yes (long distance)	>30	4	Yes
HH006	Improved		Elsewhere within the village	Yes (long distance)	>30	6	No

HH007	Improved		Elsewhere within the village	Yes (long distance)	>30	10	No
HH008	Improved		Elsewhere within the village	Yes (long distance)	>30	8	Yes
HH009	Improved		Elsewhere within the village	Yes (long distance)	>30	5	Yes
HH010	Improved		Elsewhere within the village	No	≤30	4	Yes
HH011	Unimproved	No improved source nearby				10	
HH012	Unimproved	No improved source nearby				3	
HH013	Unimproved	No improved source nearby				3	
HH014	Unimproved	No improved source nearby				4	
HH015	Unimproved	No improved source nearby				5	
HH016	Unimproved	No improved source nearby				6	
HH017	Unimproved	No improved source nearby				12	
HH018	Unimproved	No improved source nearby				5	
HH019	Unimproved	No improved source nearby				4	
HH020	Improved		In another village	No	>30	10	Yes
HH021	Improved		Elsewhere within the village	No	>30	7	Yes

HH022	Improved		Elsewhere within the village	No	>30	6	Yes
HH023	Improved		Elsewhere within the village	No	>30	5	Yes
HH024	Improved		Elsewhere within the village	No	≤30	6	Yes
HH025	Improved		Elsewhere within the village	No	>30	5	Yes
HH026	Improved		Elsewhere within the village	No	≤30	5	Yes
HH027	Improved		Elsewhere within the village	No	≤30	5	Yes
HH028	Improved		Elsewhere within the village	No	≤30	6	Yes
HH029	Improved		Elsewhere within the village	No	>30	10	Yes
HH030	Improved		Elsewhere within the village	No	>30	8	Yes
HH031	Improved		In another village	No	>30	10	Yes
HH032	Improved		In another village	No	>30	6	Yes
HH033	Improved		In another village	No	>30	10	Yes

HH034	Improved		In another village	No	>30	10	Yes
HH035	Improved		In another village	No	>30	6	Yes
HH036	Improved		In another village	Yes (long distance)	>30	5	Yes
HH037	Improved		In another village	No	>30	5	Yes
HH038	Improved		In another village	No	>30	7	Yes
HH039	Improved		Elsewhere within the village	No	>30	7	Yes
HH040	Improved		Elsewhere within the village	No	≤30	8	Yes
HH041	Improved		Elsewhere within the village	No	≤30	5	Yes
HH042	Improved		Elsewhere within the village	No	≤30	3	Yes
HH043	Improved		Elsewhere within the village	No	≤30	5	Yes
HH044	Improved		Elsewhere within the village	No	≤30	8	Yes
HH045	Improved		On premises	No	≤30	5	Yes
HH046	Improved		Elsewhere within the village	No	≤30	6	Yes

HH047	Improved		On premises	No	≤30	5	No
HH048	Improved		Elsewhere within the village	No	≤30	5	No
HH049	Improved		Elsewhere within the village	No	>30	3	No
HH050	Improved		Elsewhere within the village	No	>30	7	No
HH051	Improved		Elsewhere within the village	No	>30	3	No
HH052	Improved		Elsewhere within the village	No	>30	8	No
HH053	Improved		Elsewhere within the village	No	>30	10	No
HH054	Improved		Elsewhere within the village	No	>30	4	No
HH055	Improved		Elsewhere within the village	No	>30	6	No
HH056	Improved		Elsewhere within the village	No	>30	5	No
HH057	Improved		Elsewhere within the village	No	>30	3	No

HH058	Improved		Elsewhere within the village	No	≤30	10	Yes
HH059	Improved		Elsewhere within the village	No	≤30	6	Yes
HH060	Improved		Elsewhere within the village	No	≤30	14	Yes
HH061	Improved		Elsewhere within the village	No	≤30	15	Yes
HH062	Unimproved	No improved source nearby				7	
HH063	Unimproved	No improved source nearby				4	
HH064	Unimproved	No improved source nearby				4	
HH065	Unimproved	No improved source nearby				4	
HH066	Improved		Elsewhere within the village	No	>30	4	No
HH067	Improved		Elsewhere within the village	No	>30	5	No
HH068	Improved		Elsewhere within the village	No	>30	3	No
HH069	Improved		Elsewhere within the village	No	>30	5	No

HH070	Improved		Elsewhere within the village	No	>30	11	No
HH071	Improved		Elsewhere within the village	Yes (long distance)	>30	3	No
HH072	Improved		Elsewhere within the village	Yes (long distance)	>30	5	No
HH073	Improved		Elsewhere within the village	Yes (long distance)	>30	4	No
HH074	Improved		Elsewhere within the village	Yes (long distance)	>30	4	Yes
HH075	Improved		Elsewhere within the village	No	≤30	10	Yes
HH076	Improved		Elsewhere within the village	No	>30	10	No
HH077	Improved		Elsewhere within the village	No	>30	6	No
HH078	Improved		Elsewhere within the village	No	>30	7	No
HH079	Improved		Elsewhere within the village	No	>30	7	No

HH080	Improved		Elsewhere within the village	No	>30	5	No
HH081	Improved		Elsewhere within the village	No	>30	7	No
HH082	Improved		Elsewhere within the village	No	>30	4	No
HH083	Improved		Elsewhere within the village	No	>30	5	No
HH084	Unimproved	No improved source nearby				10	
HH085	Unimproved	No improved source nearby				6	
HH086	Improved		Elsewhere within the village	Yes (long distance)	>30	6	No
HH087	Unimproved	No improved source nearby			≤30	4	
HH088	Improved		On premises	No	≤30	5	Yes
HH089	Unimproved	No improved source nearby			≤30	2	
HH090	Improved		Elsewhere within the village	No	>30	7	No
HH091	Improved		Elsewhere within the village	No	≤30	5	Yes
HH092	Improved		Elsewhere within the village	No	≤30	7	Yes

HH093	Improved		Elsewhere within the village	No	≤30	7	Yes
HH094	Improved		Elsewhere within the village	No	≤30	4	Yes
HH095	Improved		Elsewhere within the village	No	≤30	6	Yes
HH096	Improved		Elsewhere within the village	No	≤30	4	Yes
HH097	Unimproved	No improved source nearby				6	
HH098	Improved		Elsewhere within the village	Yes (long distance)	>30	4	No
HH099	Improved		Elsewhere within the village	No	>30	2	No
HH100	Improved		Elsewhere within the village	No	>30	2	No
HH101	Improved		Elsewhere within the village	No	>30	4	No
HH102	Improved		Elsewhere within the village	No	≤30	4	Yes
HH103	Improved		Elsewhere within the village	No	≤30	3	Yes

HH104	Improved		Elsewhere within the village	No	≤30	7	Yes
HH105	Improved		Elsewhere within the village	No	≤30	7	Yes
HH106	Improved		Elsewhere within the village	Yes (long distance)	>30	3	Yes
HH107	Unimproved	No improved source nearby				6	
HH108	Unimproved	No improved source nearby				4	
HH109	Improved		Elsewhere within the village	Yes (long distance)	>30	7	Yes
HH110	Improved		Elsewhere within the village	No	>30	6	Yes
HH111	Improved		Elsewhere within the village	No	≤30	6	No
HH112	Improved		Elsewhere within the village	No	≤30	7	No
HH113	Improved		Elsewhere within the village	No	≤30	6	Yes
HH114	Improved		Elsewhere within the village	No	>30	6	Yes

HH115	Improved		Elsewhere within the village	No	≤30	6	Yes
HH116	Improved		Elsewhere within the village	Yes (long distance)	>30	4	Yes
HH117	Improved		Elsewhere within the village	No	>30	5	Yes
HH118	Improved		Elsewhere within the village	No	≤30	10	Yes
HH119	Improved		Elsewhere within the village	No	≤30	7	Yes
HH120	Improved		Elsewhere within the village	No	≤30	4	Yes
HH121	Improved		Elsewhere within the village	No	≤30	7	Yes
HH122	Improved		Elsewhere within the village	No	≤30	6	Yes
HH123	Improved		Elsewhere within the village	No	≤30	5	Yes
HH124	Improved		Elsewhere within the village	No	≤30	5	Yes

HH125	Improved		Elsewhere within the village	No	≤30	7	Yes
HH126	Improved		Elsewhere within the village	No	≤30	7	Yes
HH127	Improved		Elsewhere within the village	No	≤30	8	Yes
HH128	Improved		Elsewhere within the village	No	≤30	8	Yes
HH129	Improved		Elsewhere within the village	No	≤30	6	Yes
HH130	Improved		Elsewhere within the village	No	≤30	13	Yes
HH131	Improved		Elsewhere within the village	No	≤30	9	Yes
HH132	Improved		Elsewhere within the village	No	≤30	4	Yes
HH133	Improved		Elsewhere within the village	No	≤30	5	Yes
HH134	Improved		Elsewhere within the village	No	≤30	7	Yes

HH135	Improved		Elsewhere within the village	No	≤30	6	Yes
HH136	Improved		Elsewhere within the village	No	≤30	5	Yes
HH137	Improved		Elsewhere within the village	No	≤30	5	Yes
HH138	Improved		Elsewhere within the village	No	≤30	10	Yes
HH139	Improved		Elsewhere within the village	No	≤30	8	Yes
HH140	Improved		Elsewhere within the village	No	≤30	5	Yes
HH141	Improved		Elsewhere within the village	No	≤30	4	Yes
HH142	Improved		Elsewhere within the village	No	≤30	6	Yes
HH143	Improved		Elsewhere within the village	No	≤30	4	Yes
HH144	Improved		Elsewhere within the village	No	≤30	5	Yes

HH145	Improved		Elsewhere within the village	No	≤30	4	Yes
HH146	Improved		Elsewhere within the village	No	≤30	6	Yes
HH147	Improved		Elsewhere within the village	No	≤30	7	Yes
HH148	Improved		Elsewhere within the village	No	>30	8	Yes
HH149	Improved		Elsewhere within the village	Yes (long distance)	>30	6	Yes
HH150	Improved		Elsewhere within the village	Yes (long distance)	>30	6	Yes
HH151	Improved		Elsewhere within the village	Yes (long distance)	≤30	10	Yes
HH152	Improved		Elsewhere within the village	No	≤30	5	Yes
HH153	Improved		Elsewhere within the village	No	≤30	9	Yes
HH154	Improved		Elsewhere within the village	No	≤30	10	Yes

HH155	Improved		Elsewhere within the village	Yes (long distance)	>30	4	Yes
HH156	Unimproved	No improved source nearby				5	
HH157	Improved		Elsewhere within the village	No	≤30	8	Yes
HH158	Improved		Elsewhere within the village	No	≤30	4	Yes
HH159	Improved		Elsewhere within the village	No	≤30	4	Yes
HH160	Improved		Elsewhere within the village	No	≤30	4	Yes
HH161	Improved		Elsewhere within the village	No	≤30	5	Yes
HH162	Improved		Elsewhere within the village	No	>30	7	No
HH163	Improved		Elsewhere within the village	No	>30	16	No
HH164	Improved		Elsewhere within the village	Yes (long distance)	>30	8	No
HH165	Improved		Elsewhere within the village	Yes (long distance)	>30	10	No

HH166	Improved		Elsewhere within the village	No	≤30	5	Yes
HH167	Improved		Elsewhere within the village	No	≤30	8	Yes
HH168	Improved		Elsewhere within the village	No	≤30	10	Yes
HH169	Improved		Elsewhere within the village	No	≤30	6	Yes
HH170	Improved		Elsewhere within the village	No	≤30	5	Yes
HH171	Improved		Elsewhere within the village	No	≤30	7	Yes
HH172	Unimproved	No improved source nearby				4	
HH173	Unimproved	No improved source nearby				4	
HH174	Improved		Elsewhere within the village	Yes	>30	5	No
HH175	Improved		Elsewhere within the village	No	>30	9	Yes
HH176	Improved		Elsewhere within the village	No	≤30	5	Yes

HH177	Improved		Elsewhere within the village	No	≤30	6	Yes
HH178	Improved		Elsewhere within the village	Yes (long distance)	>30	6	No
HH179	Improved		Elsewhere within the village	No	≤30	7	Yes
HH180	Improved		On premises	No	≤30	3	No
HH181	Improved		Elsewhere within the village	No	≤30	8	No
HH182	Improved		Elsewhere within the village	No	≤30	4	No
HH183	Improved		Elsewhere within the village	No	≤30	5	Yes
HH184	Improved		Elsewhere within the village	No	≤30	9	Yes
HH185	Improved		Elsewhere within the village	No	≤30	5	Yes
HH186	Improved		Elsewhere within the village	No	≤30	5	No
HH187	Improved		Elsewhere within the village	No	≤30	2	No

HH188	Improved		Elsewhere within the village	No	≤30	12	No
HH189	Improved		Elsewhere within the village	No	≤30	5	No
HH190	Improved		Elsewhere within the village	No	≤30	5	Yes
HH191	Improved		Elsewhere within the village	No	≤30	4	Yes
HH192	Improved		Elsewhere within the village	No	≤30	4	Yes
HH193	Improved		Elsewhere within the village	No	≤30	10	Yes
HH194	Improved		Elsewhere within the village	No	≤30	6	Yes
HH195	Improved		Elsewhere within the village	No	≤30	5	Yes
HH196	Improved		Elsewhere within the village	No	≤30	6	Yes
HH197	Improved		Elsewhere within the village	No	≤30	4	Yes

HH198	Improved		Elsewhere within the village	No	≤30	8	Yes
HH199	Improved		Elsewhere within the village	No	≤30	8	Yes
HH200	Improved		Elsewhere within the village	No	≤30	8	Yes
HH201	Improved		Elsewhere within the village	No	≤30	8	Yes
HH202	Improved		Elsewhere within the village	No	≤30	7	Yes
HH203	Improved		On premises	No	≤30	7	Yes
HH204	Improved		Elsewhere within the village	No	≤30	5	Yes
HH205	Improved		On premises	No	>30	10	No
HH206	Improved		Elsewhere within the village	No	≤30	6	Yes
HH207	Improved		Elsewhere within the village	No	≤30	4	Yes
HH208	Improved		Elsewhere within the village	No	≤30	15	Yes

HH209	Improved		Elsewhere within the village	No	≤30	8	Yes
HH210	Improved		Elsewhere within the village	No	≤30	3	Yes
HH211	Improved		Elsewhere within the village	No	≤30	20	Yes
HH212	Improved		Elsewhere within the village	No	≤30	10	Yes
HH213	Improved		Elsewhere within the village	No	≤30	8	Yes
HH214	Improved		Elsewhere within the village	No	≤30	5	Yes
HH215	Improved		Elsewhere within the village	No	≤30	20	Yes
HH216	Improved		Elsewhere within the village	No	≤30	7	Yes
HH217	Improved		Elsewhere within the village	No	≤30	4	Yes
HH218	Improved		Elsewhere within the village	No	≤30	2	Yes

HH219	Improved		Elsewhere within the village	No	≤30	5	Yes
HH220	Improved		Elsewhere within the village	No	≤30	5	Yes
HH221	Improved		Elsewhere within the village	No	≤30	6	Yes
HH222	Improved		Elsewhere within the village	No	≤30	10	Yes
HH223	Improved		Elsewhere within the village	No	≤30	8	Yes
HH224	Improved		Elsewhere within the village	No	≤30	8	Yes
HH225	Improved		Elsewhere within the village	No	≤30	5	Yes
HH226	Improved		Elsewhere within the village	No	≤30	3	Yes
HH227	Improved		Elsewhere within the village	No	≤30	5	Yes
HH228	Improved		Elsewhere within the village	No	≤30	5	Yes

HH229	Improved		Elsewhere within the village	No	≤30	3	Yes
HH230	Improved		Elsewhere within the village	No	≤30	5	Yes
HH231	Improved		Elsewhere within the village	No	≤30	3	Yes
HH232	Improved		Elsewhere within the village	No	≤30	4	Yes
HH233	Improved		Elsewhere within the village	No	>30	10	Yes
HH234	Improved		Elsewhere within the village	No	>30	4	No
HH235	Improved		Elsewhere within the village	No	≤30	8	Yes
HH236	Improved		Elsewhere within the village	No	>30	2	No
HH237	Improved		Elsewhere within the village	No	>30	4	No
HH238	Improved		Elsewhere within the village	No	>30	5	No

HH239	Improved		Elsewhere within the village	No	>30	2	No
HH240	Improved		Elsewhere within the village	No	>30	2	No
HH241	Improved		Elsewhere within the village	No	>30	3	No
HH242	Improved		Elsewhere within the village	No	>30	10	Yes
HH243	Improved		Elsewhere within the village	No	>30	3	No
HH244	Improved		Elsewhere within the village	No	>30	2	No
HH245	Improved		Elsewhere within the village	Yes (long distance)	>30	4	Yes
HH246	Improved		Elsewhere within the village	No	≤30	7	Yes
HH247	Improved		Elsewhere within the village	No	≤30	4	Yes
HH248	Improved		Elsewhere within the village	No	>30	8	Yes

HH249	Improved		Elsewhere within the village	No	>30	5	Yes
HH250	Improved		Elsewhere within the village	No	≤30	4	Yes
HH251	Improved		Elsewhere within the village	Yes	>30	6	Yes
HH252	Improved		Elsewhere within the village	No	>30	3	Yes
HH253	Improved		Elsewhere within the village	No	≤30	4	Yes
HH254	Improved		Elsewhere within the village	No	≤30	3	Yes
HH255	Improved		Elsewhere within the village	No	≤30	8	Yes
HH256	Improved		Elsewhere within the village	No	≤30	4	Yes
HH257	Improved		Elsewhere within the village	No	≤30	5	Yes
HH258	Improved		Elsewhere within the village	Yes (long distance)	>30	4	No

HH259	Improved		Elsewhere within the village	Yes (long distance)	>30	8	No
HH260	Improved		Elsewhere within the village	Yes (long Distance)	>30	8	No
HH261	Improved		Elsewhere within the village	Yes (long Distance)	>30	3	No
HH262	Improved		Elsewhere within the village	No	≤30	5	Yes
HH263	Improved		Elsewhere within the village	No	≤30	8	Yes
HH264	Improved		Elsewhere within the village	No	≤30	8	Yes
HH265	Improved		Elsewhere within the village	No	≤30	4	Yes
HH266	Improved		Elsewhere within the village	No	≤30	9	Yes
HH267	Improved		Elsewhere within the village	No	≤30	7	Yes
HH268	Improved		Elsewhere within the village	No	≤30	7	Yes

HH269	Improved		Elsewhere within the village	No	≤30	6	Yes
HH270	Improved		Elsewhere within the village	No	≤30	5	Yes
HH271	Improved		Elsewhere within the village	No	≤30	7	Yes
HH272	Improved		Elsewhere within the village	No	≤30	5	Yes
HH273	Improved		Elsewhere within the village	Yes (no bridge on river)	≤30	4	Yes
HH274	Improved		Elsewhere within the village	Yes (no bridge on river)	≤30	10	Yes
HH275	Improved		Elsewhere within the village	No	≤30	5	Yes
HH276	Improved		Elsewhere within the village	No	≤30	6	Yes
HH277	Improved		Elsewhere within the village	No	≤30	8	Yes
HH278	Improved		Elsewhere within the village	No	≤30	6	Yes

HH279	Improved		Elsewhere within the village	No	≤30	3	Yes
HH280	Improved		Elsewhere within the village	No	≤30	5	Yes
HH281	Improved		Elsewhere within the village	No	>30	3	No
HH282	Improved		Elsewhere within the village	No	>30	5	Yes
HH283	Improved		Elsewhere within the village	No	>30	8	No
HH284	Improved		Elsewhere within the village	No	>30	5	No
HH285	Improved		Elsewhere within the village	No	>30	6	No
HH286	Improved		Elsewhere within the village	No	>30	4	No
HH287	Unimproved	Water quality related concerns on existing improved sources				4	
HH288	Improved		Elsewhere within the village	No	≤30	7	Yes

Household Code	Why not meeting demand	Able to draw water any time	Why not able to draw anytime	Improved water source supplies all year round	Months of no supply	# of improved water water sources	Able to draw from other sources	Why not able to draw from other sources
HH001		Yes		Yes		2	No	Other sources are very far
HH002		Yes		Yes		2	No	Other sources are very far
HH003		Yes		Yes		2	No	Other sources are very far
HH004	Many users	Yes		Yes		2	No	Other sources are very far
HH005		Yes		Yes		2	No	Other sources are very far
HH006	Very far	Yes		Yes		2	No	Other sources are very far
HH007	Yes	Yes		Yes		2	No	Other sources are very far
HH008		Yes		Yes		2	No	Other sources are very far

HH009		Yes		Yes		2	No	Other sources are very far
HH010		Yes		Yes		2	No	Other sources are very far
HH011						0		
HH012						0		
HH013						0		
HH014						0		
HH015						0		
HH016						0		
HH017						0		
HH018						0		
HH019						0		
HH020		Yes		Yes		0	Yes	
HH021		Yes		Yes		5	Yes	
HH022		Yes		Yes		5	Yes	
HH023		Yes		Yes		5	Yes	
HH024		Yes		Yes		5	Yes	
HH025		Yes		Yes		5	Yes	
HH026		Yes		Yes		5	Yes	
HH027		Yes		Yes		5	Yes	

HH028		Yes		Yes		5	Yes	
HH029		Yes		Yes		5	Yes	
HH030		Yes		Yes		5	Yes	
HH031		Yes		Yes		0	Yes	
HH032		Yes		Yes		0	Yes	
HH033		Yes		Yes		0	Yes	
HH034		Yes		Yes		0	Yes	
HH035		Yes		Yes		0	No	Other sources are very far
HH036		Yes		Yes		0	Yes	
HH037		Yes		Yes		0	Yes	
HH038		Yes		Yes		0		Yes
HH039		Yes		Yes		5	Yes	
HH040		Yes		Yes		4	Yes	
HH041		Yes		Yes		4	Yes	
HH042		Yes		Yes		4	Yes	
HH043		Yes		Yes		4	Yes	
HH044		Yes		Yes		4	Yes	
HH045		Yes		Yes		4	Yes	
HH046		Yes		Yes		4	Yes	

HH047	Low yielding	Yes		No	October, November, December	4	Yes	
HH048	Low yielding	Yes		No	October, November, December	4	Yes	
HH049	Many users	Yes		Yes		1	No	Other sources are very far
HH050	Many users	Yes		Yes		1	No	Other source are very far
HH051	Many users	Yes		Yes		1	No	Other sources are very far
HH052	Many users	Yes		Yes		1	No	Other sources are very far
HH053	Many users	Yes		Yes		1	No	Other sources are very far
HH054	Many users	Yes		Yes		1	No	Other sources are very far
HH055	Many users	Yes		Yes		1	No	Other sources are very far
HH056	Many users	Yes		Yes		1	No	Other sources are very far

HH057	Many users	Yes		Yes		1	No	Other source are very far
HH058		Yes		Yes		1	No	Other sources are very far
HH059		Yes		Yes		1	No	Other sources are very far
HH060		Yes		Yes		1	No	Other sources are very far
HH061		Yes		Yes		1	No	Other sources are very far
HH062						1		
HH063						1		
HH064						1		
HH065						1		
HH066	Many users	Yes		Yes		1	No	Other sources are very
HH067	Many users	Yes		Yes		1	No	Other sources are very far
HH068	Many users	Yes		Yes		1	No	Other sources are very far

HH069	Many users	Yes		Yes		1	No	Other sources are very far
HH070	Many users	Yes		Yes		1	No	Other sources are very far
HH071	Many users	Yes		Yes		1	No	Other sources are very far
HH072	many users	Yes		Yes		1	No	Other sources are very far
HH073	Many users	Yes		Yes		1	No	Other sources are very far
HH074		Yes		Yes		1	No	Other sources are very far
HH075		Yes		Yes		1	Yes	
HH076	Many users	Yes		Yes		1	No	Other sources are very far
HH077	Many users	Yes		Yes		1	No	Other sources are very far
HH078	Many users	Yes		Yes		1	No	Barred by the other community

HH079	Many users	Yes		Yes		1	No	Barred by the other community
HH080	Many users	Yes		Yes		1	No	Other sources are very far
HH081	Many users	Yes		Yes		1	No	Other sources are very far
HH082	Many users	Yes		Yes		1	No	Other sources are very far
HH083	Many users	Yes		Yes		1	No	Other sources are very far
HH084						1	No	
HH085						1	No	
HH086	Many users	Yes		Yes		1	No	Other sources are very far
HH087						1	No	
HH088		Yes		Yes		1	No	Other sources are very far
HH089						1	No	
HH090	Many users	Yes		Yes		1	No	Other sources are very far

HH091		Yes		Yes		1	No	Other sources are very far
HH092		Yes		Yes		1	No	Other sources are very far
HH093		Yes		Yes		2	No	Other sources
HH094		Yes		Yes		2	No	Other sources are very far
HH095		Yes		Yes		2	No	Other sources are very far
HH096		Yes		Yes		2	No	Other sources are very far
HH097						2		
HH098	Low yielding	Yes		No	January February March April May June July August September October November December	2	No	Other sources are very far
HH099	Low yielding	No		No	January February March April May June July August September October November December	2	No	Other sources are very far

HH100	Low yielding	No		No	January February March April May June July August September October November December	2	No	Other sources are very far
HH101	Low yielding	Yes		No	January February March April May June July August September October November December	2	No	Other sources are very far
HH102		Yes		Yes		2	No	
HH103		Yes		Yes		2	No	Other sources are very far
HH104		Yes		Yes		2	No	Other sources are very far
HH105		No		Yes		2	No	Other sources are very far
HH106		Yes		Yes		2	No	Other sources are very far
HH107						2		
HH108						2		
HH109		Yes		Yes		2	No	Other sources are very far

HH110		Yes		Yes		2	No	Other sources are very far
HH111	Low yielding	Yes		No	September, October, November, December	2	Yes	
HH112	Low yielding	Yes		No	September, October, November December	2	Yes	
HH113		Yes		Yes		2	Yes	
HH114		Yes		Yes		2	No	Other sources are very far
HH115		Yes		Yes		2	Yes	
HH116		Yes		Yes		2	Yes	
HH117		No	The water source is closed/locked by committee during some hours	Yes		2	Yes	
HH118		No	The water source is closed /locked by committee	Yes		2	Yes	

			during some hours					
HH119		No	Closed by committee during some hours	Yes		3	Yes	
HH120		No	Closed by committee during some hours	Yes		3	Yes	
HH121		Yes		Yes		3	Yes	
HH122		Yes		Yes		3	Yes	
HH123		Yes		Yes		3	Yes	
HH124		Yes		Yes		3	Yes	
HH125		Yes		Yes		3	Yes	
HH126		Yes		Yes		3	Yes	
HH127		Yes		Yes		11	Yes	
HH128		Yes		Yes		11	Yes	
HH129		Yes		Yes		11	Yes	
HH130		Yes		Yes		11	Yes	
HH131		Yes		Yes		11	Yes	

HH132		Yes		Yes		11	Yes	
HH133		Yes		Yes		11	Yes	
HH134		Yes		Yes		11	Yes	
HH135		Yes		Yes		9	Yes	
HH136		Yes		Yes		9	Yes	
HH137		Yes		Yes		9	Yes	
HH138		Yes		Yes		9	Yes	
HH139		Yes		Yes		9	Yes	
HH140		Yes		Yes		9	Yes	
HH141		Yes		Yes		9	Yes	
HH142		Yes		Yes		9	Yes	
HH143		Yes		Yes		9	No	Other sources are very far
HH144		Yes		Yes		9	Yes	
HH145		Yes		Yes		9	Yes	
HH146		Yes		Yes		9	No	Other sources are very far
HH147		Yes		Yes		10	Yes	
HH148		yes		Yes		10	Yes	
HH149	Yes	Yes		Yes		9	No	Other sources are very far

HH150		Yes		Yes		9	No	Other sources are very far
HH151		Yes		Yes		9	No	Other sources are very far
HH152		Yes		Yes		9	No	Other sources are very far
HH153		Yes		Yes		1	Yes	
HH154		Yes		Yes		1	No	Other sources are very far
HH155		yes		Yes		1	No	Other sources are very far
HH156						1		
HH157		Yes		Yes		1	No	Other sources are very far
HH158		Yes		Yes		1	Yes	
HH159		Yes		Yes		1	No	Other sources are very far
HH160		Yes		Yes		1	No	Other sources are very far
HH161		Yes		Yes		1	No	Other sources are very far

HH162	Many users	No	It is not safe at night	Yes		1	No	Other sources are very far
HH163	Many users	No	The water source is locked by committee some hours	Yes		1	No	Other sources are very far
HH164	Many users	No	The water source is locked by committee some hours	Yes		1	No	Other sources are very far
HH165	Many users	No	The water source is locked by committee some hours	Yes		1	No	Other sources are very far
HH166		Yes		Yes		2	No	Other sources are very far
HH167		Yes		Yes		2	No	Other sources are very far

HH168		Yes		Yes		2	No	Other sources are very far
HH169		Yes		Yes		2	No	Other sources are very far
HH170		Yes		Yes		2	No	Other sources are very far
HH171		No	It is not safe at night	Yes		3	Yes	
HH172						3		
HH173						3		
HH174	Many users	No	it is not safe at night	Tes		3	No	Other sources are very far
HH175		No	It is not safe at night	yes		8	Yes	
HH176		Yes		Yes		8	Yes	
HH177		No	It is not safe at night	Yes		8	Yes	
HH178	Many users	No	It is not safe at night	Yes		3	No	Other sources are very far
HH179		No	It not safe at night	No	October November December	3	Yes	

HH180	low yielding	Yes		No	October, November, December	4	No	Other sources are very far
HH181	Low yielding	Yes		No	October, November, December	4	No	Other sources are very far
HH182	Low yielding	Yes		No	October, November, December	4	No	Other sources are very far
HH183		Yes		Yes		4	Yes	
HH184		Yes		Yes		4	Yes	
HH185		Yes		Yes		4	Yes	
HH186	Low yielding	Yes		No	October, November, December	4	No	Other sources are very far
HH187	Low yielding	No		No	October, November, December	4	No	Other sources are very far
HH188	Low yielding	Yes		No	October, November, December	4	Yes	
HH189	Low yielding	Yes		No	August, September, October, November, December	2	No	Barred by the other community
HH190		Yes		No	August, September, October, November, December	2	Yes	

HH191		Yes		N0	August, September, October, November, December	2	Yes	
HH192		Yes		No	August, September, October, November, December	2	Yes	
HH193		Yes		Yes		2	Yes	
HH194		No	It is not safe at night	Yes		2	Yes	
HH195		Yes		Yes		2	Yes	
HH196		Yes		Yes		2	Yes	
HH197		Yes		Yes		2	Yes	
HH198		No	It is not safe at night	Yes		10	Yes	
HH199		No	It is not safe at night	Yes		10	No	Barred from other community
HH200		Yes		Yes		10	No	Barred from the other community
HH201		Yes		Yes		5	No	Barred by other community

HH202		No	It is not safe at night	Yes		5	No	Barred by the other community
HH203		Yes		Yes		5	Yes	
HH204		Yes		Yes		5	No	Barred by the other community
HH205	Many users	No	It is not safe at night	Yes		5	No	Barred by other community
HH206		Yes		Yes		10	No	Barred from the other community
HH207		Yes		Yes		10	No	Barred by the other community
HH208		Yes		Yes		2	Yes	
HH209		Yes		Yes		2	Yes	
HH210		Yes		Yes		2	Yes	
HH211		Yes		Yes		2	Yes	
HH212		Yes		Yes		2	Yes	

HH213		No		Yes		2	Yes	
HH214		Yes		yes		2	Yes	
HH215		Yes		Yes		2	Yes	
HH216		Yes		Yes		2	Yes	
HH217		Yes		Yes		2	Yes	
HH218		Yes		Yes		2	Yes	
HH219		Yes		Yes		2	Yes	
HH220		Yes		Yes		2	Yes	
HH221		Yes		Yes		2	Yes	
HH222		Yes		Yes		2	Yes	
HH223		Yes		Yes		2	Yes	
HH224		Yes		Yes		2	Yes	
HH225		Yes		Yes		2	Yes	
HH226		Yes		Yes		1	Yes	
HH227		Yes		Yes		1	Yes	
HH228		Yes		Yes		1	Yes	
HH229		Yes		Yes		1	Yes	
HH230		Yes		Yes		1	Yes	
HH231		Yes		Yes		1	Yes	
HH232		Yes		Yes		1	Yes	
HH233		Yes		Yes		1	Yes	

HH234	Many users	Yes		Yes		1	Yes	
HH235		Yes		Yes		3	Yes	
HH236	Many users	Yes		Yes		3	Yes	
HH237	Many users	Yes		Yes		3	Yes	
HH238	many users	Yes		Yes		3	No	other sources are very far
HH239	Many users	Yes		Yes		3	Yes	
HH240	Many users	Yes		Yes		3	Yes	
HH241	Many users	Yes		Yes		3	Yes	
HH242		Yes		Yes		3	Yes	
HH243	Many users	Yes		Yes		3	Yes	
HH244	Very far	Yes		Yes		2	No	Other sources are very far

HH245		No	It is not safe at night	Yes		2	Yes	
HH246		Yes		Yes		2	Yes	
HH247		Yes		Yes		2	Yes	
HH248		Yes		Yes		2	Yes	
HH249		Yes		Yes		2	Yes	
HH250		Yes		Yes		2	Yes	
HH251		Yes		Yes		2	No	Other sources are very far
HH252		Yes		Yes		2	Yes	
HH253		Yes		Yes		3	No	Other sources are very far
HH254		Yes		Yes		3	No	Other sources are very far
HH255		Yes		Yes		3	No	Other sources are very far
HH256		Yes		Yes		3	No	Other sources are very far
HH257		Yes		Yes		3	No	Other sources are very far

HH258	Low yielding	Yes		No	October, November, December	3	No	Other sources are very far
HH259	Low yielding	Yes		No	October, November, December	3	No	Other sources are very far
HH260	Low yielding	Yes		No	October, November, December	3	Yes	
HH261	Low yielding	Yes		No	October, November, December	3	Yes	
HH262		Yes		Yes		2	Yes	
HH263		Yes		Yes		2	Yes	
HH264		Yes		Yes		2	Yes	
HH265		Yes		Yes		2	Yes	
HH266		Yes		Yes		2	Yes	
HH267		Yes		Yes		2	Yes	
HH268		Yes		Yes		2	Yes	
HH269		Yes		Yes		2	Yes	
HH270		Yes		Yes		2	Yes	
HH271		Yes		Yes		2	No	Other sources are very far
HH272		Yes		Yes		2	No	Other sources are very far

HH273		Yes		Yes		2	No	Other sources are very far
HH274		Yes		Yes		2	No	Other sources are very far
HH275		No		Yes		2	Yes	
HH276		Yes		Yes		2	Yes	
HH277		Yes		Yes		2	Yes	
HH278		Yes		Yes		2	No	Other sources are very far
HH279		Yes		Yes		2	Yes	
HH280		Yes		Yes		4	Yes	
HH281	Many user's	Yes		Yes		4	No	Other sources are very far
HH282		Yes		Yes		4	Yes	
HH283	Many users	Yes		Yes		4	No	Other sources are very far
HH284	Many users	Yes		Yes		4	No	Other sources are very far
HH285	Many users	Yes		Yes		4	Yes	

HH286	Many users	Yes		Yes		4	No	Other sources are very far
HH287								
HH288		No	The water source is closed/ locked during some hours	Yes		4	No	Other sources are very far

Household Code	**Everyone able to access the water source**	**Why some don't access the water source**	**HH contributes for O&M**	**Why HH doesn't contribute for O&M**	**Mode of O&M contributions**	**Monthly contribution (if yearly, x/12)**	**Average after-breakdown contribution**
HH001	Yes		Yes		Yearly	1-100	
HH002	Yes		Yes		Yearly	1-100	
HH003	Yes		Yes		Yearly	1-100	
HH004	Yes		Yes		Yearly	1-100	
HH005	Yes		Yes		Yearly	1-100	

HH006	Yes		Yes		Yearly	1-100	
HH007	Yes		Yes		Yearly	1-100	
HH008	Yes		Yes		Yearly	1-100	
HH009	Yes		Yes		Yearly	1-100	
HH010	Yes		Yes		After break down		201-300
HH011							
HH012							
HH013							
HH014							
HH015							
HH016							
HH017							
HH018							
HH019							
HH020	No	Long distance	Yes		Yearly	1-100	
HH021	No	Long distance	Yes		Yearly	1-100	
HH022	Yes		Yes		After breakdown		201-300
HH023	Yes		Yes		After breakdown		401-500

HH024	Yes		Yes		Yearly	1-100	
HH025	Yes		Yes		Yes	1-100	
HH026	Yes		Yes		Yearly	1-100	
HH027	Yes		Yes		Yearly	1-100	
HH028	Yes		Yes		Yearly	1-100	
HH029	Yes		Yes		After break-down		1-100
HH030	Yes		Yes		Yearly	1-100	
HH031	No	Long distance	Yes		Yearly	1-100	
HH032	No	Long distance	Yes		Yearly	1-100	
HH033	Yes		Yes		Monthly	1-100	
HH034	No	Long distance	Yes		Yearly	1-100	
HH035	Yes		Yes		Yearly	1-100	
HH036	Yes		Yes		Yearly	1-100	
HH037	No	Long distance	Yes		Monthly	1-100	
HH038	No	Long distance	Yes		Yearly	1-100	
HH039	Yes		Yes		Yearly	1-100	
HH040	Yes		Yes		Monthly	1-100	
HH041	Yes		Yes		Monthly	1-100	
HH042	Yes		Yes		Monthly	1-100	
HH043	Yes		Yes		Monthly	1-100	

HH044	Yes		Yes		Monthly	1-100	
HH045	Yes		Yes		Monthly	1-100	
HH046	Yes		Yes		Monthly	1-100	
HH047	Yes		Yes		Monthly	1-100	
HH048	Yes		Yes		Monthly	1-100	
HH049	Yes		Yes		Monthly	1-100	
HH050	Yes		Yes		Monthly	1-100	
HH051	Yes		No	Other (from 70yrs above exempted from contributing)			
HH052	Yes		Yes		Monthly	1-100	
HH053	Yew		Yes		Monthly	1-100	
HH054	Yes		Yes		Monthly	1-100	
HH055	Yes		Yes		Monthly	1-100	
HH056	Yes		Yes		Monthly	1-100	
HH057	Yes		Yes		Monthly	1-100	
HH058	Yes		Yes		Monthly	1-100	
HH059	Yes		Yes		Monthly	1-100	
HH060	Yes		Yes		Monthly	1-100	
HH061	Yes		Yes		Monthly	1-100	

HH062							
HH063							
HH064							
HH065							
HH066	Yes		Yes		Monthly	101-200	
HH067	Yes		Yes		Monthly	101-200	
HH068	Yes		Yes		Monthly	101-200	
HH069	Yes		Yes		Monthly	101-200	
HH070	Yes		Yes		Monthly	101-200	
HH071	Yes		Yes		After break down		401-500
HH072	Yes		Yes		Monthly	101-200	
HH073	Yes		Yes		Monthly	101-200	
HH074	Yes		Yes		Monthly	101-200	
HH075	Yes		Yes		Monthly	1-100	
HH076	Yes		Yes		Monthly	1-100	
HH077	Yes		Yes		Monthly	1-100	
HH078		Barred due to failure to contribute	Yes		Monthly	1-100	
HH079		Barred due to failure to contribute	Yes		Monthly	1-100	
HH080	Yes		Yes		Monthly	1-100	
HH081	Yes		Yes		Monthly	1-100	

HH082	Yes		Yes		Monthly	1-100	
HH083	Yes		Yes		Monthly	1-100	
HH084							
HH085							
HH086	Yes		Yes		Monthly	1-100	
HH087							
HH088	Yes		Yes		Monthly	1-100	
HH089							
HH090	Yes		Yes		Monthly	1-100	
HH091			Yes		Monthly	1-100	
HH092	Yes		Yes		Monthly	1-100	
HH093	Yes		Yes		Monthly	1-100	
HH094	Yes		Yes		Monthly	1-100	
HH095	Yes		Yes		Monthly	1-100	
HH096	Yes		Yes		Monthly	1-100	
HH097							
HH098	Yes		Yes		After break down		401-500
HH099	Yes		Yes		After break down		401-500

HH100	Yes		Yes		After break down		401-500
HH101	Yes		Yes		After break down		410-500
HH102	Yes		Yes		Monthly	1-100	
HH103	Yes		Yes		Monthly	1-100	
HH104	Yes		Yes		Monthly	1-100	
HH105	Yes		Yes		Monthly	1-100	
HH106	Yes				Monthly	1-100	
HH107							
HH108							
HH109	Yes		Yes		After break down		401-500
HH110	Yes		Yes		Monthly	1-100	
HH111	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH112	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH113	Yes		Yes		Monthly	101-200	

HH114	Yes		Yes		Monthly	201-300	
HH115	Yes		Yes		Monthly	101-200	
HH116	Yes		Yes		Monthly	101-200	
HH117	Yes		Yes		Monthly	101-200	
HH118	Yes		Yes		Monthly	1-100	
HH119	Yes		Yes		Monthly	101-200	
HH120	Yes		Yes		Monthly	101-200	
HH121	Yes		Yes		Yearly	101-200	
HH122	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH123	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH124	Yes		Yes		After break-down		301-400
HH125	Yes		Yes		After break-down		201-300
HH126	Yes		Yes		After break-down		201-300

HH127	Yes		Yes		After break-down		201-300
HH128	Yes		Yes		After break-down		201-300
HH129	Yes		Yes		After break-down		401-500
HH130	Yes		Yes		Monthly	201-300	
HH131	Yes		Yes		After break-down		201-300
HH132	Yes		Yes		After break-down		101-200
HH133	Yes		Yes		After break-down		101-200
HH134	Yes		Yes		Monthly	1-100	
HH135	Yes		Yes		Monthly	1-100	
HH136	Yes		Yes		Monthly	1-100	
HH137	Yes		Yes		Monthly	1-100	
HH138	Yes		Yes		After break-down		401-500
HH139	Yes		Yes		After break-down		401-500

HH140	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH141	Yes		Yes		Monthly	101-200	
HH142	Yes		Yes		Monthly	101-200	
HH143	Yes		Yes		Yearly	1-100	
HH144	Yes		Yes		Monthly	1-100	
HH145	Yes		Yes		Yearly	1-100	
HH146	Yes		Yes		Yearly	1-100	
HH147	Yes		Yes		Yearly	1-100	
HH148	Yes		Yes		Yearly	1-100	
HH149	Yes		Yes		Yearly	1-100	
HH150	Yes		Yes		Yearly	1-100	
HH151	Yes		Yes		Yearly	1-100	
HH152	Yes		Yes		Yearly	1-100	
HH153	Yes		Yes		Yearly	1-100	
HH154	Yes		Yes		Yearly	1-100	
HH155	Don't know		Yes		Yearly	1-100	
HH156							
HH157	Yes		Yes		Yearly	1-100	

HH158	Yes		Yes		Yearly	1-100	
HH159	Yes		Yes		Yearly	1-100	
HH160	Yes		Yes		Yearly	1-100	
HH161	Yes		Yes		Yearly	1-100	
HH162	Yes		Yes		Monthly	101-200	
HH163	Yes		Yes		Monthly	101-200	
HH164	Yes		Yes		Monthly	101-200	
HH165	Yes		Yes		Monthly	101-200	
HH166	Yes		Yes		Monthly	101-200	
HH167	Yes		Yes		Monthly	101-200	
HH168	Yes		Yes		Monthly	101-200	
HH169	Yes		Yes		Monthly	101-200	
HH170	Yes		Yes		Monthly	101-200	
HH171	Yes		Yes		Monthly	201-300	
HH172							
HH173							
HH174	Yes		Yes		Monthly	1-100	
HH175	Yes		Yes		Monthly	101-200	
HH176	Yes		Yes		Monthly	201-300	
HH177	Yes		Yes		Monthly	101-200	
HH178	Yes		Yes		Monthly	201-300	

HH179	Yes		Yes		Monthly	201-300	
HH180	Yes		Yes		Monthly	101-200	
HH181	Yes		Yes		Monthly	101-200	
HH182	Yes		Yes		Monthly	101-200	
HH183	Yes		Yes		After break down		101-200
HH184	Yes		Yes		Yearly	201-300	
HH185	Yes		Yes		Yearly	201-300	
HH186	Yes		Yes		Monthly	401-500	
HH187	Yes		Yes		Monthly	401-500	
HH188	Yes		Yes		Monthly	401-500	
HH189	Yes		Yes		Monthly	101-200	
HH190	Yes		Yes		Monthly	101-200	
HH191	Yes		Yes		Monthly	101-200	
HH192	Yes		Yes		Monthly	101-200	
HH193	Yes		Yes		Monthly	101-200	
HH194	Yes		Yes		Monthly	101-200	
HH195	Yes		Yes		After break down		101-200
HH196	Yes		Yes		Monthly	101-200	
HH197	Yes		Yes		Monthly	101-200	

HH198	Yes		Yes		Monthly	1-100	
HH199	Yes		Yes		Monthly	1-100	
HH200	Yes		Yes		After break down		401-500
HH201	Yes		Yes		Monthly	101-200	
HH202	Yes		Yes		Monthly	1-100	
HH203	Yes		Yes		Monthly	1-100	
HH204	Yes		Yes		Monthly	1-100	
HH205	Yes		Yes		After break down		401-500
HH206	Yes		Yes		After break down		≤100
HH207	Yes		yes		Monthly	101-200	
HH208	Yes		Yes		Monthly	201-300	
HH209	Yes		Yes		Monthly	201-300	
HH210	Yes		Yes		Monthly	201-300	
HH211	Yes		Yes		Monthly	201-300	
HH212	Yes		Yes		Monthly	101-200	
HH213	Yes		Yes		Yearly	401-500	
HH214	Yes		Yes		Monthly	1-100	
HH215	Yes		Yes		Monthly	1-100	

HH216	Yes		Yes		Monthly	1-100	
HH217	Yes		Yes		Monthly	101-200	
HH218	yes		Yes		Monthly	101-200	
HH219	Yes		Yes		Monthly	101-200	
HH220	Yes		Yes		Monthly	101-200	
HH221	Yes		Yes		Yearly	101-200	
HH222	Yes		Yes		Yearly	401-500	
HH223	Yes		Yes		Yearly	401-500	
HH224	Yes		Yes		Monthly	201-300	
HH225	Yes		Yes		Yearly	401-500	
HH226	Yes		Yes		Yearly	101-200	
HH227	Yes		Yes		Monthly	101-200	
HH228	Yes		Yes		Monthly	101-200	
HH229	Yes		Yes		Monthly	101-200	
HH230	Yes		Yes		Monthly	101-200	
HH231	Yes		Yes		Monthly	101-200	
HH232	Yes		Yes		Monthly	101-200	
HH233	Yes		Yes		Monthly	101-200	
HH234	Yes		Yes		Monthly	101-200	
HH235	Yes		Yes		Yearly	1-100	
HH236	Yes		Yes		Yearly	1-100	

HH237	Yes		Yes		Yearly	1-100	
HH238	Yes		Yes		Yearly	1-100	
HH239	Yes		Yes		Yearly	1-100	
HH240	Yes		Yes		Yearly	1-100	
HH241	Yes		Yes		Yearly	1-100	
HH242	Yes		Yes		Yearly	1-100	
HH243	Yes		Yes		Yearly	1-100	
HH244	Yes		Yes		Yearly	1-100	
HH245	Yes		Yes		Yearly	1-100	
HH246	Yes		Yes		Yearly	1-100	
HH247	Yes		Yes		Yearly	1-100	
HH248	Yes		Yes		Yearly	1-100	
HH249	Yes		Yes		Yearly	1-100	
HH250	Yes		Yes		Yearly	1-100	
HH251	Yes		Yes		Yearly	1-100	
HH252	Yes		Yes		Yearly	1-100	
HH253	Yes		No	Funds are mismanaged by committee			

HH254	Yes		No	Funds are mismanaged by committee			
HH255	Yes		No	Funds are mismanaged by committee			
HH256	Yes		No	Funds are mismanaged by committee			
HH257	Yes		No	Funds are mismanaged by committee			
HH258	Yes		Yes		Monthly	401-500	
HH259	Yes		Yes		Monthly	401-500	
HH260	Yes		Yes		Monthly	1-100	
HH261	Yes		Yes		Monthly	1-100	
HH262	Yes		Yes		Monthly	201-300	
HH263	Yes		Yes		Monthly	201-300	
HH264	Yes		Yes		Monthly	201-300	
HH265	Yes		Yes		Monthly	201-300	
HH266	Yes		Yes		Monthly	201-300	

HH267	Yes		Yes		Monthly	201-300	
HH268	Yes		Yes		Monthly	101-200	
HH269	Yes		Yes		Monthly	1201-300	
HH270	Yes		Yes		Monthly	101-200	
HH271	Yes		Yes		Yearly	1-100	
HH272	Yes		Yes		Yearly	1-100	
HH273	Yes		Yes		Yearly	1-100	
HH274	Yes		Yes		Yearly	1-100	
HH275	Yes		Yes		Yearly	1-100	
HH276	Yes		Yes		Yearly	1-100	
HH277	Yes		Yes		Yearly	1-100	
HH278	Yes		Yes		Yearly	1-100	
HH279	Yes		Yes		Yearly	1-100	
HH280	Yes		Yes		Monthly	1-100	
HH281	Yes		Yes		Monthly	1-100	
HH282	Yes		Yes		Monthly	1-100	
HH283	Yes		Yes		Monthly	1-100	
HH284	Yes		Yes		Monthly	1-100	
HH285	Yes		Yes		Monthly	101-200	
HH286	Yes		Yes		Monthly	1-100	
HH287							

HH288	Yes		No	Other (O&M done by the owner - cottage tap)			

Household Code	**Everyone able to access the water source**	**Why some don't access the water source**	**HH contributes for O&M**	**Why HH doesn't contribute for O&M**	**Mode of O&M contributions**	**Monthly contribution (if yearly, x/12)**	**Average after-breakdown contribution**
HH001	Yes		Yes		Yearly	1-100	
HH002	Yes		Yes		Yearly	1-100	
HH003	Yes		Yes		Yearly	1-100	
HH004	Yes		Yes		Yearly	1-100	
HH005	Yes		Yes		Yearly	1-100	
HH006	Yes		Yes		Yearly	1-100	
HH007	Yes		Yes		Yearly	1-100	
HH008	Yes		Yes		Yearly	1-100	
HH009	Yes		Yes		Yearly	1-100	

HH010	Yes		Yes		After break down		201-300
HH011							
HH012							
HH013							
HH014							
HH015							
HH016							
HH017							
HH018							
HH019							
HH020	No	Long distance	Yes		Yearly	1-100	
HH021	No	Long distance	Yes		Yearly	1-100	
HH022	Yes		Yes		After breakdown		201-300
HH023	Yes		Yes		After breakdown		401-500
HH024	Yes		Yes		Yearly	1-100	
HH025	Yes		Yes		Yes	1-100	
HH026	Yes		Yes		Yearly	1-100	
HH027	Yes		Yes		Yearly	1-100	

HH028	Yes		Yes		Yearly	1-100	
HH029	Yes		Yes		After break-down		1-100
HH030	Yes		Yes		Yearly	1-100	
HH031	No	Long distance	Yes		Yearly	1-100	
HH032	No	Long distance	Yes		Yearly	1-100	
HH033	Yes		Yes		Monthly	1-100	
HH034	No	Long distance	Yes		Yearly	1-100	
HH035	Yes		Yes		Yearly	1-100	
HH036	Yes		Yes		Yearly	1-100	
HH037	No	Long distance	Yes		Monthly	1-100	
HH038	No	Long distance	Yes		Yearly	1-100	
HH039	Yes		Yes		Yearly	1-100	
HH040	Yes		Yes		Monthly	1-100	
HH041	Yes		Yes		Monthly	1-100	
HH042	Yes		Yes		Monthly	1-100	
HH043	Yes		Yes		Monthly	1-100	
HH044	Yes		Yes		Monthly	1-100	
HH045	Yes		Yes		Monthly	1-100	
HH046	Yes		Yes		Monthly	1-100	
HH047	Yes		Yes		Monthly	1-100	

HH048	Yes		Yes		Monthly	1-100	
HH049	Yes		Yes		Monthly	1-100	
HH050	Yes		Yes		Monthly	1-100	
HH051	Yes		No	Other (from 70yrs above exempted from contributing)			
HH052	Yes		Yes		Monthly	1-100	
HH053	Yew		Yes		Monthly	1-100	
HH054	Yes		Yes		Monthly	1-100	
HH055	Yes		Yes		Monthly	1-100	
HH056	Yes		Yes		Monthly	1-100	
HH057	Yes		Yes		Monthly	1-100	
HH058	Yes		Yes		Monthly	1-100	
HH059	Yes		Yes		Monthly	1-100	
HH060	Yes		Yes		Monthly	1-100	
HH061	Yes		Yes		Monthly	1-100	
HH062							
HH063							
HH064							
HH065							
HH066	Yes		Yes		Monthly	101-200	

HH067	Yes		Yes		Monthly	101-200	
HH068	Yes		Yes		Monthly	101-200	
HH069	Yes		Yes		Monthly	101-200	
HH070	Yes		Yes		Monthly	101-200	
HH071	Yes		Yes		After break down		401-500
HH072	Yes		Yes		Monthly	101-200	
HH073	Yes		Yes		Monthly	101-200	
HH074	Yes		Yes		Monthly	101-200	
HH075	Yes		Yes		Monthly	1-100	
HH076	Yes		Yes		Monthly	1-100	
HH077	Yes		Yes		Monthly	1-100	
HH078		Barred due to failure to contribute	Yes		Monthly	1-100	
HH079		Barred due to failure to contribute	Yes		Monthly	1-100	
HH080	Yes		Yes		Monthly	1-100	
HH081	Yes		Yes		Monthly	1-100	
HH082	Yes		Yes		Monthly	1-100	
HH083	Yes		Yes		Monthly	1-100	
HH084							
HH085							
HH086	Yes		Yes		Monthly	1-100	

HH087							
HH088	Yes		Yes		Monthly	1-100	
HH089							
HH090	Yes		Yes		Monthly	1-100	
HH091			Yes		Monthly	1-100	
HH092	Yes		Yes		Monthly	1-100	
HH093	Yes		Yes		Monthly	1-100	
HH094	Yes		Yes		Monthly	1-100	
HH095	Yes		Yes		Mother	1-100	
HH096	Yes		Yes		Monthly	1-100	
HH097							
HH098	Yes		Yes		After break down		401-500
HH099	Yes		Yes		After break down		401-500
HH100	Yes		Yes		After break down		401-500
HH101	Yes		Yes		After break down		410-500
HH102	Yes		Yes		Monthly	1-100	
HH103	Yes		Yes		Monthly	1-100	

HH104	Yes		Yes		Monthly	1-100	
HH105	Yes		Yes		Monthly	1-100	
HH106	Yes				Monthly	1-100	
HH107							
HH108							
HH109	Yes		Yes		After break down		401-500
HH110	Yes		Yes		Monthly	1-100	
HH111	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH112	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH113	Yes		Yes		Monthly	101-200	
HH114	Yes		Yes		Monthly	201-300	
HH115	Yes		Yes		Monthly	101-200	
HH116	Yes		Yes		Monthly	101-200	
HH117	Yes		Yes		Monthly	101-200	
HH118	Yes		Yes		Monthly	1-100	
HH119	Yes		Yes		Monthly	101-200	

HH120	Yes		Yes		Monthly	101-200	
HH121	Yes		Yes		Yearly	101-200	
HH122	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH123	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH124	Yes		Yes		After break-down		301-400
HH125	Yes		Yes		After break-down		201-300
HH126	Yes		Yes		After break-down		201-300
HH127	Yes		Yes		After break-down		201-300
HH128	Yes		Yes		After break-down		201-300
HH129	Yes		Yes		After break-down		401-500
HH130	Yes		Yes		Monthly	201-300	

HH131	Yes		Yes		After break-down		201-300
HH132	Yes		Yes		After break-down		101-200
HH133	Yes		Yes		After break-down		101-200
HH134	Yes		Yes		Monthly	1-100	
HH135	Yes		Yes		Monthly	1-100	
HH136	Yes		Yes		Monthly	1-100	
HH137	Yes		Yes		Monthly	1-100	
HH138	Yes		Yes		After break-down		401-500
HH139	Yes		Yes		After break-down		401-500
HH140	No	Barred due to failure to contribute towards cost of operation and maintenance	Yes		Monthly	101-200	
HH141	Yes		Yes		Monthly	101-200	
HH142	Yes		Yes		Monthly	101-200	
HH143	Yes		Yes		Yearly	1-100	
HH144	Yes		Yes		Monthly	1-100	

HH145	Yes		Yes		Yearly	1-100	
HH146	Yes		Yes		Yearly	1-100	
HH147	Yes		Yes		Yearly	1-100	
HH148	Yes		Yes		Yearly	1-100	
HH149	Yes		Yes		Yearly	1-100	
HH150	Yes		Yes		Yearly	1-100	
HH151	Yes		Yes		Yearly	1-100	
HH152	Yes		Yes		Yearly	1-100	
HH153	Yes		Yes		Yearly	1-100	
HH154	Yes		Yes		Yearly	1-100	
HH155	Don't know		Yes		Yearly	1-100	
HH156							
HH157	Yes		Yes		Yearly	1-100	
HH158	Yes		Yes		Yearly	1-100	
HH159	Yes		Yes		Yearly	1-100	
HH160	Yes		Yes		Yearly	1-100	
HH161	Yes		Yes		Yearly	1-100	
HH162	Yes		Yes		Monthly	101-200	
HH163	Yes		Yes		Monthly	101-200	
HH164	Yes		Yes		Monthly	101-200	

HH165	Yes		Yes		Monthly	101-200	
HH166	Yes		Yes		Monthly	101-200	
HH167	Yes		Yes		Monthly	101-200	
HH168	Yes		Yes		Monthly	101-200	
HH169	Yes		Yes		Monthly	101-200	
HH170	Yes		Yes		Monthly	101-200	
HH171	Yes		Yes		Monthly	201-300	
HH172							
HH173							
HH174	Yes		Yes		Monthly	1-100	
HH175	Yes		Yes		Monthly	101-200	
HH176	Yes		Yes		Monthly	201-300	
HH177	Yes		Yes		Monthly	101-200	
HH178	Yes		Yes		Monthly	201-300	
HH179	Yes		Yes		Monthly	201-300	
HH180	Yes		Yes		Monthly	101-200	
HH181	Yes		Yes		Monthly	101-200	
HH182	Yes		Yes		Monthly	101-200	
HH183	Yes		Yes		After break down		101-200
HH184	Yes		Yes		Yearly	201-300	

HH185	Yes		Yes		Yearly	201-300	
HH186	Yes		Yes		Monthly	401-500	
HH187	Yes		Yes		Monthly	401-500	
HH188	Yes		Yes		Monthly	401-500	
HH189	Yes		Yes		Monthly	101-200	
HH190	Yes		Yes		Monthly	101-200	
HH191	Yes		Yes		Monthly	101-200	
HH192	Yes		Yes		Monthly	101-200	
HH193	Yes		Yes		Monthly	101-200	
HH194	Yes		Yes		Monthly	101-200	
HH195	Yes		Yes		After break down		101-200
HH196	Yes		Yes		Monthly	101-200	
HH197	Yes		Yes		Monthly	101-200	
HH198	Yes		Yes		Monthly	1-100	
HH199	Yes		Yes		Monthly	1-100	
HH200	Yes		Yes		After break down		401-500
HH201	Yes		Yes		Monthly	101-200	
HH202	Yes		Yes		Monthly	1-100	
HH203	Yes		Yes		Monthly	1-100	

HH204	Yes		Yes		Monthly	1-100	
HH205	Yes		Yes		After break down		401-500
HH206	Yes		Yes		After break down		≤100
HH207	Yes		yes		Monthly	101-200	
HH208	Yes		Yes		Monthly	201-300	
HH209	Yes		Yes		Monthly	201-300	
HH210	Yes		Yes		Monthly	201-300	
HH211	Yes		Yes		Monthly	201-300	
HH212	Yes		Yes		Monthly	101-200	
HH213	Yes		Yes		Yearly	401-500	
HH214	Yes		Yes		Monthly	1-100	
HH215	Yes		Yes		Monthly	1-100	
HH216	Yes		Yes		Monthly	1-100	
HH217	Yes		Yes		Monthly	101-200	
HH218	yes		Yes		Monthly	101-200	
HH219	Yes		Yes		Monthly	101-200	
HH220	Yes		Yes		Monthly	101-200	
HH221	Yes		Yes		Yearly	101-200	
HH222	Yes		Yes		Yearly	401-500	

HH223	Yes		Yes		Yearly	401-500	
HH224	Yes		Yes		Monthly	201-300	
HH225	Yes		Yes		Yearly	401-500	
HH226	Yes		Yes		Yearly	101-200	
HH227	Yes		Yes		Monthly	101-200	
HH228	Yes		Yes		Monthly	101-200	
HH229	Yes		Yes		Monthly	101-200	
HH230	Yes		Yes		Monthly	101-200	
HH231	Yes		Yes		Monthly	101-200	
HH232	Yes		Yes		Monthly	101-200	
HH233	Yes		Yes		Monthly	101-200	
HH234	Yes		Yes		Monthly	101-200	
HH235	Yes		Yes		Yearly	1-100	
HH236	Yes		Yes		Yearly	1-100	
HH237	Yes		Yes		Yearly	1-100	
HH238	Yes		Yes		Yearly	1-100	
HH239	Yes		Yes		Yearly	1-100	
HH240	Yes		Yes		Yearly	1-100	
HH241	Yes		Yes		Yearly	1-100	
HH242	Yes		Yes		Yearly	1-100	
HH243	Yes		Yes		Yearly	1-100	

HH244	Yes		Yes		Yearly	1-100	
HH245	Yes		Yes		Yearly	1-100	
HH246	Yes		Yes		Yearly	1-100	
HH247	Yes		Yes		Yearly	1-100	
HH248	Yes		Yes		Yearly	1-100	
HH249	Yes		Yes		Yearly	1-100	
HH250	Yes		Yes		Yearly	1-100	
HH251	Yes		Yes		Yearly	1-100	
HH252	Yes		Yes		Yearly	1-100	
HH253	Yes		No	Funds are mismanaged by committee			
HH254	Yes		No	Funds are mismanaged by committee			
HH255	Yes		No	Funds are mismanaged by committee			
HH256	Yes		No	Funds are mismanaged by committee			
HH257	Yes		No	Funds are mismanaged by committee			
HH258	Yes		Yes		Monthly	401-500	
HH259	Yes		Yes		Monthly	401-500	

HH260	Yes		Yes		Monthly	1-100	
HH261	Yes		Yes		Monthly	1-100	
HH262	Yes		Yes		Monthly	201-300	
HH263	Yes		Yes		Monthly	201-300	
HH264	Yes		Yes		Monthly	201-300	
HH265	Yes		Yes		Monthly	201-300	
HH266	Yes		Yes		Monthly	201-300	
HH267	Yes		Yes		Monthly	201-300	
HH268	Yes		Yes		Monthly	101-200	
HH269	Yes		Yes		Monthly	1201-300	
HH270	Yes		Yes		Monthly	101-200	
HH271	Yes		Yes		Yearly	1-100	
HH272	Yes		Yes		Yearly	1-100	
HH273	Yes		Yes		Yearly	1-100	
HH274	Yes		Yes		Yearly	1-100	
HH275	Yes		Yes		Yearly	1-100	
HH276	Yes		Yes		Yearly	1-100	
HH277	Yes		Yes		Yearly	1-100	
HH278	Yes		Yes		Yearly	1-100	
HH279	Yes		Yes		Yearly	1-100	
HH280	Yes		Yes		Monthly	1-100	

HH281	Yes		Yes		Monthly	1-100	
HH282	Yes		Yes		Monthly	1-100	
HH283	Yes		Yes		Monthly	1-100	
HH284	Yes		Yes		Monthly	1-100	
HH285	Yes		Yes		Monthly	101-200	
HH286	Yes		Yes		Monthly	1-100	
HH287							
HH288	Yes		No	Other (O&M done by the owner - cottage tap)			

Household Code	**HH contribute willingly**	**Why not contributing willingly**	**Willing to pay more in case maintenance cost rises?**	**If yes__on_24___how_much_would_you_be_willing_to_pay_per_ye**	**Source of HH income**	**Average monthly earning**	**28__How_much_do_need_to_support_your_monthly_basic_needs_______**
HH001	Yes		Yes	101-250	Farming	1-7500	1-7500
HH002	Yes		Yes	101-250	Farming	28001-35000	15001-22500
HH003	Yes		Yes	101-250	Farming	1-7500	1-7500
HH004	Yes		Yes	101-250	Petty trading	1-7500	1-7500
HH005	Yes		Yes	101-250	Farming	1-7500	1-7500
HH006	Yes		Yes	101-250	Petty trading	1-7500	1-7500

HH007	Yes		Yes	101-250	Farming	7501-15000	More than 37500
HH008	Yes		Yes	101-250	Farming	More than 35000	More than 37500
HH009	Yes		Yes	101-250	Farming	1-7500	22500-30000
HH010	Yes		Yes	251-500	Employment	More than 35000	More than 37500
HH011					Petty trading	More than 35000	More than 375000
HH012					Other (Builder)	15001-28000	7501-15000
HH013					Petty trading	15001-28000	7501-15000
HH014					Petty trading	1-7500	1-7500
HH015					Farming	7501-15000	1-7500
HH016					Farming	1-7500	1-7500
HH017					Petty trading	15001-280000	7501-15000
HH018					Petty trading	1-7500	1-7500
HH019					Petty trading	1-7500	More than 37500
HH020	Yes		Yes	101- 250	Petty trading (maize mill)	More than 35000	More than 37500
HH021	Yes		Yes	251-500	Farming	More than 35000	More than 37500
HH022	Yes		Yes	501-750	Piece work	7501- 15000	More than 37500
HH023	Yes		Yes	501-750	Petty trading	7501- 15000	More than 37000
HH024	Yes		Yes	101-250	Farming	1-7500	1-7500
HH025	Yes		Yes	101-250	Petty trading	1-7500	30001 -37500
HH026	Yes		Yes	101-250	Petty trading	7501-25000	More than 37500

HH027	Yes		Yes	101-250	Petty trading	1-7500	More than 37500
HH028	Yes		Yes	101-250	Petty trading	1-7500	More than 37500
HH029	Yes		Yes	1-100	Petty trading	1-7500	More than 37500
HH030	Yea		Yes	101-250	Farming	7501-15000	More than 37500
HH031	Yes		Yes	101-250	Farming	1-7500	22501- 30000
HH032	Yes		Yes	101-250	Petty trading	7501-15000	More than 37000
HH033	Yes		Yes	101- 250	Farming	1-7500	More than 37500
HH034	Yes		Yes	101-250	Farming	7500- 15000	More than 37500
HH035	Yes		No		Begging	1-7500	7501- 15000
HH036	Yes		Yes	101-250	Piece work	15001-28000	7501-15000
HH037	Yes		Yes	101-250	Piece work	1-7500	15001- 22500
HH038	Yes		Yes	101-250	Farming, Piece work	15001- 28000	More than 37500
HH039	Yes		Yes	101-250	Petty trading	1-7500	More than 37500
HH040	Yes		Yes	101-250	Farming	28001-35000	15001-22500
HH041	Yes		Yes	101-250	Piece work	1-7500	7501-15000
HH042	Yes		Yes	101-250	Other (supported by Family member in South Africa)	7501-15000	30001-37500
HH043	Yes		Yes	101-250	Piece work	1-7500	7501-15000

HH044	Yes		Yes	101-250	Other (supported by Family member in South Africa)	More than 35000	More than 37500
HH045	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH046	Yes		Yes	101-250	Piece work	1-7500	7501-15000
HH047	Yes		Yes	101-250	Farming	7501-15000	22501-30000
HH048	Yes		Yes	101-250	Farming	7501-15000	7501-15000
HH049	Yes		Yes	101-250	Piece work	1-7500	7501-15000
HH050	Yes		Yes	101-250	Petty trading, Social Cash Transfer	1-7500	7501-15000
HH051					Other (From family members)	1-7500	7501-15000
HH052	Yes		Yes	101-250	Piece work	1-7500	15001-22500
HH053	Yes		Yes	101-250	Piece work	7501-15000	1-7500
HH054	Yes		Yes	101-250	Piece work	7501-15000	22501-30000
HH055	Yes		Yes	101-250	Petty trading	7501-15000	15001-22500
HH056	Yes		Yes	101-250	From family members	1-7500	15001-22500

HH057	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH058	Yes		Yes	101-250	Farming	1-7500	1-7500
HH059	Yes		Yes	251-500	Farming, Piece work	28001-35000	15000-22500
HH060	Yes		Yes	1-100	Farming	More than 35000	22501-30000
HH061	Yes		Yes	101-250	Farming	1-7500	1-7500
HH062					Piece work	1-7500	1-7500
HH063					Piece work	1-7500	1-7500
HH064					Piece work	1-7500	1-7500
HH065					Piece work	1-7500	1-7500
HH066	Yes		Yes	251-500	Petty trading	>35000	30001-37500
HH067	Yes		Yes	251-500	Piece work	1-7500	1-7500
HH068	Yes		Yes	251-500	Piece work	1-7500	7501-15000
HH069	Yes		Yes	251-500	Piece work	7501-15000	15001-22500
HH070	Yes		Yes	251-500	Piece work, farming	7501-15000	22501-30000
HH071	Yes		Yes	751-1000	Farming	1-7500	7501-15000
HH072	Yes		Yes	251-500	Piece work	1-7500	7501-15000
HH073	Yes		Yes	251-500	Piece work	1-7500	1-7500
HH074	Yes		Yes	251-500	Piece work	1-7500	1-7500
HH075	Yes		Yes	101-250	Farming	7501-15000	15001-22500

HH076	Yes		Yes	101-250	Petty trading	7501-15000	15001-22500
HH077	Yes		Yes	101-250	Farming	7501-15000	22501-30000
HH078	Yes		Yes	101-250	Farming	7501-15000	15001-22500
HH079	Yes		Yes	101-250	Piece work	7501-15000	15001-22500
HH080	Yes		Yes	101-250	Piece work	1-7500	7501-15000
HH081	Yes		Yes	101-250	Petty trading	7501-15000	22501-30000
HH082	Yes		Yes	101-250	Other (From family members in south Africa)	15001-2800	30001-37500
HH083	Yes		Yes	101-250	Piece work	1-7500	7501-15000
HH084					Employment	More than 35000	More than 37500
HH085					Piece work	1-7500	7501-15000
HH086	Yes		Yes	101-250	Farming	7501-15000	22501-30000
HH087					Piece work	1-7500	1-7500
HH088	Yes		Yes	101-250	Petty trading	7501-15000	22501-30000
HH089					Piece work	7501-15000	15001-22500
HH090	Yes		Yes	101-250	Piece work	7501-15000	15001-22500
HH091	Yes		Yes	101-250	Piece work	7501-15000	22501-30000
HH092	Yes		Yes		Other (Maize mill business)	More than 35000	More than 37500
HH093	Yes		Yes	101-250	Farming	15001-28000	15001-22500

HH094	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH095	Yes		Yes	101-250	Piece work	1-7500	7501-15000
HH096	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH097					Piece work	1-7500	7501-15000
HH098	Yes		Yes	501-750	Piece work	1-7500	1-7500
HH099	Yes		Yes	501-750	Piece work	1-7500	1-7500
HH100	Yes		Yes	501-750	Piece work	1-7500	15001-22500
HH101	Yes		Yes	501-750	Piece work	1-7500	7501-15000
HH102	Yes		Yes	101-250	Petty trading	1-7500	7501-15000
HH103	Yes		Yes	101-250	Farming	1-7500	7501-15000
HH104	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH105	Yes		Yes	101-250	From south Africa	15001-22500	7501-15000
HH106	Yes		Yes	101-250	Farming	28001-35000	22501-30000
HH107						1-7500	7501-15000
HH108					Piece work	1-7500	1-7500
HH109	Yes		Yes	501-750	Farming	15001-28000	7501-15000
HH110	Yes		Yes	101-250	Farming	1-7500	1-7500
HH111	Yes		Yes	501-750	Petty trading	28001-35000	15001-22500
HH112	Yes		Yes	251-500	Social cash transfer	7501-15,000	7501-15,000

HH113	Yes		Yes	251-500	Petty trading	1-7500	7501-15000
HH114	Yes		Yes	251-500	Petty trading	15001-28000	22501-30000
HH115	Yes		Yes	251-500	Piece work	7501-15000	1-7500
HH116	Yes		Yes	101- 250	Piece work	7501-15000	1-7500
HH117	Yes		Yes	751-1000	Piece work	7501-15000	22501-30000
HH118	Yes		Yes	101-250	Farming	More than 35000	More than 37500
HH119	Yes		Yes	101-200	Farming	7501-15000	7501-15000
HH120	Yes		Yes	501-750	Piece work	7501-15000	7501-15000
HH121	Yes		Yes	251-500	Employment	15001-28000	7501-15000
HH122	Yes		Yes	251-500	Petty trading	1-7500	1-7500
HH123	Yes		Yes	201-500	Petty trading	1-7500	1-7500
HH124	Yes		Yes	251-500	Farming	1-7500	1-7500
HH125	Yes		Yes	251-500	Petty trading	1-7500	1-7500
HH126	Yes		Yes	251-500	Piece work	7501 -15000	7501-15000
HH127	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH128	Yes		Yes	251-500	Petty trading	7501-15000	7501-15000
HH129	Yes		Yes	501-750	Farming	7501-15000	7501-15000
HH130	Yes		Yes	251-500	Piece work	7501-15000	7501-15000
HH131	Yes		Yes	101-250	Farming	1-7500	1-7500
HH132	Yes		Yes	250-500	Farming	7501-15000	7501-15000
HH133	Yes		Yes	101-250	Piece work	7501-15000	7501-15000

HH134	Yes		Yes	101-250	Piece work	7501-15000	7501-15000
HH135	Yes		Yes	251-500	Fishing	28001-35000	15,001-22,500
HH136	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH137	Yes		Yes	101-250	Fishing	More than 35000	30,001-37,500
HH138	Yes		Yes	501-750	Farming	7501-15000	1-7,500
HH139	Yes		Yes	251-500	Farming	More than 35000	22500-30000
HH140	Yes		Yes	101-250	Petty trading	1-7500	1-7500
HH141	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH142	Yes		Yes	251-500	Petty trading	1-7500	1-7500
HH143	Yes		Yes	101-250	Farming	1-7500	1-7500
HH144	Yes		Yes	101-250	Farming	15001-28000	30001-37500
HH145	Yes		Yes	101-250	Farming	1-7500	1-7500
HH146	Yes		Yes	101-250	Farming	1-7500	1-7500
HH147	Yes		Yes	101-250	Farming	1-7500	More than 37500
HH148	Yes		Yes	More than 1000	Petty trading	7501-15000	More than 37500
HH149	Yea		Yes	101-250	Farming	1-7500	1-7500
HH150	Yes		Yes	101-250	Farming	7501-15000	7501-15000
HH151	Yes		Yes	101-250	Farming	15001-22500	7501-15000
HH152	Yes		Yes	101-250	Farming	More than 35000	More than 37500
HH153	Yes		Yes	101-250	Petty trading	1-7500	1-7500
HH154	Yes		Yes	More than 1000	Piece work	1-7500	More than 37500

HH155	Yes		Yes	251-500	Farming	1-7500	More than 37500
HH156					Farming	1-7500	More than 37500
HH157	Yes		Yes	101-250	Petty trading	1-7500	1-7500
HH158	Yes		Yes	101-250	Petty trading	More than 35000	More than 37500
HH159	Yes		Yes	101-250	Farming	1-7500	1-7500
HH160	Yes		Yes	101-250	Petty trading	1-7500	1-7500
HH161	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH162	Yes		Yes	261-500	Piece work	7501-15000	1-7500
HH163	Yes		Yes	251-500	Farming	More than 35000	More than 37500
HH164	Yes		Yes	251-500	Farming	7501-15000	15001-22500
HH165	Yes		Yes	251-500	Farming	15001-22500	22501-30000
HH166	Yes		Yes	251-500	Farming	7501-15000	30001-37500
HH167	Yes		Yes	251-500	Farming	1-7500	More than 37500
HH168	Yes		Yes	250-500	Farming	7501-15000	More than 37500
HH169	Yes		Yes	101-250	Farming	1-7500	22501-30000
HH170	Yes		yes	251-500	Farming	15001-28000	More than 37500
HH171	Yes		Yes	251-500	Farming	1-7500	1-7500
HH172					Fishing	1-7500	1-7500
HH173					Fishing	15001-28000	15001-22500
HH174	Yes		Yes	101-250	Petty trading	1-7500	1-7500
HH175	Yes		Yes	251-500	Farming	1-7500	More than 37500

HH176	Yes		Yes	251-500	Farming	1-7500	More than 37500
HH177	Yes		Yes	251-500	Farming	1-7500	7501-15000
HH178	Yes		Yes	251	Fishing	1-7500	7501-15000
HH179	Yes		Yes	251-500	Petty trading Fishing	7501-15000	15001-22500
HH180	Yes		Yes	251-500	Petty trading	More than 35000	30001-37500
HH181	Yes		Yes	251-500	Petty trading	1-7500	1-7500
HH182	Yes		Yes	251-500	Piece work	15001-28000	15001-22500
HH183	Yes		yes	101-250	Kaunjika selling	More than 35000	More than 37500
HH184	Yes		Yes	251-500	Business selling dried fish	More than 35000	More than 37500
HH185	Yes		Yes	251-500	Piece work	1-7500	More than 37500
HH186	Yes		Yes	501-750	Piece work	1-7500	1-7500
HH187	Yes		Yes	501-750	Piece work	1-7500	1-7500
HH188	Yes		Yes	501-750	Petty trading	More than 35000	More than 37500
HH189	Yes		Yes	101-250	Piece work	15001-2800	More than 37500
HH190	Yes		Yes	101-250	Employment	28001-35000	more than 37500
HH191	Yes		Yes	251_500	Employment	More than 35000	More than 37500
HH192	Yes		Yes	101-250	Petty trading	1-7500	More than 37500
HH193	Yes		Yes	251-500	Petty trading	1-7500	More than 37500
HH194	Yes		Yes	101-250	Farming	1-7500	More than 37500

HH195	Yes		Yes	251-500	Petty trading	15001-22500	More than 37500
HH196	Yes		Yes	101-250	Petty trading	More than 35000	More than 37500
HH197	Yes		Yes	251-500	Petty trading	1-7500	More than 37500
HH198	Yes		Yes	101-250	Petty trading	7501-15000	15001-22500
HH199	Yes		Yes	101-250	Fishing	15001-28000	More than 37500
HH200	Yes		Yes	501-750	Petty trading	1-7500	More than 37500
HH201	Yes		Yes	251-500	Fishing	7501-15000	30001-37500
HH202	Yes		Yes	101-250	Fishing	7501-1500	15001-22500
HH203	Yes		Yes	251-500	Fishing	7501-15000	22501-30000
HH204	Yes		Yes	101-250	Piece work	7501-15000	22501-30000
HH205	Yes		Yes	751-1000	Petty trading	7501-15000	22501-30000
HH206	Yes		Yes	101-250	Petty trading	15001-28000	More than 37500
HH207	Yes		Yes	101-250	Farming	1-7500	More than 37500
HH208	Yes		Yes	251-500	Piece work	1-7500	1-7500
HH209	Yes		Yes	251-500	Farming	7501-15000	15001-22500
HH210	Yes		Yes	151-500	Piece work	15001-28000	30001-37500
HH211	Yes		Yes	251-500	Petty trading	7501-15000	1-7500
HH212	Yes		Yes	1001-250	Farming	28001-35000	More than 37500
HH213	Yes		Yes	501-750	Farming	1-7500	More than 37500
HH214	Yes		Yes	101-250	Fishing	15001-28000	More than 37500
HH215	Yes		Yes	251-500	Employment	More than 35000	More than 37500

HH216	Yes		Yes	101-250	Farming	1-7500	More than 37500
HH217	Yes		Yes	251-500	Farming	1-7500	30001-37500
HH218	Yes		yes	101-250	Farming	1-7500	More than 37500
HH219	Yes		Yes	101-250	Farming	1-7500	15001-22500
HH220	Yes		Yes	101-250	Farming	7501-15000	More than 37500
HH221	Yes		Yes	101-250	Farming	1-7500	More than 37500
HH222	Yes		Yes	751-1000	Petty trading	15001-28000	More than 37500
HH223	Yes		Yes	751-1000	Other (Businesses running grocery)	More than 35000	More than 37500
HH224	Yes		Yes	251-500	Petty trading	1-7500	More than 37500
HH225	Yes		Yes	251-500	Petty trading	1-7500	More than 37500
HH226	Yes		Yes	101-250	Piece work	1-7500	7501-15000
HH227	Yes		Yes	101-250	Piece work	15001-28000	More than 37500
HH228	Yes		Yes	101-250	Farming	1-7500	7501-15000
HH229	Yes		Yes	251-500	Farming	1-7500	Don't know
HH230	Yes		Yes	251-500	Piece work	1-7500	Don't know
HH231	Yes		Yes	251-500	Farming	1-7500	Don't know
HH232	Yes		Yes	251-500	Piece work	1-7500	15001-22500
HH233	Yes		Yes	251-500	Piece work	1-7500	More than 37500
HH234	Yes		Yes	251-500	Farming	1-7500	More than 37500

HH235	Yes		Yes	751-1000	Piece work	1-7500	More than 37500
HH236	Yes		Yes	>1000	Farming	7501-15000	More than 37500
HH237	Yes		Yes	>1000	Farming	1-7500	More than 37500
HH238	Yes		Yes	>1000	Piece work	1-7500	More than 37500
HH239	Yes		Yes	>1000	Farming	1-7500	Don't know
HH240	Yes		Yes	>1000	Piece work	1-7500	Don't know
HH241	Yes		Yes	>1000	Petty trading	1-7500	More than 37500
HH242	Yes		Yes	751-1000	petty trading	>35000	More than 37500
HH243	Yes		Yes	751-1000	Farming	1-7500	75001-15000
HH244	Yes		Yes	751-1000	Piece work	1-7500	More than 37500
HH245	Yes		Yes	751-1000	Farming	1-7500	More than 37500
HH246	Yes		Yes	751-1000	Farming	1-7500	75001-15000
HH247	Yes		Yes	751-1000	Petty trading	1-7500	More than 37500
HH248	Yes		Yes	751-1000	Farming	1-7500	More than 37500
HH249	Yes		Yes	751-1000	Employment	>35000	More than 37500
HH250	Yes		Yes	751-1000	Farming	1-7500	15001-22500
HH251	Yes		Yes	751-1000	Piece work	1-7500	22501-30000
HH252	Yes		Yes	751-1000	Piece work	1-7500	Don't know
HH253					Petty trading	7501-15000	1-7500
HH254					Piece work	15001-28000	7501-15000
HH255					Piece work	1-7500	1-7500

HH256					Petty trading	7501-15000	1-7500
HH257					Petty trading	1-7500	1-7500
HH258	Yes		Yes	751-1000	Petty trading	7501-15000	1-7500
HH259	Yes		Yes	751-1000	Petty trading	15001-28000	1-7500
HH260	Yes		Yes	101-250	Petty trading	15001-22500	7501-15000
HH261	Yes		Yes	101-250	Farming	7501-15000	1-7500
HH262	Yes		Yes	251-500	Farming	1-7500	More than 37500
HH263	Yes		Yes	251-500	Other (Running grocery)	More than 35000	More than 37500
HH264	Yes		yes	251-500	Farming	1-7500	More than 37500
HH265	Yes		Yes	251-500	Petty trading	1-7500	More than 37500
HH266	Yes		Yes	251-500	Petty trading	7501-15000	30001-37500
HH267	Yes		Yes	251-500	Farming	1-7500	1-7500
HH268	Yes		Yes	251-500	Farming	1-7500	More than 37500
HH269	Yes		Yes	251-500	Farming	1-7500	More than 37500
HH270	Yes		Yes	251-500	Farming	1-7500	More than 37500
HH271	Yes		Yes	101-250	Piece work	1-7500	1-7500
HH272	Yes		Yes	101-250	Farming	1-7500	1-7500
HH273	Yes		Yes	101-250	Farming	1-7500	1-7500
HH274	Yes		Yes	101-250	Petty trading	More than 35000	More than 37500
HH275	Yes		Yes	501-750	Farming	1-7500	15001-22500

HH276	Yes		Yes	251-500	Farming	1-7500	More than 37500
HH277	Yes		Yes	251-500	Farming	7501-15000	More than 37500
HH278	Yes		Yes	101-250	Farming	1-7500	1-7500
HH279	Yes		Yes	251-500	Farming	1-7500	7501-15000
HH280	Yes		Yes	101-250	Fishing	7501-15000	7501-15000
HH281	Yes		Yes	101-250	Employment	More than 35000	More than 37500
HH282	Yes		Yes	101-250	Employment	More than 35000	More than 37500
HH283	Yes		Yes	101-250	Piece work	28001-35000	15001-22500
HH284	Yes		Yes	101-250	Petty trading	More than 35000	More than 37500
HH285	Yes		Yes	251-500	From south Africa	More than 35000	More than 37500
HH286	Yes		Yes	101-250	From Family members	More than 35000	More than 37500
HH287					Petty trading	15001-28000	15001-22500
HH288					Employment	More than 35000	More than 37500