CRANFIELD UNIVERSITY

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The death of the communal handpump?
Rural water and sanitation household costs in lower-income countries

SCHOOL OF APPLIED SCIENCES
Water Sciences

PhD Water Management
Academic Year: 2007- 2014 (part-time)

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ABSTRACT

Rural water supply and sanitation in low and middle income countries face the same challenges now as in the 1970s. Despite massive efforts in providing communal “borehole with handpump” and “improved latrines” to improve the lives of millions of people, this traditional approach to development is failing to deliver long lasting improved services - even if for the last 40 years many attempts have been made to solve problems in the approach.

The main research question is “Can low-income rural families pay for rural water supply and sanitation?” This thesis has analysed household poverty and costs on water and sanitation services in Mozambique and Ghana based on 3,049 surveys collected between 2009-2010 by the IRC International Water and Sanitation Centre WASHCost project.

Evidence shows that even extreme poor households can and do pay for improved water and sanitation services. However, households prefer to pay for more expensive services to reduce the distance required to collect water instead of paying for the cheaper maintenance of communal (further away) sources. For sanitation, without targeted support towards the poorest, improved latrines might be unaffordable. Also, without follow up support, behaviour change and health impact will not be sustained. Small increases in the wealth of the poorest have a large impact on the services demanded in terms of quantity, distance and time spend as well as an increase in the level of capital and maintenance expenditure.

Ultimately, the world now is not the same as in the 1970s and for achieving universal sustainable coverage for water and sanitation we need to rethink the failed traditional approach to development in low income countries with a deeper understanding of the market segmentation in the lowest quintile of the population and their real aspirations and demand.

Keywords:

Expenditure, Poverty, Time, Distance, Access, Quantity, Affordability, Ghana, Mozambique, Maintenance, Handpumps, Boreholes, Latrines, Human Rights, Monitoring

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This thesis is dedicated to the passion and the knowledge of many professionals who have dedicated their lives to ensure that water and sanitation is considered a basic human right and provided as a service to everyone forever.

First I would like to thank the amazing women in my family who have always been a source of inspiration. My grandmother and mother who have supported my decisions through life and have taught me the perseverance, the hard work, the generosity and all that can be achieved with good food, love and a smile. A big thank you also to my husband, friends and baristas which provided the warmth and energy that kept me going through towards the completion of this thesis.

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This work would have not been possible without the incredible team of over 100 people I had the honour and privilege to work with in the WASHCost programme. During 5 years, with the generous support of the Bill and Melinda Gates Foundation and with the guidance of Rachel Cardone, the WASHCost programme has collected the cost and service level data used in this thesis. I would like to thank particularly the enthusiasm and dedication of the core research team which includes Dr. Snehalatha Mekala, Dr. Ratna Reddy, Alana Potter, André Uandela, Arjen Naafs, Julia Zita, Dr. Christelle Pezon, Richard Bassono, Amélie Dubé, Aman Klutsé, Dr. Kwabena Nyarko, Bismark Dwumfour-Asare and Peter Burr. I would like to thank Rutger Verkerk, Jeske Verhoeven and Peter McIntyre, my very close travel companions in what was a long but very joyful journey.

And finally to my dedicated supervisor at Cranfield University and esteemed colleague Dr. Richard Franceys – who has patiently waited for me to finish this long overdue thesis and guided me wisely both professionally and academically.

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LIST OF ABBREVIATIONS

CapEx	Capital expenditure (Includes money, labour and materials)
CapManEx	Capital maintenance expenditure (Includes money, labour and materials)
GDP	Gross domestic product
HH	Household
HHEx	Household expenditure
JMP	Joint Monitoring Programme (UNICEF and WHO)
Lpcd	Litres per capita (person) per day
LCCA	Life-cycle costs approach
MDG	Millennium Development Goals
Na	Not available
NGO	Non-governmental organisation
Ofwat	Water Services Regulation Authority, United Kingdom
OpEx	Operational and minor maintenance expenditure
PPP	Purchase Power Parity
UNICEF	United Nations Children's Fund
US	United States
WASH	Water, sanitation and hygiene
WHO	World Health Organisation

A NOTE ON UNITS

A variety of units are used to measure water, costs, distances, time, etc. The terminology and methodology chapters in this thesis expand on the units but a common thread is the use of US dollars (GDP) per person per day at 2011 current prices. For comparisons among countries the US dollar (PPP) has also been used.

Most of the literature currency is the US dollars and the currency conversion factors are therefore based on the dollar. 2011 is the latest year for which all the currencies have reliable converters available and was chosen as the base year for all the currencies used in this thesis.

The most used currencies in the thesis are:

- *Meticais* (Mozambique)
- *Ghana Cedis* (Ghana). The *Ghana* cedi is divided into one hundred *Ghana pesewas* (*Gp*).

1 INTRODUCTION

This first chapter describes the relevance and importance of the topic chosen for this PhD thesis: how much are rural households really spending on water and sanitation services in lower-income countries? This chapter provides the background, defines the purpose of the research and sets the context in which the research was developed. Additionally, each of the chapters of the thesis is briefly described.

1.1 The traditional approach to development in the water and sanitation sector in lower income countries

Since the 1960s, the provision of communal water services through boreholes and handpumps or gravity fed systems, as well as improved latrines has been the most common approach to development in lower and middle income countries, monitored by WHO (UN-Water, 2014).

In the past fifty years, there have been numerous efforts to make this traditional approach replicable and scalable despite its many challenges: training communities, developing monitoring processes, promoting spare parts availability, making sure there are funds for maintenance, etc. However, according to the latest world global estimates, in 2011 approximately 768 million people remained without access to improved drinking water sources. More dramatically, in 2011 there were 2.5 billion people (37 percent of the global population) who still did not have access to an improved sanitation facility (WHO/UNICEF, 2013). Of those with access to water and sanitation facilities, many suffer from poor continuity, poor quality and premature system failure. Onda, LoBuglio and Bartram (2013) estimated that in 2010, 1.8 billion people had unsafe water and an additional 1.2 billion used water with significant sanitary risk.

Thought out the years, many have blamed the failed investments in rural water supply and sanitation infrastructure on the focus on the construction of the new infrastructure rather than meeting the requirements necessary for providing sustainable long lasting services (Curtis, 1986; Churchill et al., 1987; Therkildsen, 1988; World Bank, 1994; Lockwood and Smits, 2013). As a result, there are high rates of non-functioning rural water supply systems typically ranging from 20 to 50 percent in countries such as Tanzania, Honduras, Ethiopia, Liberia, Sierra Leone, Ghana and India (GoT, 2013; Smits, 2013; GoE, 2013; WSP, 2012; GoSL, 2012; Adank et al., 2013; Reddy et al., 2010). In sanitation, high rates of open defecation after latrine construction or increased health risks have also been reported in Cambodia, Kenya, Nepal, Nigeria, India and schools in Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka (WSP, 2012; Greene et al., 2012; WaterAid, 2009; Snehalatha and Raj, 2011: UNICEF, 2012).

The problem of premature failure of water systems and lack of maintenance in least developed countries and regions has been reported in the academic literature since at least the 1970s:

> *"The major problem associated with providing water supplies in rural areas of lower income countries relates to the operation and maintenance of systems." (Saunders and Warford, 1976:198)*
>
> *"The requirements for help in cleaning and improving water sources are stronger in rural territory than in towns. […] work crews and periodic clean-up operations tend to be informal and in response to the initiative of concerned households" (White, Bradley and White, 1972:240)*
>
> *"In almost all countries with viable water supply programs, it is not difficult to find villages where the water supply system is either not working as planned (either technically or financially) or not functioning at all. In fact, in two countries we visited, one in East Africa and one in Central America, systems were actually failing at a more rapid rate than they were being constructed." (Saunders and Warford, 1976:142)*
>
> *"In yet another country, as many as 80 percent of the hand pumps were not functioning at any one time, since no provision had been made for maintenance or repair. […] In still another country, authorities installed some 2000 latrines in rural villages […] Two years later, project personnel discovered that most of the households were using the latrines as storage closets. […] In country after country systems are going out of operation almost as fast as they are being built. Such failures make the international aid community understandably wary about continuing to lend money for programs that not only have little to recommend them in terms of returns for the dollar, but also simply do not work. (Churchill et al., 1982:2-3)*

From 1967 through 1989, the World Bank financed 129 urban water supply and sanitation projects. The first Operations Evaluation Department review concludes that:

"All projects, except two, provided the physical assets set out at project appraisal. […] O&M generated the smallest number of comments, not because of its quality but because little attention was paid to it in Project Completion Reports and Project Appraisal Reports. The main reason appears to be that the Bank does not specifically require it to be addressed in PCRs and the majority of Bank staff have limited sector operation experience. When it was raised, the principal O&M issue was lack of funds, leading to lack of spare parts, lack of adequate staff, training, and management qualified to organize O&M. This lack of funds for O&M was often present during project implementation." (World Bank, 1992:iii)

It is estimated that more than a billion people gained access to safe drinking water during the first United Nations Decade on Water (1981–1990), but achievements fell short from initial ambitions:

"A question which is often posed is why did the Decade did not achieve more? The answer to this lies in the constraints to progress cited by governments consistently throughout the 1980s, most serious among which are: funding limitations, inadequate operations and maintenance, inadequate cost recovery, insufficient trained personnel" (WHO, 1992:iv)

1.2 Efforts to "fix" the traditional approach

To addess many of the challenges mentioned above, in the water and sanitation sector discourse over the past forty years it is often expected that communities pay at least for the operation and maintenance costs of their water and sanitation systems (White, Bradley and White, 1972; Churchill et al., 1987; World Bank, 1992; Briscoe and Garn, 1995; Briscoe, 1999; Dinar, 2000; Cardone and Fonseca, 2003). Household contributions towards cost recovery strategies have been seen as a potential key solution towards financial sustainability and calls for improved tarrif setting, fee collection and other mechanims to increase revenue are common recommendations in sector reviews across rurral and urban, least developed and developed countries (World Bank, 1997; Whittington, 2003; Waughray and Moran, 2003a; Winpenny, 2003; Banerjee et al., 2010).

However, in rural areas of lower-income countries, it is hardly known how much households are contributing for the construction or the maintenance of the infrastructure (WHO, 2010; WHO, 2012). The extent of non-financial expenditure in terms of individuals and communities contributions with their own time and local materials for construction and maintenance of systems are even less known (Waughray and Moran, 2003).

Furthermore, there has been limited equality in access to water and sanitation services. The poorest are more likely not to have water and sanitation services than the wealthy and rural areas have much lower coverage than urban areas. In many of the countries where access has increased, the increase is disproportionate, favouring those in the wealthier quintiles and living in urban areas. This is especially true for sanitation. The poorest 40 percent of the population in Southern Asia have barely benefited from improvements in sanitation in the last decade (WHO/UNICEF, 2013).

More recently, through resolution 64/292, the United Nations General Assembly (2010) recognised access to safe drinking water and sanitation as a human right essential to the realisation of all other human rights. One of the key priorities enshrined in the Human Rights framework for water and sanitation is that of progressive realisation across several indicators and reducing inequalities in access to services (Satterthwaite, 2012). However, there has been limited work done to date in discussing and testing the proposed indicators so they can be used to measure global progress across countries (Kayser, Moriarty, Fonseca and Bartram, 2013).

1.3 Purpose of the research

The research question in this thesis is: “Can low-income rural households pay for water supply and sanitation services?”. There are two hypothesis which will be investigated:

- Hypothesis 1: Low income rural households cannot pay for the construction and maintenance costs or/and tariffs are too high.
- Hypothesis 2: Low income rural households can pay for improved water and sanitation but are not prioritising to do so.

This thesis will investigate what is the household expenditure (financial and economic, expressed in US dollars) on rural water and sanitation services in lower-income countries. Financial expenditure refers to the costs of building or maintaining water and sanitation services, economic expenditure reflects the non-cash resources such as time spend in accessing water and in-kind contributions to the construction and maintenance of water and sanitation facilities.

To answer the main research question and test the two hypotheses, this research will:

i. Identify what are the financial costs to households to reach their present level of rural water supply and sanitation services in Mozambique and Ghana.
ii. Analyse if costs and service levels vary with household socio-economic status and to what extent

Adding to the financial analysis, the research will also attempt to identify what are the non-financial contributions (time and in-kind contributions) of households to reach their present level of services.

Additionally, the research will compare the service levels received by households with the standards proposed by the Human Rights framework – services can be affordable but are they meeting the basic standards set by the Human Rights resolution?

1.4 Generic terminology

1.4.1 Low and lower-middle income economies

The World Bank classifies economies based on the gross national income (GNI) per capita. Every economy is classified as low income, lower-middle income, upper-middle income and high-income. Mozambique is classified as a low-income economy (GNI per capita of $1,035 or less) and Ghana is classified as a lower-middle income economy (GNI per capita between $1,036 and $4,085) (The World Bank, 2013).

1.4.2 Rural and peri-urban areas

With increasing population density in rural areas and some rural characteristics of urban small towns, it becomes more difficult to identify clearly what is a rural area. Similarly, peri-urban areas are variously defined but in this thesis are taken to include urban areas with informal housing, limited infrastructure, high levels of poverty and deprivation and no formal services. They are often referred to as slums, barrio, shanty towns etc. Although the term means “around the city”, it is meant to include areas that meet this description even if they are “within” urban areas. Peri-urban is an area which is better defined by its socio-economic and institutional characteristics rather than its geographical location: poor and disorganised, where services are not formally provided and institutional arrangements are insecure. There is a proliferation of small private entrepreneurs to fill the gaps that government services are not filling. In some of these areas housing is illegal making data collection on costs more difficult (Hidding et al., 2000; Myers, 2010; Zhao, 2012).

1.5 Potential benefit of the work

Service providers cannot adequately plan, budget or set user charges for water and sanitation services without quantitative data to support – or drive – these processes. The overall goal of the research is to contribute to the policy debate in two areas:

i. Develop an understanding of the deep root causes of failure of the traditional approach to development in the sector by understanding the real costs to households of accessing services of various standards and;
ii. The implications of future global water and sanitation targets and indicators, especially those that relate with increasing access to services that fulfil basic needs and target reducing inequalities.

In the context of decentralisation, local governments, utilities, NGOs and other service providers need strategies for improved cost recovery and increased service coverage, particularly for the poorest. These strategies must be informed by a rigorous analysis of quantitative data related to the magnitude and adequacy of household finance that is available to meet both capital and recurrent costs. The present research will inform this process.

Rising inequalities are a global concern, economically inefficient and will not deliver a better world in the future (UNICEF/UN Women, 2013). In the latest risk assessment by the World Economic Forum (2013), severe income disparity has been identified as the number one likely risk to occur and water supply crises the second risk in terms of negative impact. The limited data available for inequalities in access to water and sanitation coverage shows that the gap to be covered for many countries and regions is relatively large (Satterthwaite, 2012). Setting targets specifically for reducing inequalities in access to water, sanitation and hygiene services will enable countries to strike a balance between investing in sustainable and better services and investing in reaching the people that have so far been left out.

1.6 Context: The WASHCost project

The author initiated her part-time PhD in January 2007 based on a multi-year research project in Ethiopia with a component focused on rural water and sanitation costs and benefits. The initial PhD research proposal was then further developed and submitted as a project proposal called WASHCost at the request of the Bill and Melinda Gates Foundation. The Foundation was new to the water and sanitation sector at that time and required a more in-depth understanding of the costs in lower-income countries. The WASHCost project started in February 2008 and ended in August 2013, amounting to a 15 million dollar action-research project in four countries (Ghana, Burkina Faso, Mozambique and India) with a global multidisciplinary team of 120 staff members.

The WASHCost objective was to improve access to accurate knowledge on disaggregated water, sanitation and hygiene (WASH) costs in rural and peri-urban areas. WASHCost set out to develop a methodology and data set for what the project called a 'life-cycle costs approach' (LCCA) to assist sustainable water and sanitation service delivery. It aimed to inform and influence decisions at local and national levels (focusing on Burkina Faso, Ghana, India [Andhra Pradesh] and Mozambique) and at the international level. Globally WASHCost aimed for the adoption of the life-cycle-costing terminology whilst influencing global sector agencies to incorporate these approaches into WASH policy and budgeting frameworks.

The author was the Project Director responsible for the execution of project and was also the Research Director, responsible for content development and orientation of the research and providing guidance to the country teams. In the words of the external evaluators on the conclusion of the project: "WASHCost has been a once in a generation opportunity". The terminology and methodologies that WASHCost adapted, developed, tested and applied are now being used by over 70 organisations and governments across the World (Cross, Frade, James and Trémolet, 2013).

The development of the project presented an opportunity to better link the PhD part-time research with the full-time activities of the WASHCost project but it has also presented a risk given the considerable increase of responsibilities of the author in managing such a large project. The second year of the project was particularly challenging and the PhD had to be "frozen" in the first 6 months of 2009. It was expected that the six year time frame would allow the PhD to be undertaken in parallel with the WASHCost Project but that too proved unrealistic. However, all the background work done for the PhD (Fonseca transfer review meeting, 2008; Fonseca third year report, 2010) has been at the backbone of the WASHCost research publications. These publications have been peer-reviewed and widely considered of good quality (Cross, Frade, James and Trémolet, 2013).

Although there was a large team involved, which benefited from the professional inputs of other experts, the research leadership of the WASHCost project was provided by Catarina Fonseca, who also acted as the main author and responsible for writing and compiling the core WASHCost methodological papers (Fonseca, 2007; Verhoeven, Fonseca, Kwaku et al, 2010; Fonseca, Franceys, Batchelor et al., 2011; Fonseca, Dubé and Verhoeven, 2011; Burr and Fonseca, 2011; Fonseca, Smiths, Nyarko et al., 2011; Moriarty, Batchelor, Fonseca et al, 2011; Burr and Fonseca, 2013).

1.7 Unique areas of investigation

The purpose of the research set in chapter 1.3 is unique to the research in this thesis. Specifically, areas of investigation under this PhD which were not part of WASHCost include:

- An in-depth analysis, cleaning and translation of two datasets containing more than 3.000 household surveys with more than 450 variables collected in two of the four countries: Mozambique and Ghana;
- A very limited number of variables (about 30) per country was analysed and published under WASHCost. There has been no cross-country analysis or publication of the household dataset alone;
- An in-depth analysis of household financial expenditure across the two countries for water and sanitation. A similar analysis has been done for the water dataset of Burkina Faso by researcher Ryan Schweitzer of the University of South Florida under the supervision of Dr. Christelle Pezon and Catarina Fonseca at IRC who have also co-authored the paper (Schweitzer et al. 2013) and for the India dataset by several researchers including Catarina Fonseca (LNRMI et al, 2014);
- An in-depth analysis of households non-financial contributions across the two countries for water and sanitation (for Burkina Faso this work has been done on water by Schweitzer);
- An analysis of the different measures of socio-economic status and an analysis and comparison of the dataset disaggregated by each of the categories;

- A comparison of the household dataset against the criteria being proposed as indicators of service for global benchmarking and monitoring.

Areas of research which have benefited from the knowledge and experience of the wider research team which are relevant for this thesis include:

- In 2009, the testing of the initial assumptions and methodology components. Indicators and respective questionnaires have been developed, and cost components finalised;
- In 2009, preliminary data was collected by all country teams and in 2010 large scale data collection was undertaken in each of the four countries including over 12.000 household surveys;
- A system of storing and coding data in Excel has been developed with external professional support;

Oversight, guidance and priority setting for each of these areas was the author's responsibility. The author also joined the Mozambique country team for testing questionnaires at household and district level. The questionnaires checklists for district, regional and national level have been developed by the author with support from Jeske Verhoeven in several interactions with the country-based research teams.

The aggregation of 30 key variables from the four countries as well as establishing the coding and storing procedures which allow for the aggregation was coordinated by the author, with advice provided by Dr. Kristof Bostoen and implemented by Jeske Verhoeven.

During 2011-2013, a PhD researcher from Cranfield University, Peter Burr, joined the WASHCost research team and two publications for sanitation and water respectively have been jointly written and are quoted when required (Burr and Fonseca, 2011; Burr and Fonseca, 2013). The PhD studies of Burr and Fonseca focus on different components of the research and there are no further overlaps.

In WASHCost, the four country databases – focusing on the 30 key variables from HH surveys - were aggregated to allow for the cross country analysis, this work has been done by researcher Peter Burr and the country teams under the supervision of the author. However, for the purpose of this thesis, the raw household databases have been fully translated, statistically cleaned and harmonised and compared across the 450 variables by the author.

Dr. Richard Franceys, the author's supervisor, has been part of the WASHCost team with an advisory role from the beginning of the project. His involvement means there have been frequent interactions concerning the research activities of the WASHCost project which are in tandem with those of the PhD.

Additionally, the initial work on unit cost disaggregation and comparisons developed by Fonseca (2007) for the Bill and Melinda Gates Foundation but unpublished at the request of the client, has been further updated and the first cost benchmarks for water and sanitation in rural and peri-urban areas in lower income countries have been developed (WASHCost 2012a, WASHCost 2012b).

Whenever PhD related research has been written with inputs from other WASHCost staff, these are properly acknowledged throughout the thesis.

1.8 Outline of the thesis

The second chapter of the thesis presents the key findings and gaps from the literature review mainly on the existing literature and data concerning financial and economic expenditure from households, how household socio-categories are described and defined around the world and finally what are the existing global standards and proposed indicators to measure service levels.

The third chapter describes the terminology and methodologies used to collect, store and clean the data. This chapter is followed by the description of the analysis of the country data and the cross-country comparison.

The fifth chapter presents the analysis and discussion in the four key areas: financial and economic costs, service level indicators and comparison with global standards and poverty analysis. The final chapters provide the conclusions and recommendations, followed by references and appendices.

2 Literature review

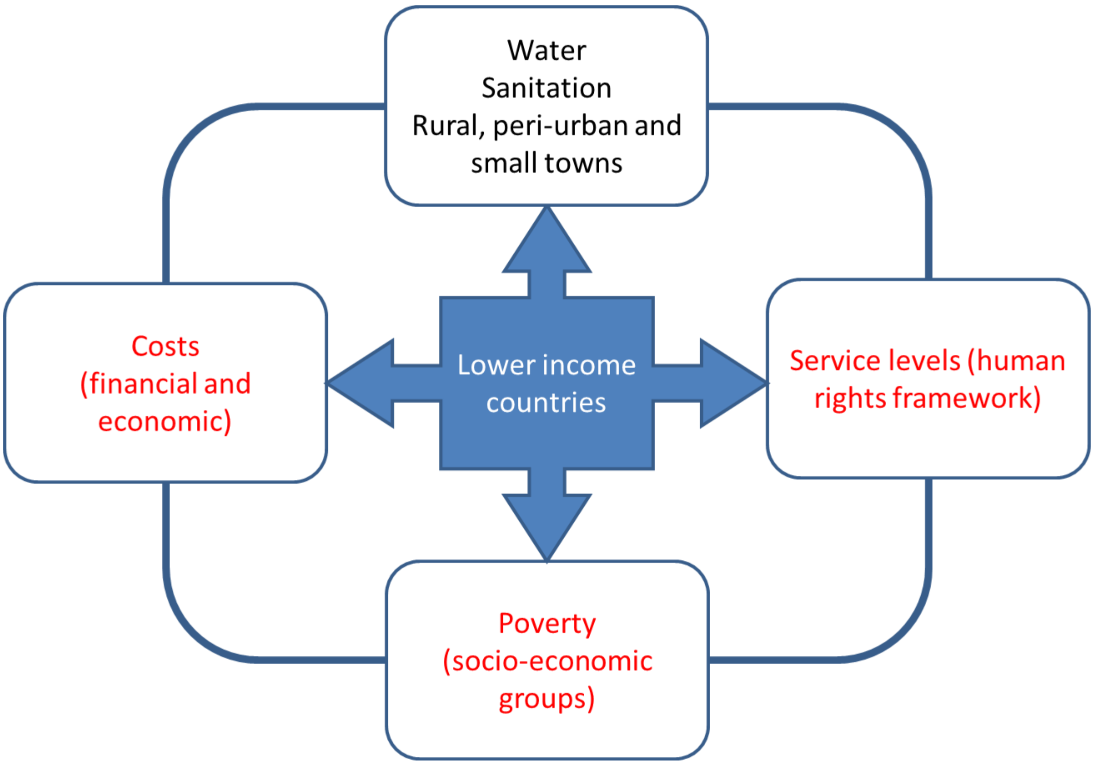
This chapter summarises and discusses the main knowledge and gaps in the literature concerning the three main blocks or areas of knowledge which will be used throughout the thesis (Figure 1):

i) The financial and economic terminology and methodologies used to define and analyse costs in the rural and peri-urban water and sanitation sector in lower income countries (required for the cost analysis);

ii) The available options for categorising and comparing households into socio-economic groups (required for the poverty analysis);

iii) The indicators and methodologies proposed behind existing global standards for water and sanitation services as defined in the human rights framework (required for service level analysis).

Figure 1 Main blocks of analysis in the literature review and in the thesis



This figure will be used as a visual index at the start of each of the chapters.

2.1 Tracking financial and economic costs in water supply and sanitation in lower-income countries

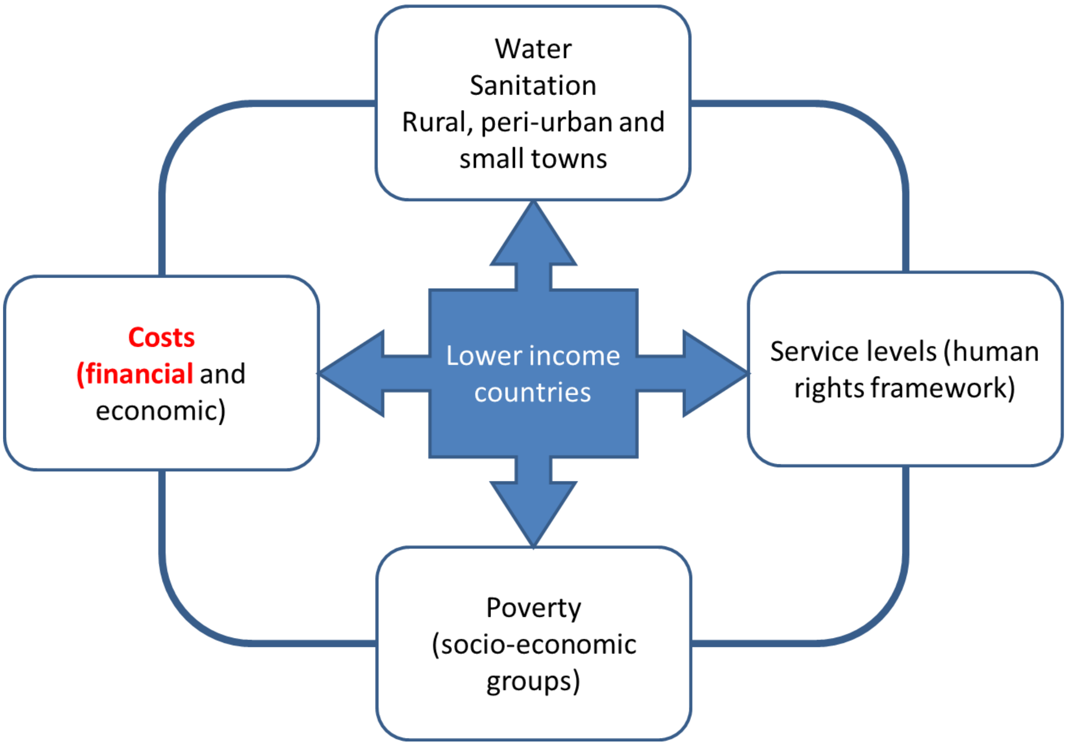
The systematic collection and publication of unit costs for water and sanitation in lower-income countries and specifically for rural and peri-urban areas which are not served by utilities is relatively recent. This thesis focuses exclusively on the water and sanitation sector in countries which are classified as lower-middle income countries according to their gross national income (The World Bank, 2013). Early examples from the urban sector and middle-higher income countries are used as a stepping stone for historical and terminology analysis.

If the urban sector is excluded, there are most certainly various cost studies in the water and sanitation sector which have taken place but have either not been identified, or reported internationally or are not in the public domain.

Through the analysis of the literature, two types of cost categories are analysed: financial and economic. Both are expressed in monetary terms but they are different by nature. Financial costs reflect expenditure undertaken in building or maintaining water and sanitation services, economic costs take a broader perspective and focus on the non-cash resource and/or opportunity costs or the “next best” alternative use of available resources (Churchill et al., 1987; Whittington et al., 1989; Rassas, 1992). Economic costs reflect the costs to the economy as a whole and not only the financial transactions that take place. When there is an economically efficient allocation of resources, financial costs reflect economic costs as closely as possible (Mara et al., 1982; Irvin, 1986).

Economic costs are particularly useful in the context of the water and sanitation sector in lower-income countries where household financial expenditure do not fully reflect the time spent on collecting or hauling water or digging pits for latrines. Such time can be spent on other productive uses such as agriculture, food preparation or employment with a formal wage. An analysis of economic costs sheds further insights into the size of investment households, particularly women, are making (Curtis, 1986; Whittington et al., 1989).

2.1.1 Financial costs for rural water and sanitation in lower-income countries



This chapter focuses on the financial costs, providing an historical perspective that sheds light on the terminology used to describe the monetary transactions in the water and sanitation sector which is mainly derived from the urban utilities. It also describes how different types of costs have been categorised, grouped and forgotten when used in the rural low-income countries context. The chapter provides cost definitions, describes the accounting frameworks which are used to compare costs and the implications of the different approaches to the sector and the methodology chapter of this thesis.

2.1.1.1 A historical perspective on reported financial costs

Reported financial costs in the sector are rather recent. In high-income countries, taking just one example, it was reported in 1969 in the Manual of British Water Engineering Practice by the Institution of Water Engineers that 'a new basis of comparing costs has been evolved in recent years' and for further information it refers to 'An Introduction to Engineering Economics for Civil Engineering Students' of 1947. In this early book the following costs are described separately:

i) *Fixed capital: "[…] assets which are not intended to be sold but to be retained as instruments of production or to produce additional wealth" (Inst. of Civil Engineers, 1947:4).*

ii) *Maintenance: "The costs of keeping an asset in good serviceable condition." (Inst. of Civil Engineers, 1947:5) and "Maintenance in civil engineering includes not only the timely routine repairs to the fabric but also the prevention of interference with the stability of the works or with their proper use or operation" (Inst. of Civil Engineers, 1947:15).*

iii) *Running costs: "Expenditure for all services, labour, materials, consumable stores, and other commitments incurred in operating an asset. Such costs generally include overhead expenses such as supervision, rates, insurance and other standing charges which may be incurred whether the asset is actually operated or not." (Inst. of Civil Engineers, 1947:6). "In general, running costs are those incurred in the use or operation of an asset as distinct from maintenance costs which are incurred in keeping the asset in good serviceable condition" (Inst. of Civil Engineers, 1947:16).*

This is relevant because the terminology separates quite clearly the running costs from the larger maintenance costs, which are more related to provisions made for the life of the asset and the fixed capital, than with daily operations.

> *"We may define capital costs as expenses incurred more or less as a lump sum to achieve certain ends, where these latter accrue or are received over a considerable period of time. By way of contrast, current or operating costs are incurred to achieve certain immediate purposes, and the expenditure must be constantly renewed if it is desired to continue receiving the benefits" (Hirshleifer et al., 1960:158)*

In 1972 White, Bradley and White collected costs from twelve rural sites in Kenya, Uganda and Tanzania. They concluded that "*on a per capita basis, the installation expenses run from less than $ 1 (2011 US$ 4) to more than $30 (US$ 130) and in the study sites $6 (US$ 26) was not uncommon*" (p. 76). The authors have also compiled the costs of construction per person described in the literature from the previous decade showing a wide range of costs from a variety of sites. The table is reproduced (Table 1) and is interesting because it links the costs of infrastructure with the per capita consumption – many years would pass until reported costs where linked again with some indication of the level of service provided.

Table 1 Capital costs and litres per capita for community water systems (1972)

Per capita consumption (litres/day)	Type of system: Simple	Type of system: More sophisticated
	Cost US$ 1972 / 2011	Cost US$ 1972 / 2011
50	4 / 17	9 / 39
100	8 / 35	18 / 78
150	12 / 52	27 / 117
200	16 / 70	36 / 156

Source: Adapted from "Data from WHO Community Water Supply Unit" reported in White, Bradley and White 1972:91

In 1977, the Water Research Centre in the United Kingdom produced a 638 page report, called TR61, with cost information on water supply and sewage disposal. This document used cost data from early 1960s to mid-1970s, reportedly taking 12.5 person years over 30 months to produce. The report produces cost functions based on Bills of Quantities and reported contract costs for preparing reliable estimates for national and regional planning purposes. Even for such a level of effort and sophistication in urban systems at the time, the cost models focused mostly on capital expenditure for piped conventional systems as "*insufficient operating cost data was available during the project for cost models to be developed. Instead, typical operating cost information is presented. There is a need for further work on operating costs*." In May 2008, WRC (formerly the Water Research Centre) completed TR61 Version 9 software, an expensive costing tool to calculate whole life costs for water and sewerage assets.

In many ways, the WRC work has been the "mother" of the models and tools used by Ofwat, the Water Services Regulation Authority, established in 1989 as the economic regulator of the newly privatised water and sewerage industry in England and Wales. Ofwat is tasked by legislation to ensure that the private monopoly water companies provide consumers with a good quality service at a fair price. They do this by, amongst other approaches, scrutinising the companies' costs and investment, for which quite sophisticated costing models have been developed. Ofwat has published very clear, consistent and useful cost terminologies for urban water supply as well as unit cost estimates (Ofwat, 1999; 2005; 2007a; 2007b). The innovation with the unit cost reports of Ofwat has been to directly link ALL costs incurred to the level of service being provided and not the costs of individual pieces of technology. The unit costs are measured in Great Britain Pound per property and Great Britain Pound per cubic meter, not per capita.

Ofwat defines "service costs", which is a useful concept used throughout this thesis, as:

> *"For each service, the sum of the functional costs for each of the service activities, plus the sum of the appropriate portions of the functional expenditure of the individually identified business activities, plus the appropriate portions of the costs of rates, doubtful debts, exceptional items, the write-off of intangible assets, and of general & support costs. (In the case of the water & sewerage companies, this will necessitate the allocation or apportionment of the functional expenditure associated with Customer Services, Scientific Services, and the Cost of Regulation, and the allocation or apportionment of the costs of rates, doubtful debts, exceptional items, the write-off of intangible assets, and of General & Support costs.) Ofwat 2007, pg.5*

The 2005 report of Ofwat further disaggregates unit costs for water into the following key two categories:

- Operating and maintenance costs (Table 2)
- Asset classification which is roughly equivalent to capital investments in non-utility settings (Table 3)

For urban utilities, there are now many reports with accounting cost details (see, for example IBNET, 2004), often based on the terminology made popular by Ofwat such as 'capex' (capital expenditure), 'opex' (operating expenditure) and 'capital maintenance', but concern lower-income countries and water and sanitation services provided to rural and peri-urban areas not many unit costs or models have been developed until fairly recently. The degree in the level of analytical sophistication and availability of data is striking.

Table 2 Cost of operations and maintenance

	Operating Costs	Maintenance costs
Water Services	Water resources and treatment	Water resource facilities
	Water distribution	Water treatment works
	Business activities	Water distribution mains
		Service reservoirs and water towers
		Pumping stations
		Management and general
Sewerage services	Sewerage	Sewerage
	Sewerage treatment	Sea outfalls and head works
	Sludge treatment and disposal	Sewage treatment works
	Business activities	Sludge treatment works
		Sludge disposal
		In-line pumping stations
		Terminal pumping stations
		Management and general
Direct costs	Employment	
	Power	
	Hired and contracted services	
	Agencies	
	Materials and consumables	
	Environment agency charges	
	Bulk imports (water)	
	Others	
General support	General support	
Business operating expenditure	Customer services	
	Scientific services	
	Rates	
	Doubtful debts	
	Other	

Source: Adapted from Ofwat, 2005

Table 3 Asset classification

Infrastructure assets	Underground systems Impounding and raw storage reservoirs Dams Sludge pipelines and sea outfalls
Non infrastructure assets – operational assets	Intake works Pumping stations Treatment works Boreholes Operational land Offices, depots and workshops Residential properties directly connected to supplies Land held for the purpose of protecting the wholesomeness of water supplies
Non infrastructure assets – other tangible assets	Non-operational plant Machinery Vehicles Surplus land

Source: Adapted from Ofwat, 2005

The unit costs for lower-income countries in the literature which have been most widely used until recent years were linked with technologies and not with levels of service (Christmas and Rooy, 1990). The estimates reproduced and updated in Table 4 provide the cost per capita for specific technologies (low-cost, intermediate and high-cost) for urban, peri-urban and rural contexts.

Through the following twenty years no robust references were found in the sector for unit costs in rural and peri-urban areas in lower-income countries. Many more studies have made references either to the amounts in Table 4 (without factoring in inflation) or to "rule of thumb" global estimates without referencing the underlying calculations. These costs have then been used as the basis of important global studies and sector frameworks such as Vision 21 from the Water Supply and Sanitation Collaborative Council (2000), the World Water Vision (Cosgrove and Rijsberman, 2000), the Framework for Action (Global Water Partnership, 2000) and the Global Water Supply and Sanitation Assessment Report (WHO/UNICEF, 2000) which calculated the global financing estimates for reaching the Millennium Development Goals targets for water supply and sanitation.

Other global reports which make terminology explicit the basis for the unit costs calculations have used the unit cost data extrapolated directly from the 2000 reports without taking into account, the price changes resulting from inflation (Evans, Hutton and Haller 2004; Hutton and Haller 2004; Lenton et al. 2004 and 2005).

Table 4 Unit cost per capita in lower-income countries

Technology category	Cost per capita US$ 1990	Cost per capita US$ 2011
High cost technology		
Urban water supply	200	319
Urban sanitation	350	558
Intermediate technology		
Peri-urban water supply	100	159
Peri-urban sanitation	25	40
Low cost technology		
Rural water supply	30	48
Rural sanitation	20	32

Source: Adapted from Christmas and Rooy, 1990

Since 2000, and more intensively from 2005, unit costs specifically for non-networked water supply and sanitation are being collected and reported. However, the differences in methodologies used and reported make it almost impossible to compare cost data either globally or even within countries.

As a component of this thesis, more than 50 documents with unit costs from more than 150 donor-funded water and sanitation programmes in rural and peri-urban areas in Sub-Saharan Africa, Asia and Latin America have been reviewed and critically analysed.

2.1.1.2 Cost definitions and how they developed for the rural and peri-urban sub-sectors

As described in the historical perspective chapter, while the urban water and sanitation sector developed accounting frameworks and consistent terminologies for reporting unit costs both for high and lower income countries (IBNET, 2004; Ofwat, 2007b), the terminology used for financial analysis in the rural water and sanitation sector has remained vague and fragmented, especially concerning discussions on cost recovery:

> *"The definition of cost recovery has become confused as disciplines - principally engineers and economists - talk at cross-purposes, mixing financial and economic interpretations of cost recovery and not fully understanding the components of either." (Waughrey and Moran, 2003:17)*

In 1987, Churchill rightly defined that the total financial costs of providing water and sanitation services in rural areas could be summarised as "the sum of annual capital charges, operating costs, and maintenance costs, taking into account the useful life of equipment" (p. 70). In a DFID review of projects in the water and sanitation sector, Waughrey and Moran (2003) proposed an adaptation of the Ofwat terminology to the rural water sector. Since then it has been rare for sector documents to separate operating and maintenance costs, or to reflect on the costs of capital.

"Capital costs" as a concept remained with its meaning throughout the years and across disciplines, it has always reflected the initial capital as a one-off investment in infrastructure, pre-feasibility studies and training. The same has happened with "costs of capital", which has retained its meaning in the water sector reflecting the costs incurred in borrowing capital or stakeholders receiving returns on equity.

"Maintenance costs" started vanishing from the rural water literature and were replaced first by "operation and maintenance" and later simply by "O&M" (Saunders and Warford, 1976). Surely not intended by its first authors, but this short acronym became synonymous of minor maintenance focusing solely on hardware costs. As a consequence (or misfortunate coincidence), over the last 30 years, large capital maintenance and support costs to service providers have been largely ignored in the sector discourse and in de facto budgeting and reporting systems.

The challenge is that without regular maintenance water supply services fall into disrepair and ultimately service failure, preventing positive impact on poor health, poverty and economic development in rural communities. Countries that have made concerted efforts to provide infrastructure in rural areas, for example Indonesia and Malaysia, have succeeded in reducing rural poverty drastically (The World Bank, 1994).

2.1.1.2.1 Operating costs

The focus on minor maintenance was perhaps motivated by its short term and urgent nature after communities "received" their water supply systems. Much of the literature from the 1970s starts focusing on how communities are not contributing as expected towards the (minor) maintenance of the systems (Saunders and Warford, 1976; Kalbermatten, 1982). With this focus, much of the responsibilities or even debates about how consumers should contribute towards capital maintenance (a medium to long term problem) is non-existent both in the academic and in the grey literature.

> *"The construction of new, highly visible public infrastructure projects has received great attention in many developing countries. Repairing and maintaining existing infrastructure has generally been neglected" (Rioja, 2003a).*

Many authors calculate percentages of annual operation and maintenance costs relative to annual capital costs. These ranges vary from 3 percent (Wiemers, 2005) to 67 percent (Whittington et al., 2007) of annual capital costs depending on the technology used. Mehta et al. (2005) assume in their cost estimate models that operation and maintenance amount to 130 percent of capital cost requirements, on top of what is needed for infrastructure replacement.

A more recent study of different technology options for rural and urban sanitation in Asia (Hutton, Rodriguez, Napitupulu et al., 2008) concludes that the technologies which are "higher on the ladder" of service levels incur larger operation and maintenance costs. Robinson (2010), revising costs in Asia, reaches the same conclusion reporting that even if low cost toilets may require more frequent repairs than other more costly options, these are very small (local materials used in the construction such as thatch for the walls and roof). In contrast, the more expensive latrines that use bricks last longer but 'require higher operational expenditure' –

though this point may in fact be referring to the more costly capital maintenance required.

2.1.1.2.2 Maintenance costs

Maintenance is defined as the activities which allow the public infrastructure to efficiently deliver the outputs for which they were built initially (Gyamfi et al., 1992). From an accounting perspective, depreciation is the charge in the accounts required to reflect the reduction in the value of an asset as it is used in the normal operations of an enterprise – reflecting its cost of replacement at the end of its lifespan, where necessary. The oldest references to depreciation are found when accounting principles were first published in 1494 by Luca Pacioli "The Father of Accounting" in The Collected Knowledge of Arithmetic, Geometry, Proportion and Proportionality where he is the first person known to describe double-entry accounting, also known as the Venetian method (Macve, 1996).

From the birth of accounting to reports of capital maintenance of large infrastructure, there are detailed studies from the UK that reviewed surviving records of costing practices from Industrial Revolution firms in late nineteenth century and the factors that made companies report (or not) depreciation (Carlon and Morris 2003; Fleischman and Parker 1992).

In the 1970's, relevant work has been published focusing on investigating the optimal level of maintenance in public capital (Kalaizidakis and Kalyvitis, 2004). In 1976, Biltros produced an econometric model to question the assumption that expenditure on capital maintenance in the railways did not "matter" in the process of capital accumulation. Data was used from the United States between 1944 and 1970 uncovering the trade-offs between capital maintenance expenditure and capital investments. Biltros's explanation for the lack of maintenance and repair analysis was rooted in earlier assumptions that replacement investments were a constant proportion of existing capital expenditure and that data on expenditure for maintenance and repair were very hard to obtain.

Almost thirty years later there are still studies emphasising the long term benefits of investing in capital maintenance. For Kalaizidakis and Kalyvitis (2004) provision for capital maintenance "[…] provides the economy with an additional benefit stemming from reduced capital decay."

In developed countries, maintenance management has evolved since the 1970s with the use of computers to document maintenance activity and use of the results for preventive maintenance of assets reducing costs of premature service lives. But progress to integrate de facto asset management in the water sector has been slow. In the UK, only in 1993, the head of Economic Regulation, writing to the regulatory directors of all water and sewerage companies, set ground rules for the provision of asset maintenance including a distinction between the provision for backlog maintenance required to bring assets up to steady state - and the long term maintenance requirement (Ofwat, 2007). In the US, the standard for infrastructure assets to be recognised in financial statements of national and local governments has only taken place since 1999 (Garvin in Amekudzi et al., 2008). As a result of the new set of rules for accounting for assets, procedures, documentation and systems have been developed to support the full implementation of asset management.

In lower income countries, regulatory accounting in the water sector is also very recent and so far applies only to urban utilities. According to the Association of Regulatory Authorities of Water and Sanitation for the Americas (Asociación de Entes Reguladores de Agua Potable y Saneamiento de las Américas - ADERASA), in many countries in Latin America there is no regulatory control of accounting practices as most entities lack detailed information on cost structures and regulatory norms leading to inconsistent accounting information (Fernandez, 2009).

Most of the contemporary research on the issue of maintenance of infrastructure in lower income countries has been conducted by the World Bank and focused on the road sector which received generous funding during the 80s. Many African and Asian countries have invested heavily in road construction but had only been able to fund 30 percent of the required maintenance expenditure, leaving the new road networks deteriorating (Jaarsma and Dijk, 2002). In Sub-Saharan Africa, for every road rehabilitated it is estimated that three kilometres of road fall into disrepair. The repair costs reportedly rise to six times the maintenance costs after three years of neglect and to 18 times after five years of neglect (The World Bank, 2003). The World Bank reported in the World Development Report 1994, that if an additional US$ 12 million annually had been spent on road maintenance in Africa, US$ 45 billion could have been saved in reconstructions (Rioja, 2003a).

Rioja (2003) has shown quantitatively that relocating funds from new infrastructure to maintenance can have positive effects A sample of Latin American countries' GDP, and empirical evidence from 47 lower-income countries, shows that current public expenditure on capital maintenance have a positive effect on growth, while public capital expenditure have a negative effect (Devarajan et al., 1996).

"Capital maintenance" in the water sector is defined by Ofwat (2005) as how "*companies are required to maintain the operating capability of their asset systems to ensure continuity of service for current and future customers*". Cutting down on capital maintenance is a decision similar to postponing fixing the roof until it collapses. Not investing in the present to keep infrastructure functioning will mean the need for larger expenditure later for total replacement (Rioja 2003b).

> *"Inadequate maintenance shortens the useful life of infrastructure facilities and reduces the capacity available to provide services, more has to be invested to produce those services [...] inadequate maintenance means that water supply systems deliver an average of 70 percent of their output to users, compared with best-practice delivery rates of 85 percent. Poor maintenance can also reduce service quality and increase the costs for users, some of whom install backup generators or water storage tanks and private wells." (World Development Report, 1994)*

When compared with urban utilities (in urban areas), there is limited financial data on the maintenance of rural water services in lower income countries.

> *"Comparable cost data on infrastructure are largely unknown in this sector in lower income countries […] we do not even know how much this sector is costing the taxpayers." (Estache, 2006)*

One possible explanation is that in the rural water sector, during the 1980s, the trend for disengaging government from capital maintenance has increased in the context of decentralisation and strengthening local organisations and community level management of water systems (Briscoe and Ferranti, 1988). However, if operation and maintenance are possible within communities with a couple hundred people, there are many examples of how management and maintenance requirements increase disproportionately with the increase in the size of the schemes (Kleemeier, 2000; Harvey and Reed, 2006).

With the supposed "hand-over" to communities and decentralised governments the responsibility for funding larger repairs and maintenance remained ignored or "hidden" within what many authors describe as "O&M". Only some lower income countries have detailed definitions separating what is considered minor repairs and what are major repairs. When referred to, most authors use the term "rehabilitation" (Lockwood and Smits, 2011) which can imply asset renewal after service failure.

In the "water and sanitation needs assessment model" (Wiemers, 2005) costs of maintenance are reported to vary between 20 percent of the capital investment costs for boreholes with handpumps and 50 percent for protected dug wells. PEM/WSP (2005) calculates annual maintenance costs as a proportion of the investment cost and the likelihood that the installation will need replacement during the lifetime. The classification system is dependent on the type of component and structure (Table 5).

Table 5 Classification of structures for capital maintenance cost calculations

Type of Component/ Structure	Annual % of capital cost
Large Civil Works e.g. dams and pipelines that are buried e.g. pipes in transmission and distribution systems.	5%
Smaller Civil works e.g. treatment plant, pipelines in connection with structures, boreholes, springs, tanks etc.	10%
M&E Equipment incl. fittings and valves, structures subject to wear and tear like public standpipes and hand pumps	100%

Source: PEM/WSP, 2005

In 2013, the WASHCost programme reviewed existing practices concerning capital maintenance for the rural water supply sector, illustrated with case studies. The working paper concludes that at present "irregular, 'lumpy' capital maintenance costs, which occur for instance when a pump needs to be replaced or a borehole redeveloped, are covered through a combination of savings made by the community service provider and ad hoc funding by the service authority or through an external project or programme. Unfortunately, in many cases, these expenditure are simply not made, resulting in insufficient capital maintenance, which is reflected in high rates of non-functionality and poor service levels" (Fonseca, Smits, Nyarko, Naafs and Franceys, 2013).

2.1.1.2.3 The remaining costs: direct costs, support and business expenditure

In Table 2 there are three other groups of costs which have no equivalence in non-utility provided rural water supply cost terminology in lower-income countries: “direct costs”, “general support” and “business operating expenditure”. These costs are not specific to the delivery of water and sanitation to a specific area, but are critical for ensuring the service is planned, supported and monitored, that regulations are adhered to, that costumers are satisfied, that research is done, etc.

In rural water supply these costs are usually described as “community support activities” and include *“the cost of community organisation, hygiene education and technical assistance, and government administrative support, which are not directly related to the construction of the facilities but which are normally provided to complement a water supply or sanitation program”* (Kabermatten et al, 1982: 32).

The earliest reference to unit costs for direct support have been found in the WHO Human Resources Development Handbook “Guidelines for Ministries and Agencies responsible for water supply and sanitation” (Carefoot and Gibson, 1984). The direct support is referred to as the “manning ratio”: the ratio of employees to population served. In 1984, the “commonly accepted range” used for lower income countries was one employee per 600 to 1,000 persons served. In a significant number of countries the ratio was found to be one employee for less than 600 people, indicating over-staffing. At the moment, in many lower income countries this situation is reversed (IWA, 2013). In 2005 in Ethiopia, the Shebedino Woreda administration, which had no vehicles and no recurrent costs allowed for in their budget, had 6 staff members to visit up to 80 kebeles (districts) in an area of 1,000 square kilometres with a population of 505,000 people (data collected by the author).

In the most recent literature there is considerable level of detail on the “software” component of implementing programmes: the community mobilisation, training courses and household contributions in cash and kind (most relevant include: Hutton and Haller, 2004; Pattanayak et al., 2005; Robinson, 2009; Trémolet, 2010). These software components are reported in the literature as ranging from 40 to 85 percent of capital investments. However, the most important component from a sustainability perspective are the software costs not at the time of the construction but those that provide continuous support to the services. Such support functions include monitoring, technical assistance, of providing post-construction support functions such as monitoring and technical assistance. These are roughly equivalent to the "direct costs and general support" referred to by Ofwat (2005).

There are then those support costs which are not directly linked with the operations of the service provider, but relate to national level regulation, general support and planning and budgeting. The guidelines for assessing unit costs for water supply and sanitation services in Kenya developed by PEM Consult refers to "supportive sector costs" which include regulation, monitoring and evaluation and hygiene promotion/demand creation (PEM/WSP, 2005). WSP's cost estimates approach for drinking water supply which took into account supportive sector costs estimate that these would range between 5 and 30 percent of overall annual costs of providing a service (Mehta et al., 2005).

For sanitation, three quotes included in WSSCC, 2010 (Sidibe and Curtis, 2002; Sugita, 2006 and Luthi, 2009) refer to about US$ 1 to 3 (PPP 2008/year/capita) for follow up activities using Community Health Clubs, PHAST (Participatory Health and Sanitation Transformation) and household centred environmental sanitation. The magnitude of community mobilisation and hygiene promotion specific to a scheme is usually planned between nothing and up to 10% of the overall capital expenditure both for rural and urban areas (Hutton and Haller, 2004; PEM, 2005; Hutton, Rodriguez, Napitupulu et al., 2008).

Some of these direct and general support costs can be accessed by looking into country and regional level strategic plans and sector expenditure reviews. Mostly these are accessible in the countries only and not digitally.

Going further into what should be considered as support costs, Whittington (2007) mentions that real costs should also include the staff time of national water agency administration and donors. In that study an example is given of a rural water supply programme estimated to cost US$ 3,500 when in reality it costs overall US$ 10,000. This would mean that the support costs would be in a range of 20 to 50 percent of the overall project costs, which are even higher than Mehta's estimates. Whittington adds "*we cannot forget that even when measured, ongoing annual software costs tend to be underestimated as a consequence of undervaluing volunteer and NGO input, time from higher level government officials in guidance and conceptualization of programs, or the use of temporarily diverted local staff to assist in intensive campaigns*".

When all these support costs are considered, they come closer to the Ofwat definition of general and support expenditure (2007:11) within a utility which include all centrally provided services, such as:

- Administrative services
- Personnel and management services
- Financial services
- Legal and property management services
- Research and development
- Policy determination, implementation and monitoring
- Audit services
- Public and employee relations services
- Data processing facilities
- Planning liaison
- Vehicle and plant (including hired vehicles and plant, and leased company
- cars)
- Electrical and mechanical maintenance facilities
- Land and property maintenance
- Storage of materials - operational and technical support
- General and support buildings

In 2011, the WASHCost programme reviewed existing support costs from 10 lower and middle-income countries in Latin America and Southern Africa in the rural water sector (Smits, Verhoeven, Moriarty, Fonseca and Lockwood, 2011). The authors have separated direct and indirect support to encase all the costs mentioned in this chapter. Direct support refers to the support provided directly to service providers in the form of monitoring, technical assistance and (re)training of service providers. Indirect support refers to general support such as macro-level planning, basin level monitoring and policy making.

The study suggests that though data needs to be interpreted with caution, an expenditure of some US$ 3 per person per year seems to be effective in providing at least a basic level of service in Latin America. African countries were found to have levels of expenditure of less than US$ 1 per person per year, and resulting services were poorer.

2.1.1.3 Financial costs: unit cost comparison studies done in the sector 2000-2010

The most recent overviews of unit costs in the water and sanitation sector for lower income countries include the compilation by Fonseca and Cardone in 2005 and in 2006 the World Water Council expanded the review (Toubkiss, 2006), as well as the Stockholm Environment Institute (Rockström et al, 2005) and other regional assessments (COWI, 2004; Metha et al., 2005; Rao and Seetharam, 2006). In addition, in 2006, Fonseca and Cardone wrote an overview of country budgets, aid and cost estimates using data from 12 Sub-Saharan African countries. This analysis was focused on the adequacy of estimates of the cost of providing access to water and sanitation per capita in these countries, however, given a) the limited unit cost data and b) any information on the services effectively provided, the paper concluded that *"updated costs should be discussed and adopted at a country level by donors and other sector actors, to feed into budget projections, investment planning, large and small projects. It is a very simplistic recommendation but in fact, cost underestimation has been one of the single most direct causes of programme, project and utility failures and inability to move from "pilot projects" to scale." (pg.12)*

Estache (2006) conducted a survey of issues concerning infrastructure and has concluded that data gaps were too large, not allowing for monitoring performance of the levels of service in terms of access or efficiency. He sharply summarises that "*we have collectively found the limits of our knowledge on a wide variety of issues relevant to policy making in infrastructure […] Most of the information necessary to ensure a minimum level of accountability from government, donors and operators is either estimated very roughly, very occasionally or often never really collected*" (p. 6).

One of the earliest global reviews of unit costs for rural and peri-urban water and sanitation with updated costs taking into account inflation has been prepared by the IRC International Water and Sanitation Centre (Fonseca, 2007). "This review provided the most comprehensive source of information on water supply and sanitation costs to date" (Robinson, 2009). However, the data collected in 2007 was still very limited to capital cost, referred to technologies only and the data ranges were broad (Table 6).

At country level, the governments of Ghana, Kenya, South Africa and Uganda (CWSA, 1999; PEM/WSP, 2005; DWAF, 2007; GoU, 2008) have commissioned detailed unit costs studies which data is part of this report. However, a history of lack of records still leaves many questions answered. The 2008 report produced by the Government of Uganda concludes that "*whilst this report increased the WSS understanding and developed hypotheses of the reasons contributing to cost variations, the report, being a desk study of the available information at District Water Departments, did not provide sufficient depth to reach concrete, independently verifiable conclusions. The sector is still not able to clearly state what caused the rise in unit cost*" (GoU, 2008).

Table 6 Review of WASH investments in the literature, annual capital and maintenance cost per capita, US$ 2004 / 2011

	Cost per capita	
	Minimum	Maximum
Water supply improvement	US$ 2004 /2011	US$ 2004 / 2011
House connection (treated)	99 /117	214 / 253
Standpost	33 / 39	69 / 81
Borehole	18 / 21	199 / 235
Dug well	9 / 11	82 / 97
Rainwater	36 /42	229 / 270
Non-networked options	1 / 1.2	229 / 270
Sanitation improvement		
Sewer connection (partial treatment)	24 / 28	260 / 307
Septic tank	107 /126	799 / 943
Pour-flush toilet	27 / 32	163 / 192
VIP toilet	10 / 12	172 / 203
Simple pit toilet	11 / 13	54 / 64
Non-networked options	0.8 / 0.9	911 / 1075

Source: Fonseca, 2007; summarised in Robinson, 2009:54

The trend is clearly changing, with the number of organisations that report on unit costs for water and sanitation in lower income countries increasingly publishing their data. In 2009 an international NGO, Plan International, produced a public study of their expenditure in the sector, publishing unit costs per technology, per programme and comparing their own costs with other global estimates (Robinson, 2009). It remains the only one available thus far.

The PEM/WSP (2005) unit cost study for the Ministry of Water and Irrigation, Kenya has clearly stated how unit cost studies are critical for achieving cost-effectiveness and can be used in monitoring the value for money in the sector and across different implementing agencies and regions:

> "*[…] If appropriately used it can provide information that will trigger sector performance improvements as inefficient practices will no longer be able to shield behind the difficulties in comparing costs. […] Between countries in the region, there is much to be gained from an exchange of unit cost and the possibilities of discovering why costs are unusually high or low in different countries. This will trigger initiatives to seek the cause of sector inefficiencies be they in the public or private sectors. Once the causes are better understood and more widely known, many of the sector inefficiencies might resolve themselves through market processes – in other cases a regulatory or other type of initiative might be needed*."

2.1.1.4 Accounting frameworks for maintenance of infrastructure[1]

Within contemporary costing practices, there are at least three relevant methodologies used for cost analysis:

- Cash accounting and cash flow management (used mainly by book keepers and accountants)
- Fixed asset accounting for asset management, also known as regulatory accounting (used by accountants, regulators, planners, major utilities)
- Economic cost approach, including life cycle assessments (used by planners, engineers, economists)

Whereas cash accounting is important for managing and controlling day to day operations and economic costing for determining the optimal future approach to service delivery it is fixed asset or regulatory accounting that indicates total income requirements for a service provider, funds which might be derived from any

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[1] This section of the thesis (which was prepared in 2009 for a review meeting) has been used as section 3 in (Fonseca, Franceys, Batchelor, McIntyre, Klutse, Komives, Moriarty, Naafs, Nyarko, Pezon, Potter, Reddy and Mekala, 2011)

combination of tariffs, taxes or taxes/transfers (national or international) (OECD, 2009).

2.1.1.4.1 Cash accounting and cash flow management

Cash flow management is concerned with the efficient use of a company's cash and short-term investments (Gregory, 1976). Cash accounting is an accounting method where receipts are recorded during the period they are received and expenses recorded in the period in which they are paid. Cash flow management is important because most businesses can survive several periods of making a financial loss, but if they run out of cash they are likely to fail. Chastain et al (1986) summarised this concept in the turbulent financial crisis of the 80s: "It is clear that cash is superseding working capital as a measure of financial health. A major reason is that cash is often a better immediate indicator of solvency or liquidity than is working capital".

When access to cash is difficult and expensive, cash flow management is critical for businesses to survive. This is the situation faced by many lower income countries when utilities are trying to expand services for water and sanitation. Unit costs are needed to determine investment cash flows (cash spent on capital expenditure and, rarely, cash received from the sale of long-life assets), operational cash flows (cash earned from user fees etc. and cash spent on recurrent activities) and financing cash flows (cash received from lenders as debt and as equity from owners or shareholders and cash paid as amortisation of debts in interest and principal repayments and as dividends to shareholders).

By contrast, fixed asset accounting (discussed in the next chapter) recognises costs when incurred rather than when paid (the accrual principle) but also separates out the capital expenditure (and the manner in which it has been financed) and reports it in the overarching financial statement (balance sheet). Any revenue or income from the service provision is accounted against the operational expenditure (the cost of operating the fixed assets), the depreciation requirement (reflecting the ‘broad equivalence’ to the cost of maintaining those fixed assets in a serviceable condition) and the cost of capital (the cost of financing the fixed assets) in the Income and Expenditure statement (or Profit and Loss Account if private sector).

Traditionally, governments have used cash accounting to budget for and record both investment costs and recurrent costs. However, this approach means that there is no necessity to account for a fixed asset after the investment has been disbursed. As a result, there is usually no record of what fixed assets have been constructed, where they are, what condition they are in and the likely cost implications for long-term maintenance. As a result, there is a tendency to undervalue and ignore capital maintenance which is likely to be unfunded in any budgeting procedures as it tends to put pressure on cash flow. Costs of capital are also usually ignored. This is a particular challenge to the capital-intensive water and sanitation sector as it can lead to a reactive and delayed response to capital asset maintenance and renewal, with a consequent loss of service to consumers.

2.1.1.4.2 Fixed asset accounting and asset management: the regulatory approach

Cash accounting and fixed asset accounting both record costs that occurred in the past (historical costs). One reason for accounting is also to estimate likely future costs so as to ensure on-going services.

In many countries the conventional way for water supply agencies and governments to plan for future investments has been to follow the cash accounting approach, adding a percentage to the previous year's cash budget, plus something for inflation. Such an approach is unlikely to deliver sustainable services as it bears little relationship to what is actually needed. A more sophisticated fixed asset accounting approach considers the state of existing fixed assets and their serviceability with regard to meeting consumers' needs, in addition to the need for new fixed assets to extend and enhance services (combined, ideally, in an asset management plan). This approach takes into account the operating expenditure needed to run those fixed assets adequately and the capital maintenance expenditure to ensure the on-going serviceability of the assets. Projections of these costs, incorporating reasonable estimates of possible efficiency gains, indicate both the future capital requirements and recurrent cost requirements.

Asset management is "the combination of management, financial, economic, engineering and other practices applied to physical assets with the objective of providing the required level of service in the most cost-effective manner" according to the New Zealand Infrastructure Asset Valuation and Depreciation Guidelines (NAMS, 2006). The asset management plan gives visibility to the costs of regular operation and maintenance, non-regular maintenance, replacement and renewal plans over the short and long term, conducted to minimise costs while ensuring the functionality of each asset in the system. A significant component of the plan is a long-term cash flow projection for capital maintenance activities. The costs profile will cover the life of the longest-lived asset in the system, so as to estimate the whole- life cost, and make it possible to determine average annual costs (Ingenium, 2006).

Fixed assets normally include land, buildings, motor vehicles, office equipment, machinery and, in the WASH sector, water and sanitation facilities. These assets are not directly sold to the end users but are used in service delivery. Fixed asset accounting is used for assets which are owned by the entity for longer than a year and which cannot easily be converted into cash. These fixed assets are depreciated, which means that the expenses generated by the use of the assets are accounted for (Sorter, 1978). Depreciation (the wear and tear that reduces an asset's historical value) is usually spread over the economic useful life of an asset because it is regarded as the cost of an asset absorbed over its useful life (Inst. of Civil Engineers, 1947). Kachelmeier and Granof (1993) conducted a study of 216 entities. Their findings suggest that depreciation is a useful cognitive reminder to decision-makers in governmental organisations of the need to replace long-lived assets as they physically deteriorate. However, historical depreciation is not necessarily sufficient to cover the replacement costs of increasingly expensive assets due to the effects of inflation. This is especially true of assets that last a long time.

The main objective of the development of an asset management plan is to ensure that infrastructure assets continue to deliver an agreed level of service during their life-cycle in the most cost effective manner. For effective asset management planning, assets need to be valued at 'current costs' rather than at historical, investment costs. This can be determined by using data from inventories and past costs, revalued by using inflation indices (consumer or construction industry). The reason for using current costs is to ensure that this generation's users/consumers are enabled to ensure (through tariffs and/or government budgets) that sufficient funds are made available to undertake capital maintenance – which has to be carried out at today's prices. If a depreciation approach is taken based upon the historical costs of constructing those assets there will not be adequate cash available from tariffs or budgets to undertake the necessary renewals. Unfortunately, in rural water supply, there is very frequently not even an inventory of the number of facilities built or their location, let alone any understanding of the current cost of maintaining them.

The main purpose of regulatory accounting is to monitor and control the efficiency and performance of service providers whilst setting appropriate tariffs (Ferro and Lentini, 2009). The gap in regulatory accounting and asset management for water supply and sanitation in developing (and to a much lesser extent in developed) countries is large and becomes even larger when the rural and urban sectors are compared. In developing countries, regulatory accounting in the water sector, if used at all, applies only to utilities and therefore mostly to urban areas. However, the literature indicates that the solution to the maintenance problems in the sector will not improve unless the 'asset maintenance' mind-set expands to the organisations responsible for funding, planning and managing rural and peri-urban WASH services.

2.1.1.4.3 Life cycle assessments and present value analysis: the economic cost approach

Whilst fixed asset accounting informs service providers of the costs of sustaining existing systems it cannot directly guide decision-making with respect to the optimum choice of investments to deliver the next generation of services.

Using a 'present value analysis' or 'engineering economics' approach is particularly useful when comparing alternative means of delivering future services. A comparison might need to be made, for example, between an expensive dam (high capital expenditure) with subsequent gravity flow transmission of water (low operational expenditure) and a cheaper well-field development of a groundwater source (lower capital expenditure) which requires high ongoing recurrent costs (high operational expenditure).

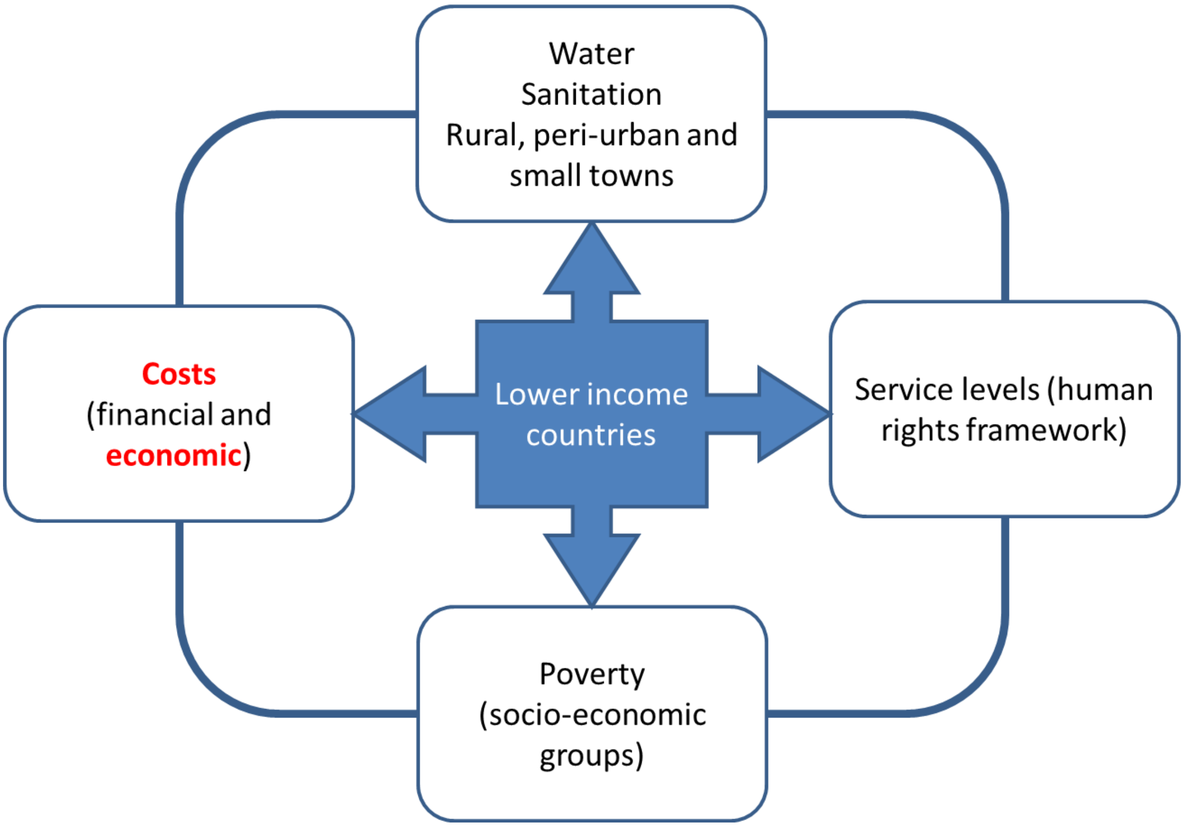
The conventional way of understanding which might be most suitable is through present value analysis. This approach takes into account what is known as the 'time value of money', reflecting the sense that society might give a higher value to money available for use now than to money available in the future. This analysis ignores any aspects of inflation as this is not relevant to the comparison and choices between alternatives in the future. It simply recognises that money that is available now could be used or invested and produce returns sooner or bigger than investments in the future. The approach of discounting future costs to the present rests on the 'opportunity cost of capital' (the likely return on use of that money in the best alternative) and enables a fairer comparison between different schemes with different intensities of capital and operational expenditure. This approach is usually extended to include not only the present value of future costs but also an estimate of future benefits (net present value analysis). The resulting ‘benefit-cost ratio’ is an important tool for policy-makers to understand whether and what future investment can be justified.

The discount rate used by economists varies broadly depending on the assumptions made (institutional structure, government policy and macro-economic conditions) and therefore costs which use different discount rates can only be compared with some caution. The lower the discount rate, the lower the overall cost estimates. For instance, the Copenhagen Consensus (2008) uses a 3–6% range for discount rate assuming that governments in lower income countries have ready access to capital and that this would be the rate of return in case donor money would be invested in alternative projects. On the other hand the World Bank uses a 10% discount rate for project evaluation assuming that investment capital in lower income countries is scarce and the opportunity costs of the project being evaluated are therefore high. More recently, Carlevaro (2010) has used an 11% discount rate for a WHO cost benefit analysis study.

An extension of this approach has been to apply the present value approach to the full ‘life-cycle’ of an asset, sometimes referred to as ‘cradle to grave’. A paper which traced the use and application of the life-cycle costing technique in the US finds that LCC was originally developed in the 1960s by the US Department of Defence to enhance the cost effectiveness of its defence system equipment. LCC then evolved and started being applied in other industrial sectors (Sherif and Kolarik, 1981). Over the years, a major area of application has been the construction of buildings where estimated savings usually result from increasing the initial investment to significantly reduce energy consumption. In 2002, one set of methodologies was formalised in the 14040 series of ISO standards (ISO, 14040-44-48) providing an internationally accepted framework for conducting life-cycle assessments. Their most common use includes (green) building construction and energy conservation.

Life-cycle assessments consider an economic approach to costs. “LCC seeks to optimise the cost of acquiring, owning and operating physical assets over their useful lives by attempting to identify and quantify all the significant costs involved in that life, using the present value technique” (Woodward, 1997).

2.1.2 Economic costs for rural water and sanitation in lower-income countries



For the purpose of analysing household expenditure in water and sanitation, the relevant economic costs considered are the manual labour used in the construction and maintenance of water schemes or latrines as well as the time spent collecting and hauling water. Similarly, there might be contributions in kind (land, materials) which have an economic cost. If only considering the financial costs, these non-monetary household investments are invisible.

There is a vast literature on economic costs developed specifically within the area of cost-benefit analysis for project appraisals (Little-Mirrlees, 1974; Irvin, 1986). The relevant components for the literature review discussed in this chapter concern those aspects of economic cost theory that apply to household non-financial expenditure for water and sanitation.

> *"When the value of time is taken into account, the rural poor of Africa and Asia are paying prices for water that are many times higher than what is being paid by their urban counterparts in both the developing and developed world" (Churchill et al., 1986:73)*

Most economists within and outside the water and sanitation sector argue that the opportunity cost of time, to access and transport water over long distances, needs to be costed independently of what could be done with that time (leisure, education, income generating activities) to reflect the value to the economy if that person or child would spend its time differently.

Most of the literature in the sector which discusses economic costs of households is derived from cost-effectiveness, cost-benefit or willingness to pay studies and mainly focusing in urban settings with piped connections (Hirshleifer et al., 1960; David and Inocencio, 1998; Nauges and Whittington, 2009; Hutton, 2011). Different authors have considered different economic costs and methodologies which are reviewed in this chapter. No studies have been found on household economic expenditure on sanitation in rural areas in low-income countries such as time spent or in kind materials for building and maintaining own latrines.

2.1.2.1 Valuing time: an historical perspective

It is relevant to note that the economic theory for valuing time started in the 1960's when the first studies were published on the idea of "value" attached to time for specific activities. The use of time and how it is valued are important in the water and sanitation sector because a reduction of time spent on in transporting water, for instance, leads to changes in how time might be spent, either for pleasure or for work, which have a positive impact in the economy. If time is used for labour with a formal wage there is a contribution to gross domestic product and on the other extreme if time is used purely for leisure, an increase in social welfare (Becker, 1965; DeSerpa, 1971; Little-Mirrlees, 1974).

The most relevant aspect of the methodologies is that a "shadow factor" or "shadow price" needs to be derived for the non-financial expenditure. It is generally accepted that market prices do not reflect the opportunity cost of time and therefore a "shadow price" is required. These shadow prices are calculated using proxies of other products or services so that the economic value can be derived (Little-Mirrlees, 1974; Irvin, 1986). A shadow wage rate reflects the opportunity cost of labour which is lost by using a person-day elsewhere (Whittington, 1989).

Against this background, White, Bradley and White, in a 1972 study across East Africa, considered that there was no practical way of determining the opportunity cost of labour time in the rural sites where they were collecting detailed information on water costs, uses and transport. As an alternative, they have decided to calculate the economic value of time by its equivalent in food consumption by including:

- The energy spent on going to the source and carrying water home
- The energy spent on waiting in line

The assumption made was that even in a partly subsistence economy, the energy spent is at least worth in monetary units the amount of food consumed. The energy is converted into cash value by estimating the amount of energy used, determining the amount of a staple food required to supply the energy and the price of the amount of food.

> *"The interviewer determined how far a person would go to the source and how long this would take, measured the slope, calculated the load from the volume of water carried and then estimated the energy expended in calories by the carrier for the round tip to carry water to her home. […] One gram of maize meal was chosen as the unit of food to provide this energy […] the cost in cents of carrying water was determined by taking the number of calories used by members of the household in carrying water in one day, dividing this by 3.5 to give the number of grams of maize flour required to furnish this energy, and then multiplying by the price of maize flour" (White, Bradley and White 1972:96)*

The application of the methodology faced some constraints, among which how to determine the time actually spent walking as opposed to waiting both of which use different amounts of energy, calculating the different energy used by carrying containers of different shapes and weights and calculating the average weight of women which also influences the amount of energy spent. The author of this thesis would add that in her own experience visiting hundreds of communities in at least 15 lower-income countries, many women carry children while they are transporting water which would further increase the average weight used and as a result increase the average energy consumed.

In conclusion, many assumptions had to be made for calculating a shadow price for time using the food consumption equivalent which could have been equally made by using informal wages. Other than this study, no similar application of the methodology to cost time was found in the water sector.

More in line with the economic theory being developed at the time, for costing sanitation technologies Kabermatten et al. (1982) described that the economic costs of sanitation projects included four components:

- For costing time, the unskilled labour wage was to be used as shadow price. The shadow price would vary considerably because in many lower income countries there are large pools of unemployed labourers which would imply that there is almost no cost to the national economy if these labourers were employed. However, on the opposite end, if a country has few unemployed unskilled workers the shadow factor indicates that the market or formal wage actually reflects the economic value of their time. Therefore the authors considered that the shadow factor for unskilled labour wage in lower income countries was in the range of 0.5 to 1.

Other economic components considered by the authors which will not be used further in this thesis – as they do not reflect household economic expenditure - but worth mentioning:

- For costing imported equipment, the foreign exchange shadow factor was used: greater than 1 whenever the local currency is overvalued or import restrictions are high (as is the case of India and Mozambique).
- For investments made by the national government, the opportunity cost of capital was used: in lower income countries usually ranges from 8 to 15 percent.
- And finally the authors considered the shadow price of water, land and other direct inputs: land might be transferred from the government to a sewerage company at no financial cost, but there is an economic cost equivalent to the cost of the land if it had been sold at market prices. The shadow rate can be obtained by reviewing recent sales records of similar land in the area.

2.1.2.2 Time savings from improved water and sanitation services

The overall time and energy spent in water collection depends on the distance to the source, the terrain that needs to be crossed, the method of transport, the queuing time at the source, the number of consumers in the household and the number of people available to carry water. Improving accessibility by reducing time in water transportation will save time which can be used in agricultural activities, education, income generating activities, leisure and child care (Evans, 1986).

Churchill et al. 1987 estimated that getting water takes up at least 15 percent of women's time and sometimes, in some areas, up to 50 percent and that improving water supply sources can lead to time savings of an hour or more per household per day.

> *"In a typical situation where a handpump is used, for example, the haul costs can account for over two-thirds of total costs when certain assumptions about value of time are followed […]. This holds true even for very low costs of labor or values of time" (Churchill et al,. 1986:34)*

Beyond economic benefits, reducing the time spent on carrying water can bring several health and social benefits. Health benefits include among others reduced workload during the dry season and improved nutrition for mother and child, reduced back pain and headaches, as well as other illnesses and injuries resulting from carrying loads (Montgomery and Elimelech, 2007; Geere, Hunter and Jagals, 2010). Social benefits include increased time to organise joint enterprises or gain stronger political voice. The economic benefits are the most relevant for the present work and include: freed time to engage in productive activities such as petty-trade or agricultural activities. For children, freed time from carrying water can increase the time they spent either at school or supporting other household activities (Haller and Bartram, 2003; Hughes, Le and Bartram, 2012).

However, it is not clear if an improved water and sanitation service will only reduce time or, because it will change preferences, it might for instance increase the quantity of water consumed and therefore some of the time saved might be less than initially thought (Evans, 1986). In Mozambique, time savings resulting from constructing new wells averaged 1.75 hours a day (approximately half of the former hauling time) (Churchill et al, 1987).

2.1.2.3 Costing unskilled labour for water and sanitation in lower income countries

Once valuing time became an important aspect of the economic approach in the water and sanitation sector, some of the main methodological questions raised in the literature include: What is the best proxy to cost labour in lower income countries? Which shadow price should be applied? Should such time be valued as the same social cost to that incurred by formal labour? Should it vary seasonally? Should it vary per gender or age? (White Bradley and White, 1972; Saunders and Warford; 1976; Churchill et al., 1987; Wittington et al., 1989; Curry and Weiss, 1993)

Irvin (1986) considered four possibilities for choosing average labour wages to value time: the “modern sector” wage, the informal sector wage, the average agricultural wage and the wage of casual labour. The wages should ideally be weighted per region factoring some degree of unemployment rates. Assuming a large pool of unemployed and unskilled labour, the opportunity cost of such labour is low because other productive uses for that same unskilled labour are limited (Saunders and Warford, 1976; Rassas, 1992). Little and Mirrlees (1974) suggested observing variations in daily casual wage rate over the year and taking a seasonally weighted average.

The methodology for costing unskilled labour can be simplified first by determining the amount of time that is saved as a result of improved water and sanitation services and then estimate the value of this time (measured in full time equivalent) to the households to derive the shadow price.

Churchill et al. 1987, recommended that although the shadow price for saved time in water transportation “*varies with circumstances, it probably reflects the rates of women’s earnings in petty trading and agricultural work and is less than average wage for males*” pg. xii. A rough estimate can be obtained by conducting an informal survey on petty trading activities in the area, for instance. Although worldwide women’s work for the same education and age overall is still paid less than that of men (Appleton et al., 1999; Blau and Khan, 2000; Blau and Khan, 2003; Bobbitt-Zeher, 2007) from an economic and moral perspective, women’s wage cannot be costed at about 58 percent of men’s work as suggested by Churchill et al., 1987. A non-discriminatory approach should be applied not only to existing income gender gaps but also other ethnic or context specific income inequalities.

In 1989 Whittington et al. derived the time spent collecting water from households in Kenya from different sources and used two different methodologies to cost the economic value to households. The results suggest that the households valued time spent collecting water highly. For households that chose a kiosk, the lower bounds on the value of time is at least 50 percent of the market wage rate for unskilled labour and for households that chose a vendor, the lower bounds are twice the market wage for unskilled labour.

No differentiations are done by gender or age in this or subsequent studies. But should there be differentiations between the dry and the wet seasons? Earlier in 1972, White et al. had suggested that *“in carrying water, the woman sacrifices the opportunity to do something else, perhaps something which would produce a greater return for her labour. […] there should be a seasonal variation in the opportunity cost of time as low during dry season, but high during planting cultivating and harvesting periods*” pg. 98

Studies with such level of detail were not found for the water and sanitation sector and throughout the last 20 years further simplifications have been used for valuing time in sector economic analyses. Mostly they use publicly available data sources to derive wages for skilled and unskilled labour and consider an arbitrary percentage to account for the opportunity cost of time.

> *“In localities lacking formal labour markets or with high unemployment, estimating an average value of time for a study population is largely guesswork.” (Nauges and Whittington, 2009:13)*

In the most recent cost-effectiveness and cost evaluation analysis in the sector, authors use a proportion of the minimum wage rates to reflect the fact that a large percentage of the working age population works in subsistence agriculture (Hutton, 2001).

Similarly, the Water and Sanitation Programme of the World Bank initiated a series of country studies under the Economics of Sanitation Initiative. These studies use an economic value of time as 30 percent of the amount paid to formal employees, and distinguish between adults and children’s time assuming that the opportunity cost of their time is different but recognizing that a child’s time is not worthless as it could be used at school which might lead to lower income levels in the future. In the studies, children’s time is valued at 50 percent of the minimum wage rate (Hutton and Haller, 2004; Sok et al., 2008). The reason for using a percentage of the formal wages for skilled work as the most appropriate global figure to reflect the average value of time (instead of unskilled labour) is to account for income forgone and balancing that some will use it for leisure time or non-income generating time.

For more conservative estimates than those provided by the minimum wage rates, 30 percent of the GNP per capita have also been used as a lower band alternative to the methodology described above (Hutton, Haller and Bartram, 2007).

Finally, Schweitzer et al 2013, have considered an even lower band alternative which consists of valuing the cost of time of households in rural villages in Burkina Faso at the same rate as household income. The advantages of the methodology is that it provides context to the income forgone for the amount of time the household spent on getting water, the disadvantages are that they assume that the income reported by the households can be considered a good proxy for their real income and it discriminates against poorer households, by valuing their time at a lower rate than better off households.

2.1.2.4 Economic costs of time found in the literature

For comparative purposes with the findings, a few studies have been reviewed which provide the time spent in collecting and transporting water as well as the valuation amounts used.

Whittington, Mu, and Roche (1990) found in one village in Kenya that time required to collect water from open wells per round trip ranged between 9 and 13 minutes and that the value of time spent hauling water could be costed at US$ 0.25 per hour (equivalent to US$ 0.40 in 2011 prices).

Similarly, based on 50 households using hand pumps, Abelin (1997) found in Udaipur, India that women were spending on average 56 minutes a day to collect water (12,7 minutes per trip and 4,4 trips a day). Women's time was valued at a very low Rs 5 per hour (equivalent to US$ 0.23 in 2011 prices) as the opportunity cost of time for other incomes forgone. Abelin used the formula in Equation 1 for calculating the collection time (T) per cubic meter.

Equation 1

$$T = \left(\frac{2D}{1000S} + \frac{q}{60} + \frac{V}{60Qd}\right) * \left(\frac{1000}{V}\right)$$

T= collection time (hours/m3)

D= one way travel distance (meters)

S= walking speed (km/hour)

q= queuing time (minutes/trip)

V= volume carried (litres/trip)

Qd= water delivery rate at the source (litres/minute)

m3= 1000 litres

Strand and Walker in 2005 have collected data on consumption and prices of water for more than 2600 households without access to tap water in 17 countries in Latin America. They found that households were spending on average about 16 minutes a day to haul water or 2 hours and 15 minutes per m^3 which is considerably lower than in the other studies above reflecting the urban context where data was collected. In a survey of 355 urban households which collected water from public taps, wells and other natural sources in Madagascar (Larson, Minten and Razafindralambo, 2006) a round trip travel time of 20 minutes or less was reported for the majority of households which reflects that almost all of these urban households collect water within one kilometre of their homes.

In conclusion, although time savings from transporting and accessing water and sanitation are an important component for costing the economic contribution of households, the economic methodology in the rural water and sanitation sector has relied on small data sets and a very diverse set of assumptions and methodologies which yield different results. It is proposed that economic analysis and time valuations are presented in ranges of minimum and maximum bounds to reflect the impact of using different shadow prices.

2.1.3 Conclusions on the literature on financial and economic costs

This chapter summarises the gaps and constraints with existing methodologies for collecting, analysing and reporting financial and economic expenditure for rural and peri-urban water and sanitation.

1. *Limited disaggregated financial cost data per cost component and per source*

Looking at the cost components used to review the literature, and comparing with expenditure requirements for sustainable service delivery, it is possible to observe that for expenditure and costs which are on-going, and expected in the short term, there is increasing availability of data. Data is accessible but is not available concerning sector expenditure on support costs in some countries and is mostly not available for capital maintenance expenditure and the costs of capital (Table 7).

When financial costs from households are reported, they relate mostly to the tariffs paid solely. Price is confused with costs. The costs paid by households are not the same as the costs of producing and distributing water.

Table 7 Data availability (and gaps) in the literature, per cost component

Cost components used to reviewed literature	Expenditure requirements	Description of data availability and gaps in the literature
Capital Expenditure – hardware and software (CapEx)	Short term and large lump sums	Data of lump sum capital expenditure is the easiest to access and most of the data available in this paper. Increasingly, software costs within capital expenditure are becoming known.
Capital maintenance expenditure (CapManEx)	Medium to long term and "bulky"	When these costs are mentioned, they refer to rehabilitation costs only. The largest gap in the literature.
Operating and minor maintenance expenditure (OpEx)	On-going and relatively lower amounts	Not collected systematically, but there is some information available mainly from household surveys.
Cost of Capital (CoC)	Medium to long term	In the water and sanitation sector large governmental loans with concessionary rates usually only need to be paid after a grace period of 5-10 years. There is very little knowledge on the terms of the grants and the amounts to be paid. Information is difficult to access at country level.
Expenditure on Direct Support (ExpDS)	On-going	The "software post-construction" which is needed to keep services running. The salaries of administration, NGOs overheads and other costs which are not reported but are to some extent accessible in–country in sector expenditure reviews.
Expenditure on Indirect Support (ExpIDS)	On-going	The macro level costs at national level. Usually possible to access by revising sector reviews and investment plans. Mostly accessible in-country.

2. *There is not a consistent financial accounting framework (or accounting understanding) being used for rural water supply and sanitation costing in lower income countries*

Unit costs being used in the literature refer to how much it costs to construct a specific technology mostly from the perspective of the implementing organisation, not from the perspective of how much it costs society overall. A subsidy to a family to be able to buy a slab is still a cost. A household contribution to capital expenditure is also a cost.

Confusion also derives from the terms used to disaggregate the unit costs. For expenditure with support there are different terminologies being used "software"; "administration costs"; "costs of running a programme"; "sector costs", etc. In conclusion, for rural water supply and sanitation there is not yet a consistent accounting framework being used by its professionals similar to the one used by (urban) utilities[2].

3. *Estimated costs are not real expenditure, real expenditure is not necessarily "ideal"*

Many cost estimates depart from a micro analysis of considering every single component of a piece of infrastructure. These are useful estimates for engineers and are based on Bills of Quantities available. Most of the country-wide studies use this methodology. The limitation of reporting on these unit costs is that they are mostly not real expenditure but estimated amounts. In South Africa and India the existing official 'Bills of Quantities' provide very high costs used as "acceptable ceilings" in tendering by contractors. On the other hand, there are also many other costs reported which are based on large data collection using contractor's reports, therefore reflecting real costs more accurately. Most costs reported do not make explicit which unit costs are estimations and which are based on empirical evidence.

Most costs reported are actual, not the ideal, therefore not reflecting inefficiencies caused for instance by tied aid and procurement systems which lead to more expensive (imported) options or other factors such as weak utility management, high leakage, limited supply chains, limited road coverage, etc. A study from 2002 (Estache) comparing productivity among 21 water utilities in Africa found that nearly two-thirds of their operating costs could be reduced with increased efficiency.

4. *Economies of scale and "levels of difficulty" are not reflected in the costs analysis*

Costs per capita are highly dependent on the population served by a set of technologies. Most costs reported do not provide a ratio of technology/population. Costs are also highly dependent on water resources availability and topography.

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[2] Although there are encouraging signs of the uptake worldwide of the accounting framework proposed in this thesis which was one of the key outcomes of the WASHCost programme.

Many of the world's poorest countries are also amongst the ones where water resources development is constrained. Increasing coverage levels has understandably been based on reaching "the low hanging fruit": rural communities presently without adequate supplies are among the most remote and inaccessible (WHO, 2012), highly densely populated areas in India or the Middle East face severe (economic) water scarcity (Rosengrant, Cai and Cline, 2002; Tropp and Jagerskog, 2006; Benjaminsen, Derman, Sjaastad et al., 2007; Kharraz, El-Sadek, Ghaffour et al. 2012). It can therefore be assumed that reaching those populations who are currently not covered will require more expensive investments than improving coverage levels for those who are not covered yet.

5. *High sensitivity to discount rates used for cost-benefit analysis of water supply and sanitation*

Cost benefit analysis brings future income into present net values by applying a discount rate which reflects the social opportunity cost of capital (the returns on capital in case the money would have been applied most efficiently elsewhere). Because they will be used for cost-benefit analysis, some unit costs in the sector are not reported using current prices but net present values (which use discount rates). Using simply GDP deflators and inflators to report costs is more accurate and not based on assumptions which have a high impact on the results.

6. *High sensitivity to annualising capital expenditure using life spans*

It is common for authors to compare different infrastructures by annualising capital expenditure. This is done by estimating an arbitrary lifespan for the infrastructure and dividing capital expenditure over the lifespan years to obtain an annual amount. The longer the lifespan estimates, the lower the annual cost expenditure.

There are two issues to resolve: each author is using its own lifespan for different system components (limiting comparability) and the design lifespans are usually much longer than in reality, making capital expenditure look lower per year, when in reality many hand pumps will only last 3-5 years, for instance. This approach is not correct from a fixed asset accounting approach and adds one more (unnecessary) layer of complexity to cost studies.

> *"Some components of network water supply and sanitation systems, such as large-diameter pipes, have a longer lifespan than 25 years in developed*

countries. For example, the American Water Works Association estimates that water supply mains installed in the post-World War II period last about 75 years. But water mains are only one relatively small component of water and sanitation network infrastructure. Smaller diameter pipes are generally not as long-lived and other components such as treatment plant elements and water meters need more frequent rehabilitation. The Asian Development Bank, for example, estimates that water meters in Phnom Penh need to be replaced every 4–8 years. In addition, systems in the developing world are prone to several problems, which tend to shorten the infrastructure lifespan. Contractors may lower specifications on materials and civil works, using pipes with lower pressure ratings, or install networks with inadequate bedding or backfilling. Pipelines designed to last 40 years may end up serving less than 10 years. Finally, systems are generally less well maintained and the replacement cycle is very uneven and activated on an emergency basis." (Whittington, 2007)

7. *The cost of yesterday is not the same as the cost of today: currency, exchange rates and dates*

Most costs are reported in US Dollars or Euros. They have been converted from local currency units to an international currency using a market exchange rate. The exchange rate is usually not mentioned, neither is the original local currency unit or the date. Comparing like with like becomes a challenge because it is then not possible to transform the local currency in a current year using PPP or the market exchange rate.

8. *Economic cost analysis is limited in sample sizes and to the urban sector*

In the literature reviewed for the economic costs, the sample sizes are very small, mostly urban, and although some of the studies measure the time, mostly this critical indicator is not costed (also indicated by Whittington, Mu and Roche, 1990).

9. *Each author costs time differently*

For the economic cost analysis, the literature is limited and each author reviewed used a different methodology and rates which affect results. Presenting the time used for the calculations and then the costing parameters would allow others to use the base data and check for the sensitivity of different shadow prices for time spent collecting water.

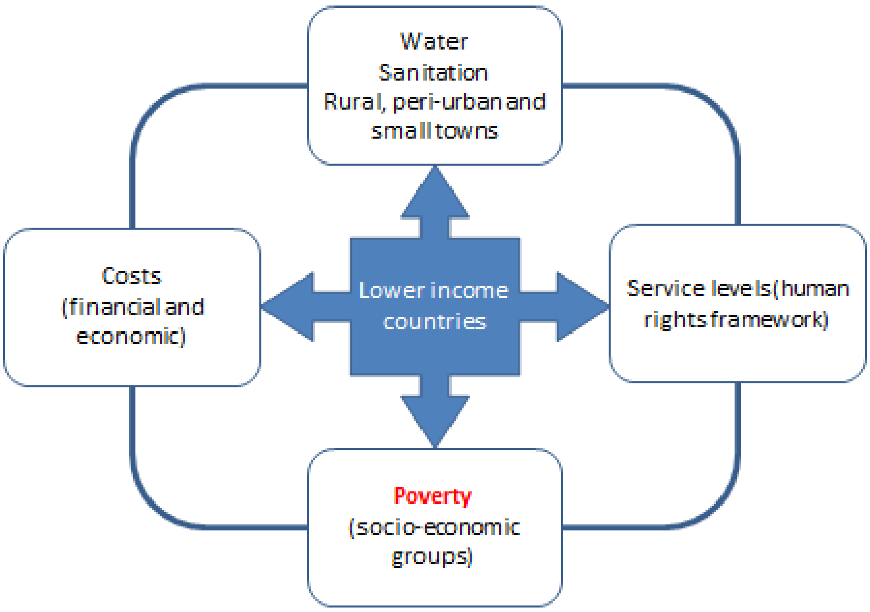
10. *No financial or economic methodology compares costs with the outcomes of providing services*

> *"The application of these costing principles to sanitation program planning presents several difficulties. The main one is the problem of finding a scaling variable that allow comparison among diverse technologies regardless of their design populations" (Kabermatten et al., 1982)*

With the exception of WASHCost, this is the single most relevant gap and failure in all the costs studies done in the sector. Once the cost is known, the studies do not provide an answer to the most relevant question: "What service are people getting for the investments made?"

This thesis main objectives (i. and ii.) aim to tap this enormous gap solely using household's costs in terms of their financial and economic expenditure.

2.2 Household socio-economic categories: relative poverty levels



The previous chapter has focused on the existing gaps in the literature in the water and sanitation sector in lower-income countries concerning household financial and economic expenditure. This sub-chapter will focus on the literature that uses socio-economic categories to differentiate households.

Socio-economic categories are essential to monitor the implementation of the Human Rights to Water and Sanitation and provide an indicator for the level of services received by the different groups within the population (Roaf, Khalfan and Langford, 2005).

> *"Measuring poverty at the local level is straightforward, at the national level it is hard but manageable, but at the level of the world as a whole it is extremely difficult, so much so that some people argue that it is not worth the effort." (Deaton, 2004)*

Household socio-economic characteristics allow for the exploration of links between poverty and water access, water use and expenditure. Some of the most relevant questions concerning poverty in the water and sanitation sector include:

- Are the poorest spending more on accessing WASH than the non-poor?
- Are the poorest receiving a lower level of service than the non-poor?
- Are the costs of accessing WASH services affordable for the poorest?

The literature, which derives mainly from welfare economics and consumer behaviour, is reviewed to understand what are the most relevant indicators for determining relative poverty levels and understand the pros and cons of each of the methodologies used for categorising households. These will be used for the data analysis. Another critical aspect of the literature review is to understand what existing additional WASH poverty related data has been collected in the study countries so that existing data can be used to undertake further analysis.

There are several income and wealth proxies being used to define household socio-economic categories. In this literature review the focus will be on:

- Household reported income
- Household reported expenditure as a proxy for income
- Indexes of household asset ownership
- Materials used for respondent's house (whether the house was painted, whether the roof was straw or tin, whether the floor of the house was dirt or concrete).
- Qualitative participatory poverty assessment (poverty status as compared to neighbours)

2.2.1 A historical perspective: household surveys and the study of inequalities

> *"Household surveys remain the basis for documenting poverty in lower income countries today." (Deaton 1997:4)*

The scientific study of consumer behaviour and income distribution dates from before 1900. There are reports of collected household budgets dating from 1795 in the United Kingdom and then larger European compilations from the late 1840s. However, the study of income inequalities between persons and its causes has started mostly after World War I and nationally representative surveys of household living standards are relatively new (Garvy, 1952; Deaton, 1997).

In 1951, the India National Sample Survey started tracking household expenditure and in the 1970s initiatives for gathering data on poor households were started in both lower and higher-income countries.

> *"In the late 1970s, it became clear that it was impossible for the World Bank – or for anyone else – to make well supported statements about world poverty, especially statements that required internationally comparable data. There was no firm basis assessing such fundamental topics as the extent of poverty in the world, which countries were the poorest, or whether the inequality within and between nations was expanding or contracting. Even within countries, the simplest statements about distributional outcomes were difficult." (Deaton, 1997:42)*

As a response to the need of having comparable data worldwide on poverty, the World Bank started in 1980 the Living Standards Measurement Study (Grosh and Glewwe, 1995). The main objective was to support the collection of comparable household survey data across countries – allowing for comparisons of poverty and inequality over time and space. With this initiative, high-quality household data on several welfare indicators that could be compared at international level started being collected from a limited initial few countries to a worldwide initiative (Lipton and Ravallion, 1995; The World Bank, 2013).

The LSMS surveys are multi-topic questionnaires designed to study multiple aspects of household welfare and behaviour with a large focus on the collection of income, consumption expenditure, savings, employment, health, education, fertility, nutrition, housing and migration. There are no specific questions related to water and sanitation in the household questionnaires, but there are questions about the water sources used featuring in the community questionnaire component of LSMS (Grosh and Glewwe, 1995).

2.2.2 Definitions and measurements of poverty

The concept of poverty is not a static or a consensual one. There is not an universally agreed definition, terminology abounds and new definitions still emerge. Different methodologies are used to measure different definitions of poverty resulting in different research conclusions (Atkinson, 1991; Spiker, Leguizamon and Gordon 2007). In a nutshell, poverty exists when a person or a group of persons falls short from a level of welfare which is considered a minimum standard from a specific society point of view (Streeten, 1981; Lipton and Ravallion, 1995).

The ranking and measurement of poverty consists of three main components (Ravallion, 1992; Deaton, 1997):

- Households (or individuals) are ranked on the basis of the indicators of living standards or welfare chosen
- A criteria is set to differentiate the poor from the non-poor
- And finally, a poverty profile is built to understand what and how policies can improve the lives of the poorest

In this thesis, the interest is not so much in measuring the level of poverty in absolute terms (which is done by setting poverty lines[3]), but in ranking households in terms of their poverty levels. In this situation, the concept of contextual or relative poverty is relevant since the levels of poverty are set in relation to a specific society always evolving cultural, economic and political structures. (Spiker, Leguizamon and Gordon, 2007).

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[3] Poverty lines define the ability to purchase a minimum amount of goods which are considered basic needs for survival (Streeten, 1981). For instance, the dollar a day is an internationally accepted measurement of absolute poverty established by the World Bank in 1990. Most critics of poverty lines relate with the “fixed” nature of poverty lines – the poverty lines used in the US retain as its basis the set of requirements established in 1961 (Deaton, 1997). Even if poverty could be considered a discrete absolute state, it is a limited measure because it does not take into account the degree of poverty or reveals how policies are impacting on the poorest (specific policy measures can make the poor even poorer for instance) (Ravallion, 1992). Other problems with poverty lines include non-comparable underlying household surveys and variations in poverty lines which prevent country comparisons (Ravallion and Bidani, 1994; Lipton and Ravallion, 1995). Finally, all poverty lines include normative assumptions and arbitrary assumptions and therefore are not objective measurements (Bidani et al., 2001).

"Much of the data we now routinely use in poverty analysis is full of errors, and that is unlikely to change." (Ravallion, 1992:2)

"The conceptual and practical difficulties over the choice of a poverty line mean that all measures of poverty should be treated with scepticism. […] Poverty lines and poverty counts make good headlines, and are an inevitable part of the policy debate, but they should not be used in policy evaluation. Perhaps the best poverty line is an infinite one; everyone is poor, but some a good deal more so than others, and the poorer they are the greater weight they should get in measuring welfare and in policy evaluation." (Deaton, 1997:154)

"At the moment, the World Bank international poverty line has been set close to the Indian one, so poverty is measured by counting everyone whose level of consumption is low enough to be counted as poor in India." (Deaton, 2004)

2.2.3 Using reported income and expenditure to rank household levels of poverty

How is welfare measured at household level? Income poverty is a key concept in almost all definitions and studies of poverty (Spicker, Leguizamon and Gordon, 2007) and not surprisingly, the two most common indicators used are real income and real expenditure on consumption as reported by households (Ravallion, 1992).

Most of the literature and supporting studies seem to indicate that consumption is a better measure of welfare than income (Lanjouw and Lanjouw, 1997). Many poor people earn no income and many poor households have difficulties in converting income into well-being (Meyer and Sullivan, 2009).

"Even in the industrialised countries, the measurement of self-employed income is notoriously inaccurate […] The practical and conceptual difficulties of collecting good income data are severe enough to raise doubts about the value of trying; the costs are large and the data may not always be of great value once collected" (Deaton, 1997:39-40)

"Economic welfare" has had many interpretations in the literature on poverty in lower-income countries but one aspect which is not controversial is that inadequate access to certain commodities is the most important aspect that defines poverty. Further, there is no consensus on the correlation between a countries' average real income with the main indicators of satisfaction of basic needs (Lipton and Ravallion, 1995; Meyer and Sullivan, 2009).

Very detailed analysis of income and expenditure in Zaria (now a major city in Nigeria) by M. G. Smith in 1955 shows already different results on the total household wealth depending on the method use. The discrepancies between reported income and expenditure are bigger, the higher the income level – which is a problem with the expenditure analysis based only on a limited arbitrary chosen assets since the importance to the household changes as its patterns of income change.

Chaudhuri and Ravallion (1994) found from longitudinal surveys (1976-1983) from 103 households in rural India that although consumption is not always a better indicator of chronic poverty than income, it does perform better than other indicators such as food share and access to land. Deaton (1997) however argues that in poor countries such as India, where food makes up a large share of the budget, and where the concern with poverty is closely associated with concerns about nutrition, it makes more sense to use food and nutritional requirements to derive poverty lines more than any other consumption items, but the problem remains that what is considered an adequate calorie level is subject to uncertainty and controversy, and some would argue that resolving the arbitrariness about the poverty line with a calorie requirement simply replaces one arbitrary decision with another.

Another argument is that measuring welfare using only a part of the total consumption of the household can distort results because where food is relatively cheap, people will consume more and therefore poverty lines will be higher where the relative price of food is higher.

Other arguments which favour expenditure as a proxy for welfare in lower income countries include:

- All the difficulties encountered with data collection of consumption expenditure such as recall bias for past expenditure, seasonality variations and non-response are much higher when collecting income data (Deaton, 1997).
- Expenditure is less volatile than income. Consumption smoothes temporary variances in income and takes into account credit, savings and assets. Further, income in agrarian societies is highly variable (Lipton and Ravallion, 1995).

- In providing responses to a survey, households are more likely to understate their incomes than they are to overstate their expenditure (Hentschel and Lanjouw, 1996).
- Finally, for many rural households in lower income countries involved in agriculture and family ran businesses it is difficult to separate or to understand what income is (Deaton, 1997).

Whether choosing income or expenditure indicators, problems remain for international comparisons when it is assumed that the underlying methodologies are similar – which is not always the case. It is also argued that given the problems of comparability and precision, and in some cases, less extensive surveys provide the necessary information for poverty headcount (Lanjouw and Lanjouw, 2001).

For the water and sanitation sector in lower income countries there is an added difficulty with reported expenditure: in rural areas most households do not pay for the water they consume, and if they exist, pit latrines are seldom emptied. If only nominal expenditure are included in the surveys it is not possible to determine actual water or sanitation use – which is also a measure of welfare. In urban areas, households in slums have often higher expenditure per cubic of water sold by private vendors than households connected to piped networks – in this case expenditure is also not a good proxy for ranking households (Hentschel and Lanjouw, 1996).

Mu, Whittington and Briscoe (1990) found from 69 households in Kenya that household income did not have a statistically significant effect on the choices of water sources. Contrary to this finding, Larson, Minten and Razafindralambo (2006) have examined income information from 547 households in Madagascar who collected their water either from public taps, wells and other natural sources or alternatively from private household connection. The households were divided into five income categories: from an income lower than 100,000 Fmg/month (< $18 per month 2006 prices) to a higher income of more than 700,000 Fmg/month (> $127 per month 2006 prices). They found that income levels for households with no household connection were substantially lower than those with a household connection. 64 percent of non-connected households reported incomes lower than $55 per month compared with only 9.4 percent of connected households.

2.2.3.1 Do subsidies distort the wealth categories?

Analysis of household expenditure relates to capturing the real expenditure of households. Some of the purchases might be subsidised and therefore below "real cost". This is a correct assumption but given that the analysis purpose is for the ranking of household expenditure, and not for absolute comparisons or for calculating the costs to the whole society, subsidies do not need to be taken into account (Deaton, 1997).

2.2.3.2 Comparing household expenditure in different currencies

The same methodology described in 7.1.5A.1.2 is used in the literature to compare expenditure across countries: purchasing power parity is used to convert currencies and neutralise the effects of over-valued or devalued currencies. However, purchasing power parity rates were not developed for the purpose of measuring poverty, and some argue that maybe they are not appropriate to convert living standards from one country to another (Deaton, 2004).

2.2.3.3 Transforming household data into per person estimates

Household surveys collect data at the level of the household and not the individual. However, most calculations of poverty and welfare assume an equal division among household members which undoubtedly will be blind to intra-household inequalities (Ravallion, 1992; Lipton and Ravallion, 1995; Deaton, 1997). This means that the expenditure or income that is collected per household is then attributed to all members of the household, not because it is believed to be equally distributed but because there is not yet a widely accepted alternative methodology[4] (Hentschel and Lanjouw, 1996).

The main problem with assuming that household expenditure is uniform among its members is that it does not capture economies of scale among the poor (Lipton and Ravallion, 1995). While food expenditure does not vary much with household size, in non-food expenditure such as water and sanitation for instance, the fixed expenditure on construction or maintenance of a borehole or toilet for the family will be much lower

[4] Most literature refers to "equivalence scales" which sets rules for allocating household expenditure to household members of different gender and age by making assumptions on different needs in terms of nutritional requirements and non-food consumption. These choices tend to be somewhat arbitrary and controversial since consumption expenditure might not reflect household "needs" but the existing possibilities within the poverty status.

per capita the larger the household. Given that a sizeable amount of household expenditure is devoted to non-food items researchers might want to test the sensitivity of results to economies of scale assumptions (Hentschel and Lanjouw, 1996).

2.2.4 Using assets to rank household wealth

Another possible indicator to measure and rank household welfare is to create an index from asset ownership indicators, using its main components to derive weights. This approach is used in the Demographic and Health Surveys (Measure DHS, 2013) a programme that collects and analyses data from more than 90 countries on population, education, health, gender, HIV prevalence and nutrition among others, using more than 300 surveys. The surveys do not collect income or expenditure data but other housing characteristics are collected to develop a wealth index where households are divided into five quintiles. A statistical method known as principal components analysis is used for allocating a weight or score to each household.

Filmer and Pritchett (2001) have validated the method by using data from India to estimate the relationship between household wealth and school enrolment. The results showed that the wealth index performed better than the expenditure index. Rutstein and Johnson (2004) have compared the use of both a wealth index and a expenditure index for five countries and show that the results from using asset-based ranking explain the same or a greater amount of the differences between households health indicators as well as requiring less effort when compared with an expenditure index.

The DHS wealth index basically tries to measure the ability to pay for health services and the distribution of services among the poor (very similar to the objectives of this thesis but for the health sector). For this reason, the assets and services asked about in DHS surveys include:

- Type of flooring
- Water supply
- Sanitation facilities
- Electivity
- Radio
- Television
- Telephone

- Refrigerator
- Type of vehicle
- Persons per sleeping room
- Persons per sleeping room
- Ownership of agricultural lands
- Domestic servant
- Country-specific items

Type of occupation and level of education are normally associated with socio economic status but left out as they impact on the economic status and the authors wanted to isolate the pure economic variables. However *"the determination of specific indicator variables is somewhat of an art, depending on knowledge of conditions in each country*" (Rutstein and Johnson, 2004:9) and there are few studies that have studied the reliability of the collected asset data, which has impact in the overall results (Vyas and Kumaranayake, 2006).

Some of the difficulties in applying this methodology include the fact that electricity, water and sanitation are sometimes publicly provided so there are some questions whether they reflect household economic status or simply a matter of being inaccessible/accessible. DHS chooses for its inclusion given that wealthy households will reside in areas where these services are provided. The methodology also suffers from the lack of disaggregation of data within households and by assuming there are no economies of scale related with household size. This list is not exhaustive for further details see Rutstein et al., 2004.

Howe, Hargreaves and Huttly (2008) and other researchers have also compared several assets indices with consumption expenditure in middle and lower income countries. They found that although studies claim that collection of asset data is more reliable and cheaper than the income or expenditure methods since it does not rely on the recall method (Morris, Carletto and Christiaensen 2000; Sah and Stifel 2003; Garenne and Hobnann-Garenne 2003; Henry, Sharma, Zeller et al. 2003; Schellenberg, Victora, Mushi et al., 2003), there are also studies that contradict this conclusion (Onwujekwe, Hanson and Fox-Rushby, 2006; Pascoe, Hargreaves, Langhaug et al., 2013).

"While it is possible to consider methods for combining these indicators into a single measure, there is no adequate theory underlying such an aggregate so that weighting schemes are inevitably arbitrary, and it is more informative-as well as honest-to keep the different indicators separate. This is not to downplay the importance of these other indicators, nor to deny that public goods such as hospitals and schools contribute an important part of individual welfare. However, it is important not to confuse the components of economic welfare with their aggregate. We have already seen how the definition of a poverty line in terms of calories can give misleading results when relative prices differ. The same argument applies to attempts to shortcut welfare measurement using indicators such as housing, or the ownership of durable goods. Immigrants to big cities often live in very poor-quality housing in order to have access to employment. In such cases, their poor housing reflects the high price of housing in urban areas, but may tell us little about their living standards." (Deaton, 1997:159)

2.2.5 Ranking poverty levels by using qualitative perceptions of welfare

Being considered poor by someone else's standards is different from feeling poor. People do not find it hard to answer the question "Do you consider yourself poor/non-poor? What about your neighbours?" These questions are the basis of assessing poverty using qualitative participatory assessments and, in the evidence produced so far, the results are good. Pradhan and Ravallion (1998) have identified a subjective poverty line by asking respondents in Jamaica and Nepal if they thought their food, housing and clothing was adequate to meet the family needs. They found that the poverty lines derived from this methodology come close to the alternative method which asked detailed consumption expenditure. This qualitative method has also been used in the US to define what is the amount of income that people think is the borderline between being poor and non-poor (Deaton, 2004).

Other evidence includes work over the last 30 years by Mahar Mangahas in the Philippines (1977; 1983) which further states that the benefits of the poverty self-rating approach include that it is not institutionally possible to manipulate results and its far cheaper than the other methodologies described above (Mangahas, 1995). The findings of self-rated poverty research done in the Philippines at the national level 56 times between 1983 and 2001 have found that the self-rated poor were about twice as high as the reported officially poor. The methodology also captures chronic and seasonal poverty by asking additional questions: “How many times in the last 5 years have you felt this way?” and “How many times in the last 12 months have you felt this way”, respectively (Mangahas, 2001).

Place, Adato and Hebinck (2007) have compared quantitative and qualitative analysis of poverty in 1600 households in Kenya and found that poverty carries a stigma and some respondents did not want to be labelled as such. They have compared different poverty assessments: asset classification, relative ranking and welfare conditions evaluated by the enumerator. The self-ranking was the best to differentiate households in terms of livestock, farm and food consumption indicators close to the enumerator evaluation while the asset classification did not correspond at all to food consumption. Similarly, Howe and McKay (2007) have combined participatory poverty assessments with household surveys to identify the chronically poor in Rwanda which are difficultly measured with income and expenditure assessments.

Hargreaves et al. (2007) have used participatory wealth ranking to analyse the poor in 9,671 households in rural South Africa, using standardized methods for large scale ranking which take two days: one day to map all the households in the village and a second day to discuss with small groups aspects of poverty within the village and rank the households from “very poor”, “poor, but a bit better off” and those that are “doing ok”. Each household is ranked three times by different community members in a series of meetings. The same methodology was used by Aryeetey et al. (2010) in Ghana. The methodology was considered successful to rank households, but when compared with other methodologies the evidence that participatory poverty assessments are valid – even when combined with solid quantitative analysis – still provides contradictory results depending on the method used or the setting (rural or urban) or even that detailed expenditure assessments are more expensive than the standardised large scale poverty assessments.

2.2.6 Conclusions on the methodologies used in the literature to rank poverty among households

It’s interesting to note that the three core methodologies for ranking households above have developed from different strands of research:

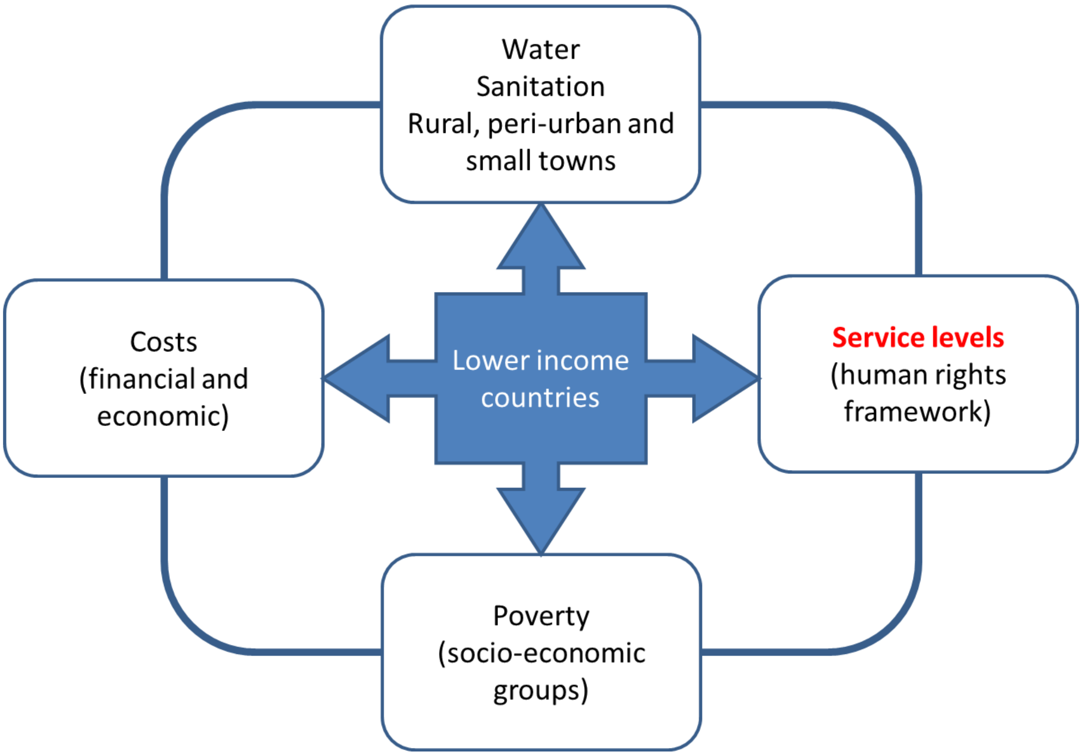
- Income and expenditure analysis from economics and earlier consumer behaviour studies (Deaton, 1997)

- Ranking assets as proxies for defining household socio-economic position (SEP) is a concept used widely in epidemiology studies (Howe, Hargreaves and Huttly, 2008)
- Qualitative perceptions of welfare derive mainly from participatory rural appraisals related literature (Hargreaves et al., 2007)

The methodologies are still compartmentalised in their own disciplines and the relationships between the different measurements of poverty have not been fully analysed except for income and expenditure. The main separation has been between the quantitative and the qualitative methodologies (Place, Adato and Hebinck, 2007; Howe and McKay, 2007). Most of the research published for ranking households socio-economic status try to assert the superiority of one methodology above another. An index, for instance could be derived to combine these different methods which capture different dimensions of poverty.

It is surprising that qualitative perceptions of welfare are not more widely used or explored further as a relatively cheaper and easier method for ranking poverty levels among households. For smaller scale interventions, and in the WASH sector in particular, this can be a very useful and cost-effective method to define where the poorest are located within a community and what is the level of service they are receiving, before and after an intervention.

2.3 Global standards for (rural) water services: indicators and measurements



Global standards for water services have been reviewed by Kayser, Moriarty, Fonseca and Bartram (2013). This chapter will summarise some of the findings for some of the indicators described in the paper which are relevant for the analysis of findings in this thesis and to identify the gaps. Further, the author has been the co-chair of the JMP/UNICEF Water Working Group which has been a process of reflection that started in 2011 to review the possible future goals and indicators for the global monitoring framework that will replace the existing Millennium Development Goals (WHO/UNICEF/JMP, 2012). This chapter also draws from some of the insights discussed in the working groups.

The focus of the literature review will not be on the amount of global standards used, but which indicators and measurements are being proposed and a critical analysis on their use – a similar analysis done with the literature review for measuring household wealth in the previous chapter.

2.3.1 Background to global standards for the sector

Standards and indicators for rural water services have been mostly set by implementing agencies to monitor completion of their infrastructure programmes and one of the many components of poverty reduction strategies (Warner, 1973; Saunders et al, 1976; World Bank, 1994; 2002) as well as governments and regulatory agencies around the World to monitor service delivery (WHO, 1997; 2003). Each country has its own set of criteria and measurements for the sector: India has about 9 criteria, Mozambique has three (crowding, quantity and quality) and Ghana has six (distance, crowding, quantity, quality and reliability) (Moriarty et al., 2012). The JMP has attempted to set the first internationally comparable indicator which measures global water coverage by assessing the type of technology used and classifying it as improved or non-improved (JMP, 2008).

However, globally comparable standards have gained recent attention when on 28 July 2010, the United Nations General Assembly recognized water and sanitation as a human right (UNGS, 2010). The resolution states that water and sanitation as a human right must fulfil the following criteria:

- *Physically accessible.* Water and sanitation services need to be accessible within or in the immediate vicinity of the household, workplace and educational or health institutions, ensuring access by the disabled, elderly, women and children. According to WHO, a water source to provide a basic service needs to be within 1.000 metres from the home and time should not exceed 30 minutes (WHO, 2003 based on Howard, G. and Bartram, J. 2003).
- *Continuous and sufficient*. According to the World Health Organisation between 50 and 100 litres of water per person per day are needed to ensure that most basic needs are met (WHO, 2003 based on Howard, G. and Bartram, J. 2003).
- *Safe.* The water required for personal use must be free from micro-organisms, chemical substances and radiological hazards (WHO, 1997).
- *Affordable.* The costs for water and sanitation should not exceed 5% of the household's income.
- *Acceptable.* Water should be of acceptable colour, odour and taste and water and sanitation facilities must be culturally appropriate, respecting gender, lifecycle, dignity and privacy requirements.

These criteria and how they can be measured for international comparisons are presently under discussion in several international Fora (UN-Water, JMP/UNICEF working groups, country consultations, etc). Some of the indicators have been already been collected by country level studies, and the conclusions from the data and methodology of this thesis is a further contribution to that debate.

There is relevant literature (but mostly grey literature from UN agencies) for the rural water sector concerning accessibility, sufficiency (when understood as quantity) and safety (when understood as quality). There is limited information and studies on continuity, acceptability and affordability.

2.3.2 Physically accessible (accessibility)

Accessibility has been measured in the literature using distance and time required for water collection. As described in the economic costs literature review, collecting the time that people spent collecting water can be done in many different ways and increasing accuracy can be very costly as it implies travelling with several persons (women, men, children, elderly) from the house to the water source and time the trip at least twice a year. Therefore mainly for practical reasons, distance has been used as a proxy for time in most studies.

The United Nations has reported that the "average distance that women in Africa and Asia walk to collect water is 6 kilometres" (UNHR/UN-Habitat/WHO, 2010). This assumes a rural setting. For areas with more urban characteristics the distances and time reported are much lower. Larson et al. (2006) reported from a study in Madagascar that households travelled on average seven minutes per round trip to collect water and more than 80 per cent of the sample travel on average less than ten minutes. Most of the urban households also collect water within one kilometre from their homes (2 kilometres per round trip).

Distances and time derived from distances do not account for queuing times which can be considerably different in the wet and dry seasons and in rural and peri-urban areas (Ray, 2007). White, Bradley and White (1972) report an average of 54 minutes spent per day but with time ranging between 3 minutes and 4,4 hours. Maximum distances quoted were 22 and 25 km for a round trip, which is considerably higher than the previous authors.

Sorenson, Morissink and Abril Campos (2011) have summarised data about water access and carrying from 44 countries that have participated in the MICS programme (described in the previous chapter on measuring poverty). They conclude that women are the ones that usually carry water (followed by men and children) and spent more than one hour per day and several trips to collect the water needed for their households' needs. The mean time to fetch water varied greatly. In Ghana the mean time to water source in minutes is 18.4 and in Burkina Faso it is 35.8. Interestingly the authors refer to one of the initial methodologies used to cost time and explored in the economic costs literature review: caloric expenditure and the impact it has on health and quality of life particularly during periods of scarcity.

The standards for crowding aim to address queuing or water availability problems. These standards have been adopted by some countries reflecting the nature of water as a limited resource. For instance, in Mozambique crowding per water point should be less than 500 people. In Ghana, crowding is defined per technology: less than 300 people for boreholes with handpumps and standpipes, less than 150 people for wells. India and Burkina Faso have other crowding standards (Moriarty et al. 2012). However, the basis for translating crowding into what is an acceptable or non-acceptable waiting time is not clear or documented.

The minimum standard set by the Human Rights to Water and Sanitation using as indicators the accessibility of the source within 1.000 metres from the home and less than 30 minutes for collection will be a much higher standard than the existing situation in rural contexts in developing countries. Further, there needs to be a comparison on methodologies used to collect both distance and time and if one is a good proxy for the other.

Recent research (Pickering and Davis, 2012) points to a decrease in diarrheal disease as time to fetch water decreases. Data from 200,000 Demographic and Health Surveys from 26 countries assessed the relationship between household walking time to collect water and child health outcomes. A 15 minutes decrease in one-way walk time to the water source is associated with a 41% average relative reduction in diarrhoea prevalence and a 11% relative reduction in under-five child mortality.

2.3.3 Sufficiency (quantity)

The best proxy available for sufficiency is the quantity of water consumed. The World Health Organisation recommends that for a basic service level, between 50 and 100 litres of water per person per day are required to at least use water for drinking and cooking. Hygiene may be compromise and laundry may occur away from home (WHO, 2003 based on Howard, G. and Bartram, J. 2003).

Quantity is probably the indicator which has had more reported studies, reflecting the relative easiness in collecting the litres used per person and per day:

- For point sources and non-metered sources asking respondents about the containers used to collect water, how many containers and how many trips are done in one day
- For metered sources, collecting the monthly readings.

Larger households are found to have greater water use and per capita consumption decreases with the number of members in the household (Deaton, 1997).

Reported litres per capita per day in rural areas in early literature are reproduced in Table 8 (Bradley, White and Bradley, 1972:288).

Table 8 Estimated daily used per capita in litres for rural connected/non connected households

	Place	Lpcd
Connected		
Republic of China	Rural area with water systems	50
West Germany	Rural systems	83
Not connected		
Bolivia	Seven villages	10
Kenya	Zaina	7
Nigeria	Anchau District	23-27
Sudan	Kordofan	9-16
Tanzania	26 villages in 10 districts	5-26

Source: Adapted from Table D (White, Bradley and White, 1972)

2.3.3.1 Quantity, distance and sources

There are a number of studies that correlate quantity with distance (discussed in the previous chapter). In 1972, White, Bradley and White reported that *as* travel time to the water source increases, there is also a reported decrease in water carriage to the household. The turning point has been quantified in Cairncross and Feachem (Figure

2) and in Bosch et al. (2002): when water sources are between 30 and 1.000 metres from the household (or roundtrips take between 5 and 30 minutes), the volume of water collected varies little, with a distance less than 30 meters the amount of litres increases and with a distance higher than 1.000 metres the amount of litres per capita per day decreases.

Larson, Minten and Razafindralambo 2006 found, in Madagascar that better educated and less poor households rely more on private connections and consume more litres per month at an average of 88 litres per capita per day while the households that need to collect water consume an average of 14.5 litres per capita per day. The increase in use is explained in the increase in water for hygienic purposes. When water is expensive or it takes too much time and energy, consumption is cut back to 15 litres per person per day or less by among others cutting back on bathing (Bosch et al., 2002; Thompson et al., 2001).

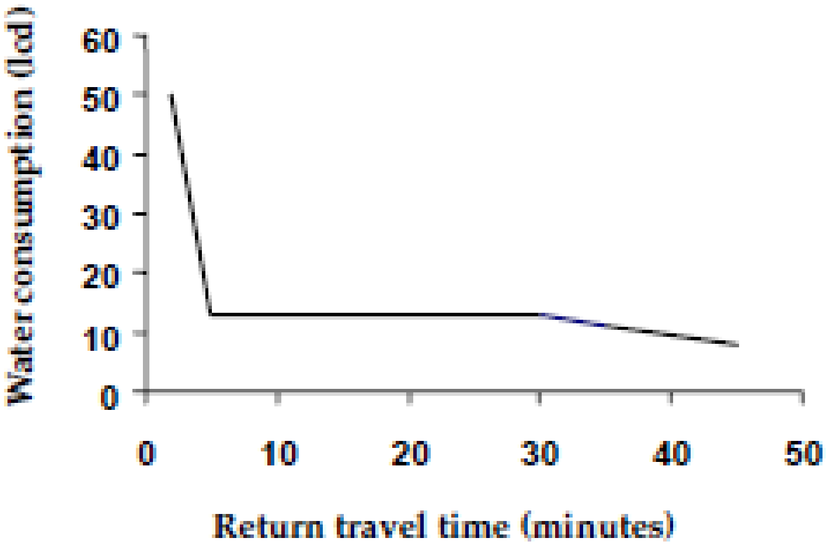


Figure 2 Per capita water consumption (litres per day) and roundtrips in minutes

Source: Cairncross and Feachem, 1993:63)

Nauges and Whittington (2009) reviewed several case studies from across the world and covered a 20 year time span and show the diversity in consumption patterns in urban and peri-urban areas. Even in these areas, households that have a private well (average 110 litres per capita per day) have a higher consumption when compared with those relying on public taps outside the home (average 25 litres per capita per day).

In an even higher band, Strand and Walker in 2005 have collected data on consumption and prices of water for more than 2600 households without access to tap water in 17 countries in Latin America. They found that on average household water consumption was 29 m^3 per month (966 litres per day per household) for metered tap households, and about 5.5 m^3 per month (183 litres per day) for households not connected to any water system which were relying on a variety of water sources. For comparison purposes, Figure 3 reproduced from Waterwise in OFWAT (2007) shows USA at the top of the list with 360 litres per person a day and Lithuania at the other end with 97 litres.

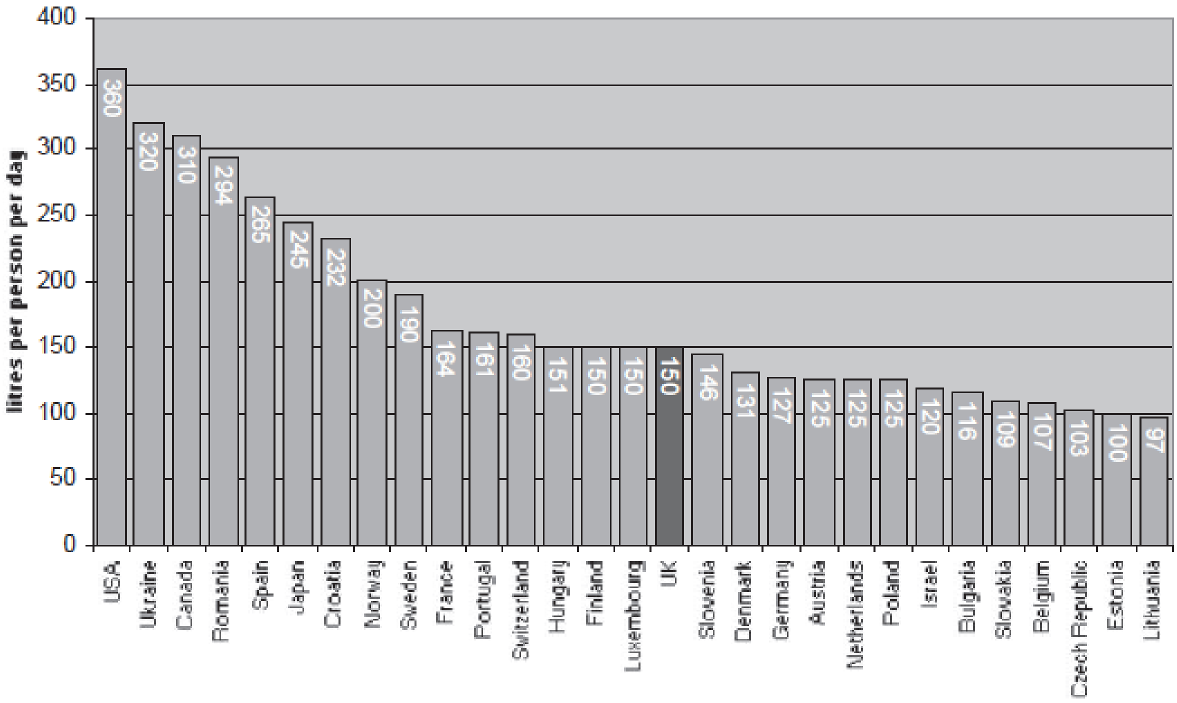


Figure 3 Per capita water consumption (litres per day) in higher income countries

Souce: Watewise in OFWAT 2007:48

2.3.3.1 Quantity, costs and household wealth

There are suggestions that the costs prevent households to consume more quantity of water per day (similar to the graph on distance), but there is less evidence where are the cutting points and how sensitive is consumption to costs (Howard and Bartram 2003). In a study in Sudan, even with very high water costs, the litres consumed have not been affected, suggesting that given the lack of alternative sources the poorest will spend a disproportionate amount of their income on water (in this study up to 56%) (Cairncross and Kinnear,1992).

Mu, Whittington and Briscoe (1990) found that household income appears to be relatively unimportant for a household to decide which source to use, others report that households with higher wealth are more likely to be connected to a pipe service in urban areas which are not served exclusively by private utilities (Garn, Isham and Kähkönen, 2002). Thompson et al. (2001) found that one of the most important factors to impact on the quantity consumed was the wealth status of the household followed by the cost of water, both for connected and not connected households.

2.3.4 Continuity (reliability)

Continuity is defined as the proportion of time that water is available either as hours per day or/and days per year (WHO, 2008). It is intended as an indicator to capture interruptions or discontinuity in the provision of water. "The frequency of data collection on continuity in piped water supply would seem to be primarily determined by the predictability of the discontinuity" (Howard, 2002). Continuity is a concept closely related with quantity and quality, but the literature refers mainly to piped urban systems.

Reliability refers to whether water is available every day and when the consumer can expect it (Garn, Isham and Kähkönen 2002). Reliability is a much better indicator than continuity because it measures the predictability of discontinuity which is critical for water services in rural contexts with frequent breakdowns, since people might only get a couple hours of water available per day or per week but as long as they know when water is available then consumption can be planned for (or use of alternative sources). The number of times per month/year that a system is working is a government norm in countries like Mozambique and Ghana (Moriarty et al, 2012).

2.3.5 Safe water (quality)

International norms for drinking water quality are published by WHO (2008). At its minimum, water quality is accessed by measuring faecal indicator bacteria and E.coli is the most used indicator as proxy for the degree of contamination (Kayser et al, 2013). Similarly to other water service indicators described above, the sampling methodology can have a great influence on results (WHO, 2003).

Most importantly, in the absence of water testing, a water source can be considered "safe" or not: "improved water sources have relatively greater protection from faecal contamination than unimproved sources" (Keyser et al, 2013).

This indicator is going to be discussed in the thesis to a very limited extent and further details can be found in the literature quoted above.

2.3.6 Affordability

Affordability to households means that by spending on water and sanitation related items, the households are not reducing the consumption of other items essential for their well-being or/and reducing the consumption of water and sanitation with negative consequences or their well-being.

> *"Water and sanitation facilities and services must be available and affordable for everyone, even the poorest. The costs for water and sanitation services should not exceed 5% of a household's income, meaning services must not affect peoples' capacity to acquire other essential goods and services, including food, housing, health services and education". (UNGS, 2010)*

The indicator proposed in Roaf (2005) to measure affordability is the percentage of household expenditure spent on drinking water by persons living below the State's poverty line.

Affordability is one of many indicators of access. It's the author's view that measuring affordability has implicit three important assumptions: it assumes that consumers have an income, that they are paying for water and sanitation related items and that one of the reasons for not accessing water is because they cannot pay for them. One or more than one of these assumptions is not present in many lower income countries.

In the chapter that reviews the literature on household socio-economic categories, the main problems with measurements and comparability in defining the poor included:

1. collecting household expenditure in its totality,
2. collecting expenditure specifically for water,
3. defining who is poor and,
4. setting a poverty line.

These apply equally to the proposed measurement of affordability. The additional challenge introduced with the proposed indicator refers to the choice of measurements and units of analysis:

5. what is considered an appropriate maximum percentage of expenditure which is considered affordable,

6. what are the expenditure related with (costs of construction, maintenance, tariffs, bottled water…),
7. what service is being received (households can spent little and have a great service or the other way around) and,
8. what is the unit of analysis (daily/weekly/monthly/yearly) since this will have an influence on the type of expenditure made.

The existing literature on the topic is limited and related mostly to point 5 above: the percentage of overall household budget spent on water services that are considerable affordable. The most quoted amount is the 3 to 5 percent affordability rule (van Damme and White, 1984; Saunders and Warford, 1986; McPhail, 1993). It has been widely recognised by the World Bank, UNDP, the Asian Development Bank and DFID that setting these percentages has been an arbitrary process but that as an initial tool they can provide a rule of thumb (Briscoe, 1998; Waughrey and Moran, 2003). However, Dworkin and Pillsbury (1980) have actually shown that the use of such rules of thumb in Thailand prevented providing higher levels of service (or closer to their homes) which households would be willing and were already paying 8 to 9 percent of their incomes. It has also been proposed that the poor should not pay more than three times what the average user pays (Roaf, 2005).

Smets (2012) has conducted a study on affordability in high, middle and lower income countries including the benchmarks presently used (between 2 and 6 percent) and examples of countries with low-income populations which are spending a high proportion of their income on water and sanitation services, including Burkina Faso (29% of income of lower quintile), Poland (10.8% for the poorest), United Kingdom (2% of households spend more than 8% of income) (Hutton, 2012).

> *"Who is to decide what the word "appropriate" means in each case? Who decides that the villager should give up an additional three glasses of beer a week and one pair of shoes each year in order to pay a monthly water charge that covers total cost or that is equal to marginal cost?" (Saunders and Warford 1986: 187-188)*

For the household costs on water to be considered in the affordability calculations, the cost items need to be identified (point 6.). In 1976, Saunders and Warford have proposed theoretically a point where ability to pay and maintain village systems had to be matched with economies of scale from the population served (the graph is reproduced in Figure 4 (Saunders 1976:24) However, as seen in the cost chapter of the literature review, few communities are able to cover fully the maintenance of their systems (Saunders and Warford, 1986). Affordability measurements would need to take into account all the costs required to provide a service and the different transfer mechanisms both financial (tariffs, taxes, transfers) and in kind (time and in kind contribution towards construction or maintenance) (Kayser et al., 2013).

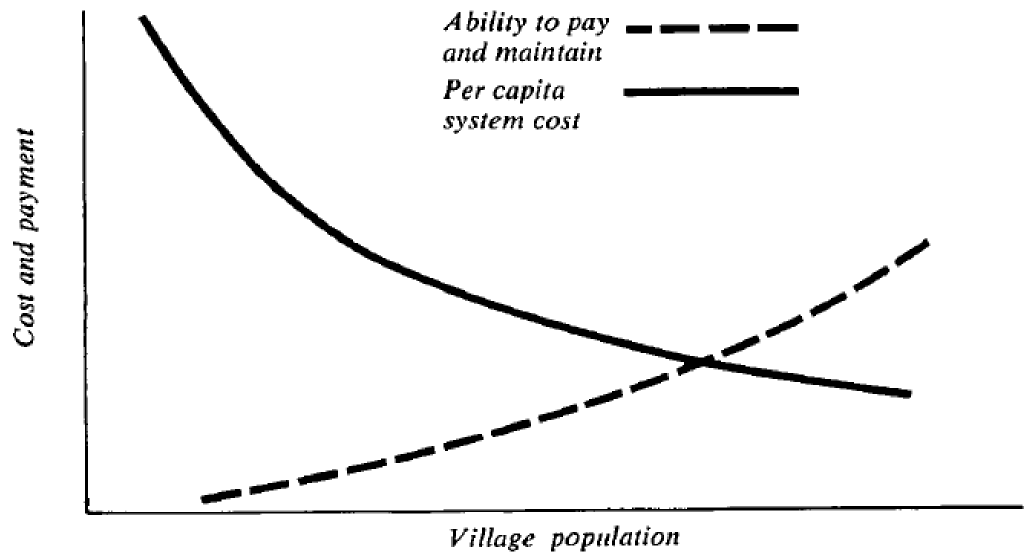


Figure 4 Relation between village population, system costs and ability to pay and maintain

Source: Saunders, 1976:24

Recent work on the proposals for the development goals post 2015 based on a review of possible indicators has proposed the following indicators (adapted from Hutton, 2012) which addresses the identification of costs (6.), but none of the remaining challenges with the indicator:

- Annual household water and sanitation expenditure (only tariff) as a percentage of total annual income;
- Household capital expenditure on water and sanitation as a percentage of total annual income;
- Total (capital and maintenance) household water and sanitation expenditure as a percentage of total annual income;
- Total financial and economic household costs as a percentage of total annual income

The main limiting aspects of this proposal is that it uses income and not expenditure (which as shown in the previous chapter is more robust) and it is not associated with the other human rights to water and sanitation indicators proposed above (quantity, quality, distance, etc). A service could be affordable and not achieve any of the minimum requirements for quantity or quality. Additionally as it is also recognised by Hutton, each of the indicators above have limitations and challenges. The first one by only capturing the tariffs actually fails to acknowledge all the costs incurred by the poorest with non-networked services, which are the ones that are supposed to be targeted with the human rights to water and sanitation.

The “affordability” indicator might be difficult to collect and to compare among countries, but if used in combination with other indicators has the potential to be useful within each country to measure progressive realisation towards reducing the proportion of those that do not have access because water and sanitation services are not affordable to them – but, as described in the recommendations, to answer this question there are simple and more accurate proxies that can be used.

In many countries in the World water and sanitation are not a minor expenditure. Several countries have measures in place to limit the financial impact of water price increases in the most vulnerable groups of the population (OECD, 2006). These measures include among others large subsidies, reduced VAT, social tariffs, targeted assistance, no disconnection, unmetered water and income support. For an overview per country see Water Academy (2004).

2.3.7 Acceptability

Acceptability can be defined as the “willingness of consumption of water by the target consumers for the purpose for which the scheme is intended”. For instance, there are large number of drinking water schemes in Kerala, India which are not used for drinking or cooking even if they satisfy other user criteria such as access, quality and reliability. The perception of consumers have forced them not to use the scheme for the purpose it was intended. The negative perception might be based on colour, odour, taste or the performance of the service provider and the water tariffs that have been set (Otum, 2011).

In a study of 88 services in 10 countries there was a statistically significant positive correlation between quality and degree of participatory planning and quality of management on the one hand and sustainability and use of the water supply service on the other hand (Van Wijk Sijbesma, 2008). It can be argued that acceptability is not only a function of good service delivery (measured by quantity, quality, reliability, etc.) but also a function of the service/scheme planning and management (siting, type of uses possible, who can use the system, maintenance arrangements, billing process, rules and regulations, process towards the implementation, et.).

Acceptability depends on who is using/receiving a water service and it also depends on the purpose. Traditional sources are often found acceptable to the users above the safe water sources but not acceptable to the government and not complying with health norms. In studies done by IRC staff in Colombia, Ghana and Andhra Pradesh, user satisfaction was high even when water quality was not complying with the country norms. On the other hand, there are high investments in water schemes in areas where people do not use the schemes for the purposes they were designed because of acceptability. Therefore, what constitutes acceptability and for whom, is very relative.

2.3.8 Conclusions on the literature that relate with global standards

The main gaps with the global standards being set by the Human Rights Framework and the literature that supports it are many.

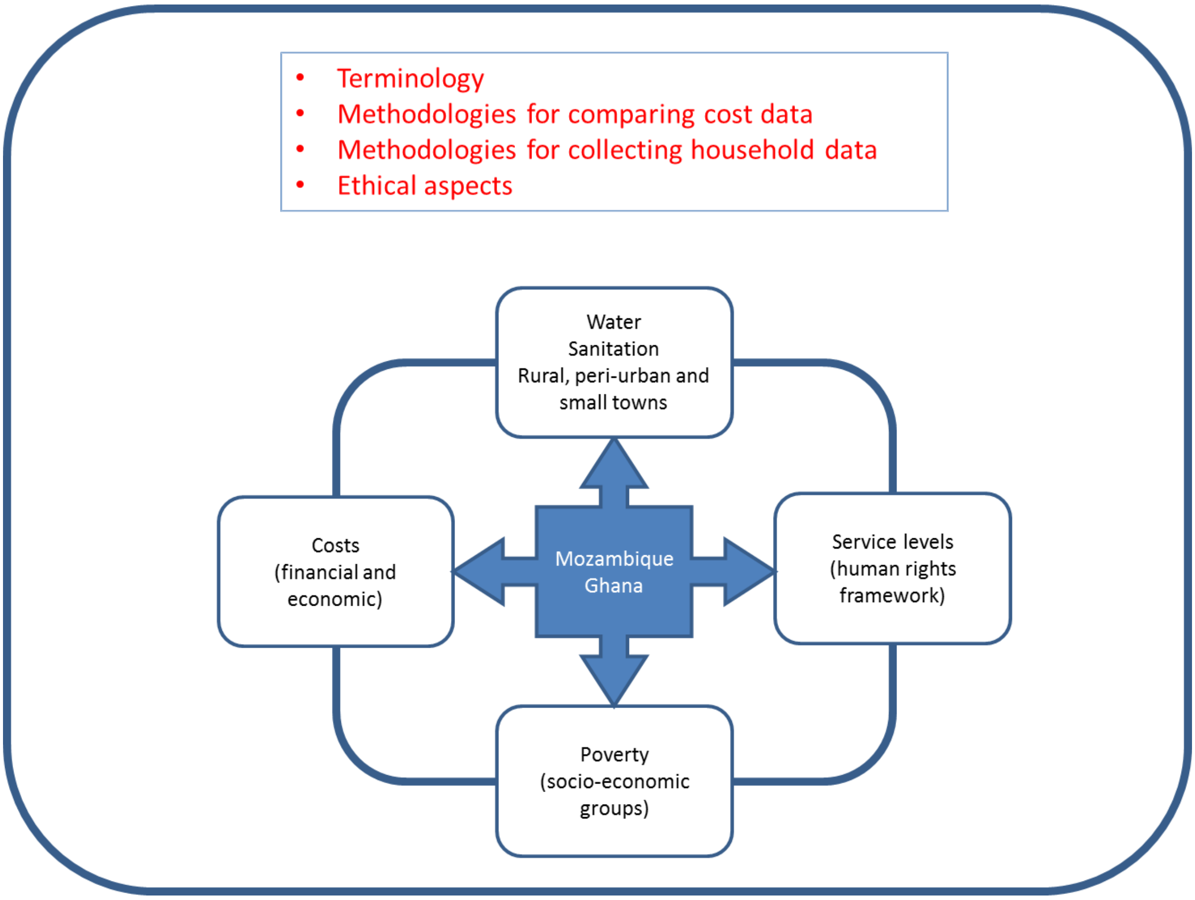
The first gap relates with the amount of indicators available for accessing a sanitation service when compared with water. There are no indicators on what “continuity/reliability”, “sufficiency” and “safety” might mean or how they are applicable to measure sanitation services. Indicators related with the environmental impact of faecal sludge disposal are also absent from the framework.

The second gap derives from the possible lack of quality of two of the indicators chosen to measure water and sanitation services. “Affordability” and “Acceptability” would fall under this category since there is no evidence to support what is being measured or on what basis can a “judgement” be issued either at international or national level.

The third gap is related with the reliability of the measurement for some of the indicators. For instance, affordability is based on reported household income and the previous chapter has discussed some of the limitations in using income as a basis for analysis. Sanitation access is usually measured by asking households if they are using the latrines. Results are often biased.

3 Methodologies used in the thesis

This chapter describes the terminology used to analyse the financial and economic expenditure on rural water and sanitation in the literature and from the household surveys conducted, the characteristics of the sample, the variables required for the analysis, the data collection process including the tools used and the data quality and reliability procedures, ethical aspects which have been considered throughout the research and the limitations of the methodology.



For the purposes of the thesis, the Ghana and Mozambique household data sets have been selected as these have not been analysed in-depth or results published previously to the level of detail of this thesis. The household surveys contained more than 450 variables concerning their socio-economic characteristics, the financial and economic expenditure and the description of the water and sanitation services received.

The methodology chapter has components which were partly published in three WASHCost documents and were prepared for the review reports in the context of this PhD. Specifically:

- The cost terminology has been described in the WASHCost Briefing Note 1a (Fonseca, Franceys, Batchelor et al, 2011) remaining terminology chapter is unique to this thesis;
- The sample methodology for the water data has been partly described in the WASHCost Working Paper 8 (Burr and Fonseca, 2012), the detailed sampling clustering and the sanitation sample are unique to this thesis;
- The data quality control, reliability and anonymity have been discussed in the WASHCost data organisation and coding protocol (Verhoeven, Fonseca, Adjei et al, 2010). The thesis explains each of the chapters in more detail;
- The tools used for data collection have been described in the WASHCost training package (Verhoeven and Fonseca, 2012).

3.1 Terminology used for the analysis

The three different areas of this thesis: costs, technologies and services, are terms which mean many different things to different people. In the context of this thesis it is critical to understand what they mean and how they come to be. The background to each of the components is in the literature review.

3.1.1 Cost components

Based on the costs literature review described in chapter 2.1.1.2, the OFWAT terminology (Table 2) used for the urban WASH sector has been adapted to the rural WASH sector (Fonseca, Franceys and Perry, 2010) and termed in the WASHCost study a 'life-cycle cost approach' (LCCA). There are several approaches that use life-cycle costs as described in the literature, for the analysis of the data in this thesis they represent the aggregate financial costs of ensuring delivery of adequate, equitable and sustainable water, sanitation and hygiene services to a population in a specified area (Fonseca, Franceys, Batchelor et al. 2011).

The life-cycle costs include the construction and maintenance of systems in the short and longer term, taking into account the need for hardware and software, operation and maintenance, capital maintenance, the cost of capital, source protection, and the need for direct and indirect support, including training, planning and institutional pro-poor support. These cost components include all expenditure undertaken by a whole range of stakeholders throughout the asset life-cycle.

Unlike other uses of the terminology, the term life-cycle costs as used in this thesis should be understood as the costs of providing and sustaining a service, rather than the "cradle-to-grave" costs of individual technical components and infrastructure on which it relies. Again, unlike most life-cycle cost assessments, the approach used in the WASHCost study is purely financial but in this study is extended to economic values as well.

The main components of life-cycle costs being proposed for the analysis are described in Table 9. This thesis will only analyse the costs incurred by households. Therefore the analysis will be limited to capital expenditure, capital maintenance expenditure and operating and minor maintenance expenditure.

Table 9 Life-cycle cost components

Terminology	Description	Household financial expenditure component for water and sanitation
Capital Expenditure – hardware and software (CapEx)	CapEx hardware includes the capital invested in constructing fixed assets such as concrete structures, pumps and pipes. Investments in fixed assets are occasional and 'lumpy'. It includes the first time the system is build, extension of the system, enhancement and augmentation.	Water: Community or household contribution to initial infrastructure costs, costs of water supply infrastructure purchased by users (water storage tanks, filtration systems, catchment systems, piping, etc), private borewells and one-off connection charges Sanitation: costs of on-site sanitation, costs of on-site grey waste water treatment and disposal (soakpits at home and public taps, storage structures), costs with storm water disposal (drains and soakpits) and one-off connection charges to sewerage system.
	CapEx software includes one-off work with stakeholders or specific studies prior to construction or implementation, extension, enhancement and augmentation.	CapEx software includes the costs incurred in capacity building and stakeholder participation in planning, design and implementation. Investments in campaigns for behavioural change and use of safe sanitation.
Capital maintenance expenditure (CapManEx)	Expenditure on asset renewal, replacement and rehabilitation costs, based upon serviceability and risk criteria. Accounting rules may guide or govern what is included under capital maintenance and the extent to which broad equivalence is achieved between charges for depreciation and expenditure on capital maintenance. Capital maintenance expenditure and potential revenue streams to pay those costs are critical to avoid the failures represented by haphazard system rehabilitation.	Water: Costs of rehabilitating, replacing or renewing infrastructure incurred by users Sanitation: Costs of non-regular emptying and disposing latrines

(cont.)

Life-cycle cost components (cont.)

Terminology	Description	Household financial expenditure component for water and sanitation
Operating and minor maintenance expenditure (OpEx)	Recurrent, regular expenditure on labour, fuel, chemicals, materials, regular purchases of any bulk water for service providers and/or households.	Water: Costs of transport, costs of filtration and treatment (consumables, chloride, fuel for boiling water, buckets, etc), costs incurred to supplement the service with regular costs of alternative sources Sanitation: costs related with hygienic behaviour (e.g. use of soap), regular costs for connections with sewerage systems, costs of regularly emptying and disposing latrines.
Cost of Capital (CoC)	Expenditure on the weighted average cost of capital representing interest payments on debt and dividend payments to the equity providers. Very context specific but an indicative 5% on current costs fixed assets can be used. Cost of Capital is composed of three elements: Paying back loans (debt is cheaper than equity because it is less risky as it is first in the queue to be repaid once revenues are available) Return on owners risk capital invested (usually higher than interest payments on loan). Also called equity risk premium on top of risk free rate Excess profit	Costs of interest payments from personal loans (e.g. for connections) or microfinance (including group based loans). Interest surplus from collection fees distributed to members of the community of reinvested.

(cont.)

Life-cycle cost components (cont.)

Terminology	Description	Household financial expenditure component for water and sanitation
Expenditure on direct Support (ExpDS)	Includes expenditure with post-construction support activities for local-level stakeholders, users or user groups. In utility management, expenditure on direct support such as overheads are usually included in OpEx. However, they are rarely included in rural water and sanitation cost estimates. The costs of ensuring that the local government staff has the capacities and resources to help the communities when systems break down or to monitor private sector performance are usually overlooked.	Rarely applicable – includes expenditure paid by the households to the service authorities (when it occurs is though tax transfers, which are not common in the areas of the study) or other regular costs such as reporting and monitoring incurred by households.
Expenditure on Indirect Support (ExpIDS)	This cost component includes macro-level support, planning and policy making. Indirect support costs include government macro-level planning and policy-making, developing and maintaining frameworks and institutional arrangements, capacity-building for professionals and technicians.	Not applicable

Adapted from Fonseca, Franceys and Perry, 2010

3.1.2 Technologies: terminology used for analysis of cost data

This chapter describes the main terms used in the literature to characterise technologies (or facilities) and used to analyse some of the cost data found in documents of the last twenty years as well as the household surveys. The choices made for the technology options reviewed in this paper has been based on the availability of data and the evidence that these are the technologies and options most used in less developed countries. Only some of these technologies are captured in the country level household surveys analysed in this thesis.

Although there is not a clear distinction between the technological options used in rural areas and those in peri-urban areas, the cost data is available in the literature for rural and peri-urban water in lower-income countries for (Table 10): hand dug wells, protected household shallow wells (self-supply), household rainwater harvesting, shallow wells fitted with hand pumps, manual and mechanically drilled boreholes fitted with handpumps, gravity fed water supplied through standposts, small (up to 5 stand posts) borehole distribution systems, small, medium and large piped systems (respectively up to 500 household connections; between 500 and 2000 household connections and above); water provided by tankers and in sachets; water treatment before distribution; sand dams, spring protection and large spring development. (Carefoot and Gibson, 1984; Christmas and Rooy, 1990; WaterAid, 2004; PEM/WSP, 2005b; GoE, 2006; GoU, 2008; GoU-DWD, 2008; Hutton and Bartram, 2008; Hill, 2009; Robinson, 2009).

The cost data that relates with rural and peri-urban sanitation options refers to on-plot and on-site sanitation options (Table 10): traditional latrine, single and double vault latrine, slab/compost/tree, VIP for rural and (peri-)urban areas, toilets with septic tanks (rural and urban), pour flush latrines with and without septic tanks, toilets with sewer connection, small bore sewerage, urine diversion and composting toilets (rural and urban), basic sanitation units (shower, sink and toilet with septic tank), wastewater treatment, public latrine and school latrine. (Christmas and Rooy, 1990; Franceys, Pickford & Reed, 1992; WHO/UNICEF, 2000; Allan, 2003; WaterAid, 2004; Hutton and Haller, 2004; Pattanayak, 2005; PEM/WSP, 2005; Rockstrom, 2006; WSP/EUWI/AfDB/UNDP, 2006; DWAF, 2007; Hutton and Bartram, 2008; Shayamal, 2008; Susana, 2008; Hutton, Rodriguez, Napitupulu et al., 2008; Robinson, 2009;

Schuen and Parkinson, 2009; Bonu and Kim, 2009; Sijbesma, Truong and Devine 2010; Trémolet, 2010; WSSCC, 2010).

Table 10 Technology options water and sanitation covered by the grey literature

Water	Sanitation
Hand dug well	Single pit latrine
Protected household shallow well	Double vault latrine
Household rain water harvesting	Slab, compost kit and tree/arboloo
Shallow well with handpump	VIP Latrine rural
Manually drilled borehole with handpump	VIP Latrine urban
Mechanically drilled borehole with handpump	Toilet with septic tank (rural)
Gravity fed (mostly with standpipes). Usually gravity-fed scheme serving more than one community.	Toilet with septic tank (urban)
Borehole distribution system with public standposts. Max 5 standpipes, no HH connection	Pour flush latrine
Small piped system. Up to 500 HH connections + standpipes	Pour flush latrine with septic tank
Medium piped system. 500 to 2000 HH connections + standpipes	Toilet with sewer connection
Large urban system. More than 2000 HH connections	Small bore sewerage
Tanker water	Urine Diversion/composting toilet rural
Sachet water	Urine Diversion/composting toilet urban
Water treatment before distribution	Basic sanitation units (shower, sink and toilet with septic tank)
Sand dam	Wastewater treatment
Spring protection	Public latrine
Large spring development	School latrine
Other options when technologies are not defined in the literature	
Rural water	Rural sanitation
Peri-urban water	Peri-urban sanitation

Pictures on the different water and sanitation technologies from Mozambique and Ghana are available in chapter 4.8.

3.1.3 Indicators for the level of service

A significant and innovative element of the life-cycle cost approach as developed by WASHCost is an understanding that costs can only be compared and properly assessed when they are related to particular levels of service. Methodologically, one of the options to compare like with like in terms of costs is to compare the costs of a service provided and not, as is common in the water sector comparing the costs of the technologies used to provide the services.

Service levels are intended to provide a structure to analyse the costing data being collected in different countries and settings. Service levels are based on what are considered critical criteria and indicators of service (see chapter on global standards for rural services in the literature review). For the purpose of the analysis, the indicators which were part of the household surveys provide the perspective of the households. Table 11 describes the indicators used for water supply. For sanitation, the human rights resolution is less clear therefore some additional measurements and proxies are proposed below (Table 12).

Table 11 Service level criteria and measurements for water supply

Criteria	Measurements and proxies for data analysis
Accessibility	The time per round trip spent fetching water. It incorporates distance and waiting/queuing time for primary and secondary sources, dry and wet season Distance from household to main source dry season (GIS) Distance from household to secondary source dry season and primary and secondary sources wet season
Quantity	Litres per person per day in primary and secondary sources, dry and wet season Number of trips per day/week Metered water per month
Quality	No bacteriological analysis done at the time of the survey One-off bacteriological analysis when system was installed Perception for the households on the water quality If the source is considered safe or unsafe using the technology profile
Reliability	Reliability refers to the extent to which the service performs according to expectations. Expressed as a percentage of time that the service is not fully functional.
Affordability	The costs for water and sanitation should not exceed 5% of the household's income.
Acceptability	Water should be of acceptable colour, odour and taste and water be culturally appropriate, respecting gender, lifecycle, privacy and dignity.

Adapted from UNGS 2010 and Moriarty, Batchelor, Fonseca et al. 2011

Table 12 Service level criteria and measurements used for sanitation

Criteria	Measurement
Accessibility	Availability of a platform with impermeable slab separating faeces from users, either within the household or easily accessed
Use	Number of household members using the sanitation facilities
Reliability	Cleanliness and availability of emptying services
Affordable	The costs for water and sanitation should not exceed 5% of the household's income.
Acceptable	Ensuring among others privacy and dignity

Adapted from Potter, Snehalatha, Batchelor et al. 2011

3.2 Methodologies for comparing financial data in the grey literature

This chapter reviews the details of the costs in the literature in order to determine:

- The classification system used to assess the cost data found in the literature
- The data analysis framework which includes the process to ensure comparability of different currencies
- Remaining methodological challenges and assumptions
- Most importantly: to be able to compare the findings resulting from the analysis of the household surveys with the cost data found in the literature

For this thesis, over 50 documents with unit costs have been reviewed from more than 150 water and sanitation programmes in rural and peri-urban areas in Sub-Saharan Africa, Asia and Latin America. However, only 30 have comparable cost information. Only from 2001 detailed disaggregated costs for the water and sanitation in rural and peri-urban areas in lower income countries started being publicly reported and some of the most reliable extensive data collection processes date back only to 2005. More details from this analysis is available in Appendix A.

Most of the cost data for this chapter was found in grey literature in the form of reports from different multilateral agencies and NGOs working in the sector. A few reviews with extensive data collection procedures and disaggregated analysis have been commissioned by governments of Ghana, Kenya, South Africa and Uganda and only a few of the cost data can be found in academic papers.

Unit costs in the literature have been collected by professionals of different backgrounds, in different currencies at different points in time. For data analysis, and ensuring data comparability, all the cost information needs to be brought into one currency and a base year. US$ have been chosen as the basis currency because the most complete database which contains comparable data uses it as a base for all calculations. The Dababank is a consortium of several international organisations with harmonised approaches to global financial data. 2011 has been chosen as the basis year because this is the last date for which all currencies have comparable data.

For the purpose of comparing cost data, the following currency information has been collected:

- GDP deflator index (2011 current prices) for the currencies used
- US$ Purchasing Power Parity, 2011
- US$ market exchange rates, 2011

Cost data was collected from several countries with different dates. The first step (Equation 2) is to be able to compare costs from different years in a specified local currency. The inflation rate (GDP deflator[5]) has been used to bring all costs to their value in the year 2011 (Griffiths and Wall, 2012).

Equation 2

$$\text{Local Currency}_{\text{(current prices 2011)}} = \text{Local Currency}_{\text{(year x)}} * \text{Deflator multiplier}_{\text{(year base 2011)}}$$

Unlike an inflation rate based on price index (consumer price index), the GDP deflator is not based on a fixed basket of goods and services. The basket is allowed to change with people's consumption and investment patterns. Specifically, for GDP, the "basket" in each year is the set of all goods that were produced domestically, weighted by the market value of the total consumption of each good. Therefore, new expenditure patterns are allowed to show up in the deflator as people respond to changing prices. The advantage of this approach is that the GDP deflator measures changes in both prices and the composition of the basket - i.e. as prices and consumer preferences change, the GDP deflator accurately tracks both. For this

[5] Databank code: Inflation, GDP deflator (annual %)

reason, the GDP deflator is a more accurate, and thus ideal measure of pure price changes in the overall economy (Griffiths and Wall, 2012).

After inflating/deflating all costs from all countries for the year 2011, in a second step (Equation 3), all the currencies have been computed into US$ Purchasing Power Parity (PPP). The PPP between two countries is the rate at which the currency of one country needs to be converted into that of a second country to represent the same volume of goods and services in both countries (Griffiths and Wall, 2012).

Equation 3

$$\text{US\$ PPP}_{(2011)} = \text{Local Currency}_{(\text{current prices 2011})} / \text{PPP conversion factor}_{(\text{LC 2011 per international \$})}$$

PPP is used because exchange rates can be misleading. Since market exchange rates are based on short-term factors and are subject to substantial distortions from speculative movements and government interventions, comparisons based on exchange rates, even when averaged over a period of time such as a year, yield and misleading results (Sarno and Taylor, 2002; Rogoff, 1996). Example: the imbalance in apparent water implementation costs between many Africa countries and India is partly explained by the undervaluation of the rupee, perhaps by a factor of almost three, by the sophistication of the Asian supply chain which reduces their costs and the dependence of the African supply chain on rent-seeking international imports which increases their costs. The PPP conversion factors[6] are available from the Databank.

Alternatively, all the unit costs can also be analysed using the official 'market' exchange rate (Equation 4). This is useful because if an X amount of US$ are needed to reach 100 borehole drilling in a specific country, then the cost of implementation must be related to the amount in the local currency that it costs to drill the boreholes.

Equation 3 is indicated for international comparison motive. For the purpose of knowing how much budget is needed in a specific country to implement programmes, then Equation 4 is advised where the cost calculations need to be based on the

[6] Databank code: PPP conversion factor, GDP (LCU per international $)

official exchange rate. This step is also more accurate in situations when most of the labour and materials are imported (Griffiths and Wall, 2012). The official exchange rates are available from the Databank[7].

Equation 4

$$US\$_{(2011)} = \text{Local Currency}_{(\text{current prices 2011})} / \text{Official exchange rate}_{(\text{LC 2011 per US \$})}$$

3.3 Methodologies used for selecting and collecting household surveys

The chapter describes the sample strategy and criteria used for the household surveys in Mozambique and Ghana to collect financial expenditure and service levels within the scope of the WASHCost project. The sample was not designed to collect either poverty or economic expenditure and therefore the analysis is sometimes lacking completeness in all the areas of study. The advantages and limitations of the sample strategy are also explained.

The process that led to the completion of the household surveys is discussed as well as the differences between the data collection in the two countries, the variables and the sources of information. Coding the household surveys, storing data, quality and reliability procedures and finally ethical issues are also presented.

3.3.1 Sample strategy

In WASHCost, costs and service levels have been collected in four countries: Mozambique, India, Ghana and Burkina Faso. The research countries were selected in part because of the diversity of their respective WASH services which has allowed for data collection across numerous supply systems, the services they provide, and their associated costs. The sample could not be completely random because, given the levels of low coverage for water and sanitation in the study countries, there would be a large chance to encounter no financial costs. Therefore, given that the main question was “In rural areas of lower income countries, how much are households spending on improved water and sanitation services?” the solution was to opt for a stratified random sampling.

[7] Databank code: Official exchange rate (LCU per US$, period average)

In a stratified random sampling, sample clusters of households in a district or a village are randomly selected and then samples are taken from those clusters (Deaton, 1997). With this method different sub-groups of the population will have different but a known chance of being selected and certain regions where the poor are concentrated can be over-sampled to guarantee the information required (Ravallion, 1992).

Clustered samples, which imply selecting households in a two-stage design is the most common method for sampling nearly in all surveys (with the exception of telephone surveys). Clusters are randomly selected with a probability proportional to the number of households they contain – if the same number of households is selected from each cluster there is a self-weighting design in which each households has the same change of being included in the survey. This means that the sample has households which are not randomly distributed over space, but geographically grouped. The main advantage is that it is cost effective for the teams to travel from one village to another and spent in each considerable time, instead of visiting households dispersed from each other. It's also easier to collect village level information such as technical surveys on the water supply.

One disadvantage is that the precision usually increases for one variable (in this case costs of water supply) while it increases the imprecision for another (costs of sanitation). It is practically costly to design two sample strategies to fulfil both requirements and this meant that many of the households sampled did not have a latrine and therefore fewer costs for sanitation were collected.

Another disadvantage is that households selected in the same clusters such as rural villages will tend to have similar characteristics such as sharing the same agro-climatic conditions, have access to same sources of income or belong to the same ethnic of tribal group. If these are very specific or unique, then the results are less representative within the region chosen.

3.3.2 Criteria for clustering the sample

The first criteria were applied to the choice of regions and districts within each country:

1) These had to reflect diverse hydro-geological and hydro-climatic conditions prevailing in each country, maximising diversity of infrastructure and providing different costs for different technologies and different service levels;
2) The presence of development partners or donors to guarantee that there had been implementation of improved water supply services and sanitation, maximising data availability;
3) The amount of funds available for data collection limiting the number of regions and provinces sampled.

The second level criteria concerned the choices of rural communities and small towns within the districts:

4) Population size and point source intensity of use (for the rural communities), ensuring a diversity of disperse and more densely populated areas;
5) Socio economic status of community within the district; the choice has been to achieve a balance between the poorest areas and the not so poor;
6) Infrastructure availability within the communities (to keep ensuring the technological diversity mentioned in the first set of criteria);
7) Age of water supply facilities; communities with older sources of water supply were preferably chosen to be able to collect the maintenance costs.

With an initial quick survey and focus group discussion, information was collected on household socio-economic status and basic estimates of service levels. This took place mainly by observing a water point and discussing with water users. Once the basic information was analysed, the teams decided which communities were worth going back to in order to complete a full set of household interviews. The third level criteria concerned the selection of households within each community:

8) 20 to 30 households per community/area were randomly chosen using systematic random sampling which involves selecting a starting point and then using a constant interval between the households selected (Kish, 1995).

In Mozambique the enumerators used a pen and spin it at the water point to get the direction to start walking. If it was a piped source the start would be at the most central public tap stand. Then the snake method was used (first left, then right, etc.) to determine the rest of the houses only selecting houses on the right side and in general taking every 2nd house (Photo 1).

In Ghana in the rural communities the households were numbered and balloting was done to select the respondents. For the small towns systematic random sampling was done by dividing the areas into zones. For instance to select 10 households from an area with about 40 houses, every 4th house was chosen.

Photo 1 Enumerator collecting information from one household in Nampula province, Mozambique

Photo credit: Jeske Verhoeven

3.3.3 Household surveys used for the analysis

The data analysis in this thesis concerns Mozambique and Ghana. Cross-sectional household surveys are a one-time survey and are designed to obtain a snapshot of a group of households at a specific moment in time (Kish, 1995).

The data is not statistically representative at a national level. However, the data set is the most complete of its kind that currently exists. The ranges identified are valid indicative ranges for Ghana and Mozambique and, given the feedback at several training sessions where datasets from many other countries have been analysed, the results are also valid for countries with similar development approaches to rural water supply and sanitation in low income areas in Africa and Asia.

A common approach to data collection comparable across the countries was agreed through WASHCost international research team meetings but the detail was determined by the needs of stakeholders in each country. The differing interests of the various stakeholders resulted in different sample sizes for household surveys in each country (Table 13). The Mozambique country teams collected extensive data sets across all the country agro-climatic regions, the Ghana country team focused on three regions.

In rural areas of Mozambique, water services are provided through boreholes with a manual “AfriDev” handpump. Other supply options include open wells, protected spring sources as well as piped water networks in some villages or small towns. Overall responsibility for water resource management lies with the Ministry of Public Works and Housing, and responsibility for policy development lies with the National Directorate of Water (DNA). In rural communities, water committees are responsible for the day to day operation and maintenance of water supply infrastructure. The policy is that if the communities are unable to carry out the repairs themselves, they should seek to engage local pump mechanics or operators, and have a duty to inform district operators. The costs of repair and replacement are designed to be borne by the communities through user charges.

Sanitation in rural areas in Mozambique is the responsibility of the households. Families build their own latrines with traditional materials, many can be found that use the “Mozambique slab”. The Mozambique slab (also called domed slab) was successfully introduced at scale between 1985 and 1998 to target the peri-urban areas (Photo 2). The slab is a non-reinforced concrete dome with a lid that fits tightly into the squatting hole to control odours and flies. At the time it was technically innovative and has since been reproduced all over the world (Colin, 2002).

Photo 2 A slab for a latrine in Mozambique.

Photo credit: Catarina Fonseca

Data on water points and households was collected in six out of the ten regions of Mozambique. The sampling methodology follows an approach developed by the National Bureau of Statistics (INE) of Mozambique as part of their multiple cluster survey of 2008, designed to deliver a representative sample of areas with access to formal water sources (WASHCost Mozambique, 2010).

Table 13 Household samples used in the analysis

Data Sample	Ghana	Mozambique
Regions	4 out of 10	6 out of 10
Districts	4	36
Communities visited	39	68
Household surveys (water and sanitation)	1,339 in total 1032 rural 66 peri-urban 241 small town[8]	1,710 in total 978 rural 732 peri-urban No small town

[8] This is the official classification in Ghana. Some of the areas such as Akame, Kpogedi, Bakamba and Kpandai have, in practice, settings similar to rural communities even though they are classified formally

Water service delivery in rural areas and small towns of Ghana are managed in different ways. Rural communities are typically supplied through boreholes with handpumps that are managed day to day by local Water and Sanitation Committees (WATSANs). The most common water service delivery models used to supply small towns are groundwater supplied piped networks, with provision for storage and household connections. There are two models of small town supply: single-town services, where the source, pumping and distribution are located within the service area; and multi-town services, where the source and pumping station are located close to a centralised source that supplies many communities. The development of piped town networks has happened relatively recently in Ghana, with the majority of systems constructed in the last decade. Small-town piped networks are typically managed by elected Water and Sanitation Development Boards (WSDBs) that take responsibility for operation and maintenance.

Overall responsibility for the on-going provision of services in both rural and small town areas lies with district authorities, who in turn receive support from the Community Water and Sanitation Agency (CWSA) in the form of standards, guidelines for operations and maintenance, and in preparing strategic investment plans.

Similar to Mozambique, households are expected to build their own latrines. Latrines found in rural Ghana tend to be made with more sturdy materials than those found in Mozambique. In Ghana a lot of emphasis has been placed in constructing (paid) latrines in public areas.

3.3.4 Main advantages and limitations of the sample strategy

A clustered approach to sampling was considered more useful than random sampling given that it was difficult to find valid financial cost data through a random selection, and therefore the choice was to select areas where data was likely to be found and a sufficient diversity of rural and peri-urban communities were represented to increase the confidence in the results.

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as small towns. This will have somewhat impact in the analysis since no distinction will be found among many variables and the geographic context.

The approach to sampling outlined above had four main advantages:

- It is possible to draw a sample of villages that is representative of a geographic area (region and district)
- Having information about all the unit cost components in a number of cases makes it possible to compare the relative magnitude of different costs
- It is possible to relate unit costs information to detailed information about service levels at the village and household levels
- The approach saves resources by allowing for strategic choices of where to conduct detailed household surveys.

The sample approach also presented a number of disadvantages:

- Collecting the full range of unit cost components for a single village was effectively very difficult. The availability of information about CapEx, OpEx and CapManEx vary across sites and even across systems within a particular site. To have a complete picture of costs for each site, data points of different qualities had to be combined: data in village records (Photo 3), estimated data from household recollected expenditure and estimated data from district officers. Therefore to have a complete picture of the life-cycle costs, the household surveys present only a small component.
- The entry point for the sampling strategy was water and as a result availability of sanitation data on costs and service levels is even lower compared with water data. However, this also reflects the low sanitation coverage in the study counties.

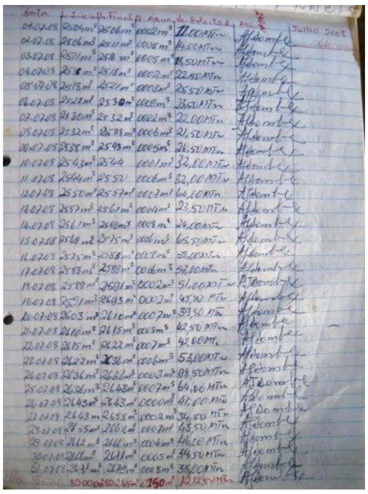


Photo 3 Community records: water consumption and payments, Mozambique.

Photo credit: Catarina Fonseca

3.3.5 Data collection process

This chapter describes the process, the main sources of information and the methodologies used to collect and triangulate the variables and data collected solely though the household surveys in Ghana and Mozambique.

3.3.5.1 Variables and sources of information

Variables and data had to be collected both for costs and for the service levels. There were multiple sources of information, but for the purposes of the analysis in this thesis only the household surveys and GIS coordinates were considered.

The household surveys are at the heart of getting a detailed and statistically valid understanding of key issues ranging from access and use of services to expenditure and own contributions to maintain and increasing service levels. See Appendix J for the Mozambique questionnaire and Appendix K for the Ghana questionnaire.

GIS coordinates were used as a proxy to distance triangulated with the self-reported time that households spent on transporting and queuing. The outlines of the villages, the main roads and the water points were being identified with GPS.

Having these maps made household sampling easier in terms of identifying a representative sample at different distances from the main sources.

The first drafts of the questionnaires were developed by each country team using a checklist which had been compiled in the research protocol by the author and validated in a research group meeting in India. The draft questionnaires were used to pilot the data collection in one rural and one peri-urban area and improved and sometimes adapted for the worse by each country team (Photo 4). In a research team meeting in Ghana all the final questionnaires were revised, there were many country specific questions added and a smaller number of variables was common to all countries. However, the way the questions are organised, asked and stored has impact on the analysis, and full coherence was not complied with and significant differences only identified when analysing the data.

Photo 4 The author, during the field testing of the questionnaires in Inhambane Province, Mozambique. The handpump is functional but has a lock.

Photo credit: Arjen Naafs

The largest differences per country relate with poverty measurements and how some proxy indicators were chosen for the water and sanitation service levels. Nevertheless, not until the global data analysis started was it possible to identify small differences in some questions and indicators which made international comparisons more difficult or not possible (chapter 4.8. on cross country comparability will discuss these aspects in further detail).

3.3.5.1.1 Mozambique household survey

For the Mozambique household surveys, each questionnaire took between 60-90 minutes to be answered and included thirteen key chapters (appendices 1):

- The first chapters (A. and B) identify the household, with its unique code (see next chapter), contain the details of the interview date, who is the enumerator and the GIS coordinates as well as the general characteristics of the household;
- The core sections of the questionnaire (D to I) ask detail questions on the main and alternative sources of drinking water for the dry and the wet season (therefore

most questions are asked four times). In these sections details are asked on access, quantity, quality, construction and maintenance costs and level of satisfaction for each of the sources. The questionnaires also captures time spent in accessing and collecting water to allow for economic analysis.

- Section L concern the socioeconomic characteristics: income, expenditure and household assets.

The sanitation section (J) include questions about:

- Where does the household dispose of the excreta (showing a picture board so the household could identify the option) and the location;
- If the toilets and latrines were shared and by how many people;
- The costs for the household to build the latrine (labour, materials, subsidy received, others)
- Because many households build their own latrine, there was also a question on the costs if the households would have to buy or pay for labour and materials.
- The costs of maintaining the latrine (last week, last month, last year)
- The frequency of pit emptying
- The costs of moving and emptying the latrine

Additionally, the enumerator was to observe (section M):

- The material which made up the walls of the latrine
- To check if the latrine was in use
- To assess how clean the latrine was inside
- To assess the state of the maintenance of the superstructure surrounding the latrine

Section K is about hygiene but was not used for analysis in this thesis.

3.3.5.1.2 Ghana household survey

The questionnaire (appendices 2) used in the pilot was as long as the Mozambique one and followed a similar structure, but after analysis of the poverty indicators the team decided to cut the socio-economic indicators and select only the main activity of the head of household (this is explained in section 4.7). This is the main difference between the questionnaires of the two countries.

Additionally, to avoid the repetition of questions for each water source used by the households the answer sheets were organised as a matrix. This process – instead of the more systematic approach of the Mozambique questionnaires – might be faster and provide more answers but produced less accuracy since households had to remember the order in which they mentioned each water source for each of the service level questions (Rea and Parker, 2005).

The questions on service levels and on costs were also less detailed: instead of asking for the number of containers, the number of trips per day, the size of the containers, questions were more direct and asked for the "amount of litres per day" and "time spend per day to collect water". Households contributed small amounts to the construction of the water points but these amounts were not captured in the household surveys but elsewhere and not used in this analysis.

In Ghana, households access much more paid formal and informal water sources as well as public toilets compared with Mozambique. Therefore the questionnaire includes details on water tanker services, sachet water and public toilets.

There are additional sections on households solid waste management and waste water but these were not used for analysis in this thesis.

3.3.5.2 Identification numbers for household surveys

Given the size of the sample it was important to organise and store the household surveys in a transparent and accountable manner that enabled easy tracking and cross country analysis. One of the most important measures implemented was to use a unique identification number for each household survey. The surveys were done before widespread use of mobile data collection using bar codes started to be used in the sector.

The household and systems identification number is composed of unique country identifiers: for each governance level at which data collection takes place and for each household for the household surveys. The different codes together form the unique identification number. Figure 5 shows the different components that make each unique code. The code for the water point within the household questionnaire was not used because households accessed many different sources.

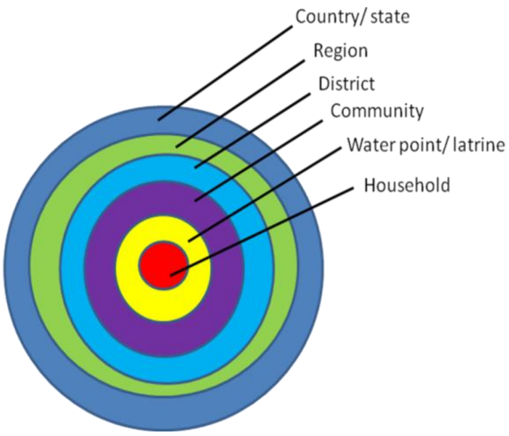


Figure 5 Schematic overview showing how an identification number is constructed

Table 14 provides an overview of the governance levels in the two countries with their equivalents and describes the variables that form the basis of the identification number for each country. This was inserted in the surveys before the data collection to prevent as much as possible problems with data entry. The code was then inserted in the first rows of the data entry forms (Photo 5).

Table 14 Variables of the identification number

Level	International	Ghana	Mozambique
1	Country/State	Country	Country
2	Region	Region	Provincia
3	District	District	Districto
4	Community	Community/Village/ Town	Community
5	Household	Household	Household

Photo 5 Enumerator coding the household before there was mobile data collection widely available (2009), Mozambique

Photo credit: Jeske Verhoeven

3.3.5.3 Data storage, quality control and reliability procedures

In addition to the unique identification numbers, the key to the success of organising, coding and storing the information was based on a clear and precise dictionary for each country which was inserted as a first sheet while storing data. The country dictionary was meant for outsiders to be able to 'read' the identification number and to trace each data point to its source. The country dictionary provides an overview for each country of:

- The research locations under each governance level for each country and its specific codes.
- The surveyed water technologies and their specific codes
- The surveyed sanitation technologies and their specific codes
- An overview of the variables each country collected

- An overview with a description of the different formulae used to calculate the composite indicators

All the country data was stored in Excel using the local languages. For the purposes of this thesis all the data was converted to SPSS and translated into English.

The main principle used for data quality control and reliability procedures was accuracy, measured as the degree of closeness of a measured or calculated quantity to its actual (true) value. The main aim was therefore not to be *precise* but to be *accurate*. The sample strategies aimed to address the precision; the data quality control and reliability procedures were implemented to ensure the accuracy. The relationship between accuracy and precision is explained in chapter 7.1.5A.1.1. Each country research team implemented their own data quality control and reliability procedures summarised in Table 15.

These procedures were developed by the overall research team in 2009 during three rounds of pilot testing and revision which refined the data collection process. Such procedures installed a culture of checks and balances at the different levels of data collection, data entry and analysis. The core of the system for each country consisted of triangulation of information, filtering for outliers and manual checking of data for logic by different experts (Rea and Parker, 2005).

For data entry the team agreed to accept an error margin of 5%. This means that when records are checked randomly the error rate must be less than 5% (meaning that fewer than 1 in 20 of the records is incorrect) or the whole batch must be cross-checked and re-entered (or discarded). Common mistakes detected while cleaning the data included: decimal points in the wrong place or letters that have been placed when there should be a number. Double data entry for the household surveys (data which was entered twice by two different people and the entries are cross-checked) was considered a good practice but not a requirement and only implemented in by the Mozambique research team (who found that the second data entry was of considerable lower quality than the first data entry).

In addition to the above country processes, at international level the overall key indicators and costs have been checked for comparability with the support of researcher Peter Burr and made available on-line. For the purposes of this thesis the household questionnaires have been further cleaned, processed, translated and made fit for comparability. The purpose is to make them also available on-line for others to use.

During the processes of data cleaning and analysis, information collected from various sources has been cross-verified with field data and an exhaustive peer-review process has taken place within country teams and amongst external experts. Nevertheless uncertainty remains. Expenditure and service level data collected from household respondents can be unreliable, especially when information is being recalled about construction activities that took place many years before. Although there is no way to eliminate unreliability completely, iterative data cleaning throughout the process of analysing data has strengthened the accuracy of the results.

Table 15 Specific country procedures for data quality control and reliability

Procedure	Ghana	Mozambique
Data collection was designed in three rounds of pilot testing and revision of the research format.	✓	✓
The research tools have been reviewed and revised by a team of external experts of different fields	✓	✓
The system of data collection was validated by an external advisory group	✓	✓
Field enumerators and supervisors have entered the data collected during the pilot testing in order to understand the set up of the database and the data entry process.	✓	
During data collection in the field enumerators checked each answer for logic and if unclear verified the answer.		✓
During data collection in the field both the field investigator/enumerator and the field supervisor checked all the collected research formats for inconsistencies and gaps. If consistencies or gaps were found the field investigator/enumerator tried to fill the gaps or verified the information.	✓	✓
The data was entered by experienced data entry staff. Data entry is restricted by software to minimise data entry mistakes.	✓	✓
All formats (except the household questionnaires) were entered twice (double data entry) by two different people and differences were compared and corrected.	✓	
All household questionnaires are entered twice (double data entry) by two different people and differences are compared and corrected.		✓
The data base manager supervised data entry. The database manager visited the field teams regularly.	✓	✓
The database manager checked data entry. Out of a 100 records at least 5 records were checked at random. If more than 5 records were incorrect all data had to be cross checked and re-entered.	✓	✓
The database manager cleaned the database by filtering and screening for outliners with cross tabulation and basic statistics. Errors were corrected and information is verified when needed.	✓	✓
The aggregated figures were checked by two (or four in the case of India) different experts for consistency. All inconsistencies were verified. After the approval of these two experts the database is send to the lead researcher for analysis.	✓	✓
The lead researcher filtered the database for inconsistencies before starting the analysis.	✓	✓

3.3.5.4 Lessons learned from data collection

Collecting financial cost data was a very significant task for the research teams. Some of the common difficulties across the teams included for households to recall maintenance expenditure. When community financial records were accessible, finding cost data older than three years was a problem. Financial data was especially limited and difficult to collect for sanitation since traditional toilets are hardly said to have financial costs in rural areas, while in urban areas, emptying toilets is very irregular.

In countries where capital investments are normally financed from government budgets or by transfers from donors or by NGOs there has been little reliance on loans that require interest payments to be made, either from micro-finance providers or project or commercial lending. Similarly it was difficult to obtain data with regard to the costs of owner/shareholder returns for small scale private providers.

The teams also faced delays outside of their control. There were elections in both countries and the teams were not allowed to collect any data at community level for three months and political tense moments which delayed the official approval for data collection in some of the regions in Mozambique.

Some critical requirements for data collection in both countries included institutional embedding with and within National level WASH governmental departments and large project implementation agencies to facilitate the data collection, test bed site selection, approval of sampling strategies, engagement and debate in data analysis. Establishing partnerships with operators and formal utilities for access to peri-urban cost data and information was also required.

Engagement with national level sector information and monitoring initiatives was needed for the use of existing data and statistics, coding procedures, to enable synergies (staff and other resources) for data collection and data entry and to strengthen access to secondary data.

Relationships were formalised with universities and research institutions which were willing to mobilise researchers and students for data collection, conducting specific side studies to replicate the methodology (social sciences and economics departments) and to support data analysis and visualisation (departments of applied maths/statistics).

Agreements were established with regional/district staff when conducting data collection. Some government staff volunteered to be part of the team and cost-sharing arrangements (transport, initial contact with communities) made it easier and faster for the teams to keep to a tight schedule for data collection.

Facilitation of a number of sector meetings at central and provincial level contributed for the discussion of relevant sector issues such as data collection and storage, service level and decentralization support to districts. These meetings were also relevant for regular (minimum bi-annually) cycles of feedback and preliminary data analysis.

3.4 Ethical aspects

3.4.1 Generic ethical issues

The Cranfield Science and Engineering Research Ethics Committee required that the following ethical issues are addressed Table 16.

Table 16 Cranfield University ethical issues to be considered

Ethical issues to be addressed	Actions taken
Selection of research focus and design: *sponsors; promoters, other relationships* - transparency issues	The "intellectual property rights" for the data or other information used in this thesis are not kept in exclusivity by any of the organisations where the PhD student has been involved in similar work. Example: Bill and Melinda Gates Foundation or any of the partner organisations.
Survey respondent issues: *selection; involvement /informed consent; openness; approach to questioning; avoiding deception; role of participant observation; generating undue expectations; reporting;*	Communities, households and other stakeholders were informed about the context and use of the information that was collected. Official letters of approval for household data collection were issued at national level and official district officials accompanied the data collection team. See chapter 3.4.3 on consent.
Gender awareness issues	When making interviews at community level men and women were addressed separately so that the views of women were taken into account. Focus group discussions, especially around sanitation issues took place separately with female interviewees.
Cross-cultural issues	When approaching issues related with health and hygiene (sanitation) specific care and preliminary consultations were made on existing practices and what is allowed to be mentioned (for some ethnic groups is taboo to discuss excreta related issues).

	Local research teams and visitors were respectful of local dressing codes.
Language issues	Translators and multi-lingual staff have been required for most of the field work in Ghana and Mozambique.
Vulnerable groups issues	See cross-cultural issues.
Confidentiality & data protection issues	All the data published will be available for public access and not restrained by data protection issues. The names of the organisations/persons which provided unit costs and service level data has been omitted. See chapter 3.4.2 on anonymity.
Publication/use of knowledge issues	Several researchers have used and published on data collected under WASHCost. Each has been clear about the portions of the data used and peer-review and approval has taken place within the researcher's team.

3.4.2 Guaranteeing anonymity

The data has been reported, organised, stored and shared in a way that guarantees respondents anonymity. The names of respondents, households, enumerators and the field coordinators have been removed from the shared data sheets. Names of respondents have been stored separately from primary data, in a password protected file.

The Geographic Information System (GIS) data allows household to be tracked. This resulting calculated distance is in the data sheet for analysis but not the GIS coordinates. The team has discussed the possibility of removing or randomising the last two digits of the GPS coordinates but this would make housing density inaccurate.

3.4.3 Consent

For the household surveys, the script introduction to the surveys included something along these lines in each of the local languages: “We are from XX carrying out research on water and sanitation services and we would like to ask you some questions which will take about 45 minutes. You are free to join or refuse to participate. Do you want to participate?”

For the analysis of the data in this thesis, a written consent by the owner of the data, the IRC – International Water and Sanitation Centre, clearly states the organisation's responsibility for collective consent on behalf of the individuals whose data it comprises. The full written consent has been provided to the academic supervisor.

4 Findings from the grey literature, data cleaning and household data analysis

This chapter describes the findings from the costs available in the grey literature, the data cleaning process and the preliminary analysis resulting from the statistical analysis of the household surveys.

4.1 Financial costs in the grey literature: a comparison

This chapter presents the findings from the analysis of the cost information in the grey literature using the methodology described in chapter 3.2. It is organised per cost component and disaggregated for water and sanitation. This analysis is relevant to be able to compare the results from the household surveys.

4.1.1 Capital expenditure in the literature

4.1.1.1 Rural and peri-urban water supply

Table 17 provides a summary overview of 64 cost entries from the literature 2001-2010 and the estimates from 1990 (Christmas and de Rooy) sorted by the average capital expenditure in US$ 2011 and with more than one datapoint (N>1). Comparing this recent overview with the earlier version (Table 6) it can be concluded that there is more cost data available related with more diverse technological options, but the ranges remain broad. Some of the information could not be used because there was no possibility to make calculations per capita as the data was reported in cubic metres or per technology without population estimates.

The capital expenditure reviewed includes hardware and software costs, when the latter has been costed. The most recent literature goes into a fair amount of detail to separate capital expenditure hardware (the infrastructure component of technologies) from the software (the staff time, sensitization and mobilization campaigns, etc). However, that level of detail is not presented here because from a sustainability perspective, capital expenditure are large lump sums disbursed in the first year/s of project implementation.

Table 17 Summary overview capital expenditure per capita, water supply in lower income countries 2001-2010

Technology options	N	Min CapEx US$ PPP 2011	Max CapEx US$ PPP 2011	Average CapEx US$ PPP 2011	Min CapEx US$ 2011	Max CapEx US$ 2011	Average CapEx US$ 2011
Spring catchment and protection	3	4	55	37	2	18	12
Manually drilled borehole with handpump	4	12	54	36	6	53	25
Hand dug well	8	5	89	30	5	89	28
Mechanically drilled borehole with handpump	10	3	238	67	3	102	40
Water treatment before distribution	2	0	170	85	0	80	40
Multi village scheme (gravity fed mostly with standpipes)	2	53	59	56	53	59	56
Household rain water harvesting	6	47	356	112	16	167	75
Shallow well with handpump	3	12	651	235	12	216	80
Small piped system	5	47	130	86	47	130	86
Medium piped system	6	64	268	196	30	267	136
Large spring development	2	33	4113	2073	11	1363	687
Rural water	6	42	217	75	42	209	78
Peri-urban water	4	89	193	134	89	184	141

The ranges are broad, but they fall within similar categories for all regions, with a two outliers for shallow wells and household water harvesting. Rural and peri-urban sanitation

For sanitation capital expenditure, there are considerably more data sources available in comparison with drinking water. Data reliability did not increase with data quantity (**Error! Reference source not found.**) but the level of disaggregation of capital expenditure is more detailed with an increasing separation of household contributions against project investments.

Table 18 provides a summary overview of the literature 2001-2010 and the estimates from 1990 (Christmas and de Rooy) sorted by the average capital expenditure in US$ 2011 and the number of relevant entries (N>1). Data from the Department of Water Affairs and Forestry, South Africa (2007) has not been included in the calculations below as the unit costs estimates are extremely high compared with any other source and would distort significantly the data. The reason might be that the unit cost estimates are to be considered "ceilings" for construction instead of reflecting real expenditure.

Table 18 Summary overview capital expenditure per capita, sanitation in lower income countries 2000-2010

Technology options	N	Min CapEx US$ PPP 2011	Max CapEx US$ PPP 2011	Average CapEx US$ PPP 2011	Min CapEx US$ 2011	Max CapEx US$ 2011	Average CapEx US$ 2011
Single pit latrine	17	1	112	27	1	112	26
Pour flush latrine	7	4	169	73	4	169	69
VIP Latrine rural	10	6	136	58	6	106	49
Double vault latrine	4	36	251	98	15	118	59
Urine diversion/ composting toilet (rural)	10	8	791	107	8	372	65
Toilet with septic tank (rural)	8	26	492	181	25	297	144
Rural sanitation	5	10	57	33	10	57	33
Wastewater treatment	3	4	106	59	4	106	59
Small bore sewerage	5	67	251	123	67	163	105
VIP Latrine urban	4	101	416	218	101	247	162
Toilet with septic tank (urban)	4	35	984	313	35	462	183
Urine Diversion/composting toilet urban	9	78	1119	269	78	526	203
Toilet with sewer connection	14	74	811	268	39	811	256
Sanitation peri-urban	5	15	312	105	15	312	105

4.1.2 Operational expenditure and capital maintenance

4.1.2.1 Rural and peri-urban water supply

From the 64 data entries for capital expenditure of rural and peri-urban water supply, the data collected for operational expenses is very meager. The information below (Table 19 and Table 20) is for evidence only as most operation and maintenance costs are not collected or reported. These costs are expected to be paid by households and will be used for comparisons with findings from the analysis chapter.

Operation and maintenance expenditure for household rain water harvesting is higher than the other technologies reported, except for medium piped systems (Figure 6). The limited capital maintenance expenditure collected from the literature, reflect larger maintenance costs, the more complex the technologies.

Table 19 Summary overview operation and maintenance costs per capita water supply in lower income countries 2000-2010

Technology options	N	Min OpEx US$ PPP 2011	Max OpEx US$ PPP 2011	Average OpEx US$ PPP 2011	Min OpEx US$ 2011	Max OpEx US$ 2011	Average OpEx US$ 2011
Hand dug well	3	0.2	0.6	0.3	0.2	0.6	0.3
Mechanically drilled borehole with handpump	4	0.2	1.0	0.5	0.2	0.7	0.4
Small piped system	3	0.6	1.2	0.8	0.6	1.2	0.8
Household rain water harvesting	4	0.5	5.1	1.6	0.5	2.4	1.0
Medium piped system	4	5.4	16.8	12.2	2.5	16.8	11.4

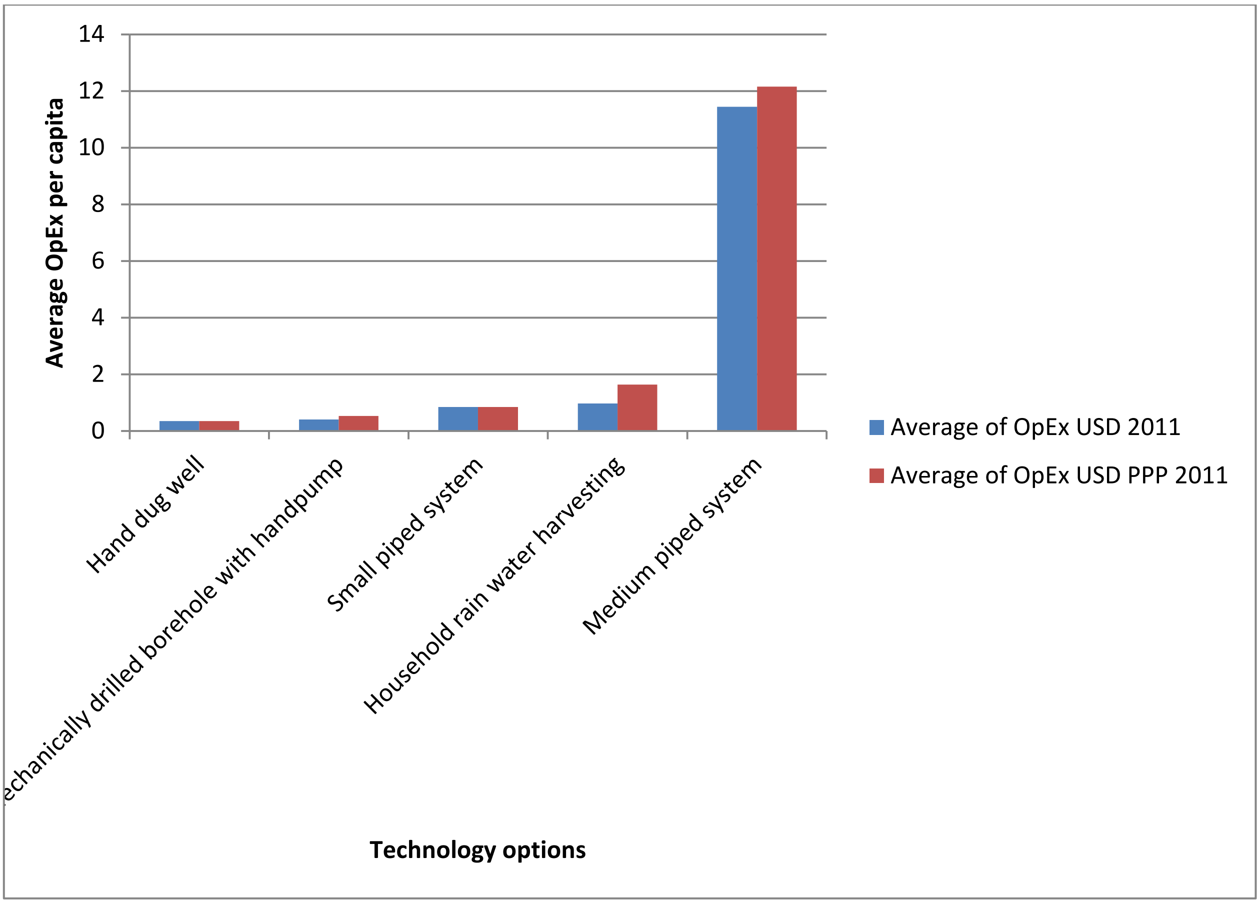


Figure 6 Average per capita operation and maintenance expenditure water rural and peri-urban areas US$ 2011

Table 20 A few examples capital maintenance expenditure per capita, water supply in lower income countries 2000-2010

Technology options	N	CapManEx US$ PPP 2011	CapManEx US$ 2011
Shallow well with handpump	1	6	2
Spring catchment and protection	1	7	2
Manually drilled borehole with handpump	1	8	3
Mechanically drilled borehole with handpump	1	10	3

4.1.2.2 Rural and peri-urban sanitation

From the 131 data entries for sanitation, there are significantly more entries collected on operation and maintenance for sanitation with N>1 (35) when compared with water supply, but the number of observations (Table 21) still provides insufficient data to draw solid conclusions on household expenditure. Amounts are reported in US$ only as there are no original currencies to perform US$ PPP conversions.

Table 21 Summary overview per capita operation and maintenance expenditure for sanitation in lower income countries 2000-2010

Technology options	N	Average OpEx US$ PPP 2011	Min OpEx US$ 2011	Max OpEx US$ 2011	Average OpEx US$ 2011
Toilet with sewer connection	4	23	12	41	23
Sanitation peri-urban	2	18	6	29	18
Toilet with septic tank (rural)	5	9	6	16	9
Urine Diversion/composting toilet urban	3	7	2	12	7
Pour flush latrine	4	5	1	7	5
Urine Diversion/composting toilet rural	2	5	4	5	5
VIP Latrine rural	3	4	4	4	4
VIP Latrine urban	3	4	1	6	4
Single pit latrine	6	3	1	4	3
Wastewater treatment	3	2	0	3	2

From the reported operational expenditure, households in rural areas spent less than 5 US$ per person on a yearly basis. The operational expenditure increases for the urban technologies (Figure 7).

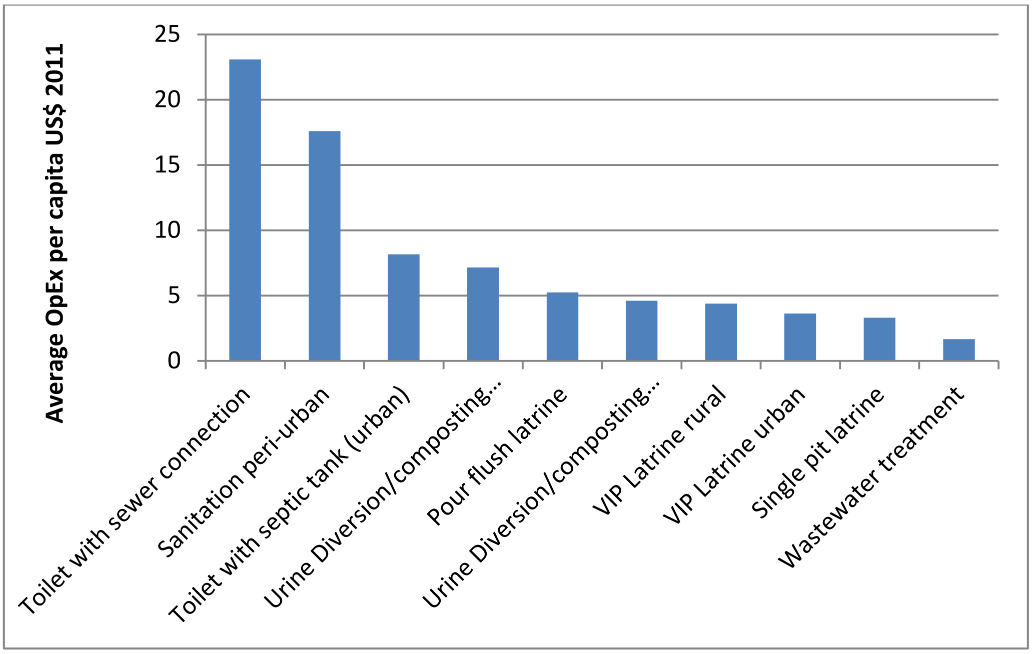


Figure 7 Average per capita operation and maintenance expenditure sanitation rural and peri-urban areas US$ 2011

Capital expenditure reported per person per year is generally much higher than the examples collected from water supply literature (Table 22).

Table 22 A few examples capital maintenance expenditure per capita, sanitation in lower income countries 2000-2010

Technology options	N	Min CapManEx US$ 2011	Max CapManEx US$ 2011	Average CapManEx US$ 2011
Toilet with sewer connection	4	24	24	24
Sanitation peri-urban	2	4	30	17
Toilet with septic tank (rural)	5	12	20	16
Urine Diversion/composting toilet rural	2	15	17	16
Single pit latrine	6	2	14	8
Pour flush latrine	4	1	1	1

4.1.3 Conclusions from revising the grey literature on unit costs

Large implementing organisations, governments in developed and lower-income countries could adapt their financial reporting systems to improve availability of unit cost data. At country level, storing electronically expenditure records and completion reports would be a tremendous improvement. The report on unit costs from the Government of Uganda (2008) acknowledges that “record keeping at the districts is very poor.

It is common to find documents of an entire financial year missing and no specific reason can be given for this anomaly. No storage space for documents is availed in most of the districts and personnel tend to discard documents pertaining to earlier financial years without much care. It was found that no detailed project completion reports are prepared in most cases, which renders tracking a specific project, difficult.” This is a common situation found by the author in other countries such as Ethiopia, Cabo Verde, Ghana, Burkina Faso and Mozambique.

4.2 Statistical analysis of survey results

The Excel files with the data entry from the household surveys have been transferred to IBM SPSS for further cleaning and analysis. This was done because the files were too large for Excel to read and analyse and given the limitations of excel for conducting statistical analysis. Although Stata is known as a robust package to analyse socio-economic data, SPPS has been chosen over Stata for three main reasons:

- The type of statistical analysis done is not too complex and can be handled by SPSS (Stata has further advanced functions);
- The output tables and graphs of SPSS are known to be “ready” for copy/paste not requiring further editing;
- Stata has a steeper learning curve than SPSS and the time available constrained the decision.

The analysis in this study starts with the data and through simple statistic procedures illuminates or informs present theory and practice. Data is described through descriptive statistics, graphical representations and correlation methods for continuous and discrete variables. This has been done to avoid any arbitrary assumptions (see conclusions of the literature review on financial costs) and unnecessary complexity which would make replicability of analysis difficult. The results of the analysis are therefore generating real features of the data.

> *“The use of survey data to investigate living standards is often straightforward, requiring little statistical technique beyond the calculation of measures of central tendency and dispersion. Although there are deep and still-controversial conceptual issues in deciding how to measure welfare, poverty, and inequality, the measurement itself is direct in that there is no need to estimate behavioral responses nor to construct the econometric models required to do so.” (Deaton, 1997:133)*

The standard analysis that has been undertaken follows the following steps (Fields, 2013):

- Creation of frequency tables that display the number and percentage of cases for each observed value of a variable;

- Derivation of measures of central tendency and spread in the data (mean and median; standard deviation). Checked for skewedness and kurtosis;
- Investigation of measures of bias: check of outliers, normality and linearity;
- Outliers were checked and sometimes removed using box plots and robust tests (bootstrapping);
- Normality was checked using histograms and P-P plots, but given the size of the sample the central limit theorem applies and more focus was placed on non-linearity (which affects confidence intervals) and the large amounts of outliers;
- Non–parametric tests were used for testing correlations (Pearson's, Kendall's, bi-serial and point bi-sarial correlations) and the bootstrap function was used to get more robust confidence intervals;
- Checking of the relationship between two or more variables by using cross tabulation tables and tests for significance.

4.3 Data cleaning

4.3.1 Mozambique

The Mozambique country files consisted of 486 columns with variables and 1,710 rows that each represent one household survey. Each variable and answers were translated from Portuguese to English. The coding used in the variable names matches the coding used in the household survey questionnaires. The variables without coding have either different sources than the household survey or are computed variables (formulas available in SPSS).

In the process of translation and cleaning, the most common mistakes detected were invalid numeric numbers. Some mistakes have been the result of mistyping, others from typing "0" when the answer is not applicable. These mistakes had to be removed one by one (Fields 2013).

During this process detailed descriptive names were selected for all variables, making it possible for an external analyst to understand them with limited guidance. Other relevant coding:

- 999 or NR was the value used for missing numeric variables when respondents failed to answer or for removed answers due to errors.
- 666 or not applicable used when no values should be found

The most serious data entry mistake occurred from inserting the wrong GIS distances and the reported time spent per household collecting water. The mistakes were consistent with the locations (and the data collection teams). As a result, GIS and reported time for Balama, Cidade de Inhambane, Cidade de Nampula, Govuro, Ilha de Mocambique, Jamgamo, Mabote, Massinga, Memba, Monapo, Nacaroa and Zavala (540 households or about 32% of the dataset) could not be considered valid for the distance analysis. These are all locations far from the capital city and the teams have not returned to correct the data points.

Other mistakes were found in the values of the household reported expenditure. There were about 30 data points with abnormally high values resulting most probably from adding zeros (>5.000 meticais) which were deleted from the dataset and not replaced by estimated amounts. The remaining removal of outliers was done statistically for a few cases only and is mentioned in the calculation sheets.

4.3.2 Ghana

The Ghana dataset was initially in three separate Excel sheets: one for the pilot data collection, one for the rural areas and one for the small towns. Each of the sheets had slightly different data and entry protocols. The data had to be harmonised variable by variable while being transferred into one SPSS file and cleaned similarly to the process described above for Mozambique.

Only the variables that were going to be compared with the Mozambique survey were cleaned which resulted in about 120 variables (columns) and 1139 households (rows).

The data collected in the pilot areas (161 valid household surveys) does not have exactly the same questions as the surveys conducted in the rural areas and the small towns, it is much longer and detailed and was used as a basis for some assumptions, for instance on socio-economic categories.

Most of the mistakes spotted in the data sheets were related with calculations and not so much with data entry. Unfortunately given the survey design, many nonresponses have been observed compared with the Mozambique dataset. As a result there almost no differences between the data reported for the wet and the dry season and the analysis was done for the whole year only.

4.4 Financial costs

This chapter describes the steps which were undertaken to facilitate the collation and comparison of financial cost information gathered.

Researchers' collected actual expenditure at various dates, including capital expenditure (CapEx) incurred several years earlier. All expenditure collected was brought to their current value in 2011 prices in meticais (Mozambique) or cedis (Ghana) and US dollars, using the Gross Domestic Product (GDP) deflators. In order to be able to make comparisons between water service delivery systems of different sizes, expenditure per year has been translated into expenditure values per person (or per capita) by dividing amounts by the real household size reported in the surveys.

For comparisons between the countries, an additional analysis has been made using the purchasing power parity adjustments to compare results among the different countries. The PPP, often termed the basket of goods approach, represents the exchange rate which the currency of one country needs to be converted by in order to purchase the same volume of comparable goods and services in a second country (see 7.1.5A.1.2).

4.4.1 Mozambique

4.4.1.1 Water

For the water component, the questionnaires asked extensive questions for the dry and wet seasons, for primary and alternative sources to capture capital expenditure, operational expenditure, capital maintenance and any costs of capital. However, asking the same questions four times was rather repetitive and while the first questions for the primary source in the dry season were generally answered, the others have very few answers and were mostly not used for the financial analysis (Table 23).

Overall, the contribution to capital expenditure from households was the easiest to capture with 218 data points used for the analysis. For operational expenditure 60 data points were considered valid for the analysis after removal of extreme outliers. The questionnaires were able to capture some irregular maintenance – capital maintenance expenditure – but not its frequency. There were no costs of capital reported at household level.

Table 23 Cost categories and transformations used in the analysis (water, Mozambique)

Survey code	Cost category/variable	Transformation for obtaining yearly costs	Valid instances
E1.A	CapEx contribution		138
E1.B	CapEx contract		51
E1.C	CapEx materials		49
E1.D	CapEx paid labour		44
	SumCapex.E1.2011prices	Sum CapEx E1 Transform Sum E1 with deflators for each year	219
E6.B	*CapEx tank storage*	*Not used*	*1*
E6.C	*CapEx elevated tank*	*Not used*	*0*
E6.D	*CapEx mechanised pump*	*Not used*	*0*
E6.E	*CapEx water pipes*	*Assumption that capex was done in 2010 and therefore 2010 prices were used*	*19*
E6.F	*CapEx external labour*	*Not used*	*3*
	Sum.CapexE6.2011prices	Transform E6.E with deflator for 2011	19
	CapEx.PC.2011prices.meticais	Sum.CapexE1 + CapexE6 Divide per HH size	221
	CapEx.PC.2011prices.meticais.outliers.removed	Removed three outliers	218
	CapEx.PC.2011prices.USD.GDP	Divide by GDP deflator 2011 = 29.07	218
	CapEx.PC.2011prices.USD.PPP	Divide by PPP deflator 2011 = 15.83	218
H01.C	*CapEx wet season install*	*Not used*	*2*
H01.D	*CapEx wet season install*	*Not used*	*2*
D15	OpEx transport	Cost per round trip Multiply per trips a day D3.T Multiply per 365 to obtain yearly amount	5
D10	OpEx water treatment	Multiply by 12 to obtain yearly amount	58
	Sum.Opex.2010prices	Sum.Opex transport + water treatment	63

	Sum.Opex.2011prices	Transform Sum.Opex.2010prices with deflator for 2011	63
G10	*OpEx water treatment (wet)*	*Not used: Answers not reliable (all instances either 0 or 7 meticais in different communities) and answer to previous question is no treatment)*	*47*
	OpEx.PC.2011prices.meticais	Divide per HH size	63
	OpEx.PC.2011prices.meticais.outliers removed	Removed three outliers	60
	OpEx.PC.2011prices.USD.GDP	Divide by GDP deflator 2011 = 29.07	60
	OpEx.PC.2011prices.USD.PPP	Divide by PPP deflator 2011 = 15.83	60
E4.	HH water payment method dry season	Select cases 2 "Payment when it breaks"	
E5.	HH payment for capmanex in 2010 dry season	Derive capital maintenance dry season from selecting E4 and then E5	107
H4.	*HH water payment method wet season*	*Select cases 2 "Payment when it breaks"*	
H5.	*HH payment for capmanex in 2010 wet season*	*Not used because identical to dry season minus 3 cases.*	*104*
	CapManEx.2011prices.USD.GDP	Divide E5 by GDP deflator 2011 = 29.07	107
	CapManEx.PC.2011prices.USD.GDP	Divide per HH size	107
	CapManEx.PC.2011prices.USD.PPP	Divide E5 by PPP deflator 2011 = 15.83	107

4.4.1.2 Sanitation

For sanitation the survey answers were more limited. Capital expenditure was asked for labour, materials and if any subsidy had been received. Costs were summed. The year of construction of the latrine allowed for these costs to be normalised to US$ 2011.However, the costs were similar if the latrine had been constructed after 2000 or in the 80s. The recall period of households tends to be limited and the author assumes that for all the latrines constructed prior to 2007, the expenditures were reported in 2007.

For regular minor maintenance, the costs were requested for last week, last month and last year and normalised to yearly costs. For capital maintenance, households were asked about the frequency and costs of moving or emptying their latrines. The overall valid financial costs collected and details on the calculations and data transformation are shown in Table 24.

Table 24 Cost categories and transformations used in the analysis (sanitation, Mozambique)

Survey code	Cost category/variable	Transformation for obtaining yearly costs	Valid instances
J6.A	CapEx labour		1039
J6.B	CapEx materials		1025
J6.C	CapEx subsidy		1054
	Sum.CapEx.J6		1066
	SumCapex.J6.2011prices	Transform Sum J6 with deflators for each year (assuming that 2007 is the longest recall period possible)	1066
		Removed one outlier	1065
	CapEx.PC.2011prices.meticais	Divide per HH size	1065
	CapEx.PC.2011prices.USD.GDP	Divide by GDP deflator 2011 = 29.07	1065
		For analysis only zeros removed	345
	CapEx.PC.2011prices.USD.PPP	Divide by PPP deflator 2011 = 15.83	1065
J7A	OpEx last week	Multiply per 52 to obtain yearly amount	1075 >0 = 0
J7B	OpEx last month	Multiply by 12 to obtain yearly amount	1077 >0 = 7
J7C	OpEx last year		1076 >0 = 35
	Sum.Opex.2010prices	Sum.Opex week, month, year	1077
	OpEx.PC.2010prices.meticais	Divide per HH size	1077
	OpEx.PC.2011prices.meticais	Multiply by 2011 multiplier 1.1	1077
	OpEx.PC.2011prices.USD.GDP	Divide by GDP deflator 2011 = 29.07	1077 >0 = 36
	OpEx.PC.2011prices.USD.PPP	Divide by PPP deflator 2011 = 15.83	1077 >0 = 39
J8.	How many times latrine had to be replaced		1059 >0 = 303

J8.A	Assumptions on replacement	If never = 0 One time = 1 If between 2 and 5 = assume 3 More than 5 = assume 5	1077 >0 = 120
	Total cost rebuilding latrine.2011prices. meticais	Multiply J8.A By SumCapex.J6.2011prices	120
	Total cost rebuilding latrine.2011prices. USD	Divide by GDP deflator 2011 = 29.07	120
	Per year cost of rebuilding latrine USD 2011	Divide total cost rebuilding by age of latrine	120
	Per year, per capita costs of rebuilding latrine	Divide by HH size	120
J9.	How many times latrine had to be emptied		1079
J10.	What have been the costs of emptying		111 >0 = 52
	Total cost emptying 2010 meticais	Multiply J9 with J10 Assumptions: If between 2 and 5 = assume 3 If more than 5 = assume 5	
	Total cost emptying 2011 meticais	Multiply by 2011 multiplier 1.1	97 >0 = 52
	Total cost emptying 2011 prices USD	Divide by GDP deflator 2011 = 29.07	52
	Per year cost emptying 2011 prices USD	Divide total cost emptying by age of latrine	50
	Per capita cost emptying 2011 prices USD	Divide by HH size	50
	CapManExSan.2011prices.USD. GDP.zeros.removed	Sum total costs rebuilding/replacement and pit emptying	158
	CapManExSan.per.year.2011prices.USD.GDP.zeros.removed	Divide per age of latrine	156
	CapManExSan.PC.per.year.2011 prices.USD.GDP.zeros.removed	Divide per HH size	156
	For PPP analysis	Meticais 2011 have been divided by 15.83	

4.4.2 Ghana

4.4.2.1 Water

The Ghana questionnaire has separated first the type of sources between formal and informal and then for each of the dry and wet season. The questions were asked in a matrix format per source and there were few differences recorded between the dry and the wet season.

There were more financial expenditure valid records in the Ghana surveys, but they were of a different nature than those encountered in Mozambique. There were more household expenses with tariffs and user charges than with direct contributions to capital expenditure or operational expenditure (Table 25).

Capital or operational expenditure contributions from households were not captured in the household surveys but in the community water and sanitation committee records. These are not being examined in this thesis because they cannot be linked with the specific household surveys (the overall community contribution is available but not the contribution from the households in the survey specifically). Unlike Mozambique, 811 respondents pay water as they fetch to operators which undoubtedly will then cover the minor maintenance requirements using the user fees.

Table 25 Cost categories and transformations used in the analysis (water, Ghana)

Survey code	Cost category/variable	Transformation for obtaining yearly costs	Valid instances
Q16	Payments for formal sources		870
Q.37	Payments for informal sources		66
Q.45	Payments for vendor services		345
	Total.water.payment.HH.month.Cedis		
	TF.Water.payment.formal.PC.year.Cedis2010	Divide by HH size	
	TF.Water.payment.formal.PC.year.USD2011	Transform into Cedis 2011 with deflator = 1.1 Divide by GDP deflator 2011 = 29.09	
	TF.Water.payment.formal.PC.year.PPP2011	Divide by PPP deflator 2011 = 15.83	
		Calculations above were done for each of the variables – no outliers	

		have been removed	
	TT.Water.payments.all.sources.PC.year.USD2011	Sum of formal + informal + vendors	938
Q18.	HH water payment method per source		919

4.4.2.2 Sanitation

Similar questions on financial expenditure were part of the Ghana survey. The survey included additional questions on the use, payment and satisfaction of public toilets. The same assumption was made as in the Mozambique survey and for all the latrines constructed prior to 2007, the expenditure was converted to 2007 prices given the recall time.

For regular minor maintenance, the costs were requested for the last month or/and last year and normalised to yearly costs. For capital maintenance, households were asked specifically about desludging, replacement or repairs to the slabs but there were no answers on costs. The overall valid financial costs collected are limited (Table 26).

Table 26 Cost categories and transformations used in the analysis (sanitation, Ghana)

Survey code	Cost category/variable	Transformation for obtaining yearly costs	Valid instances
56	CapEx superstructure		0
56	CapEx substructure		0
56	CapEx Total		40
	SumCapex.56..2011prices	Transform Sum J6 with deflators for each year (assuming that 2007 is the longest recall period possible)	40
	CapEx.PC.2011prices.cedis	Divide per HH size	40
	CapEx.PC.2011prices.USD.GDP	Divide by GDP deflator 2011 = 1.51	40
	CapEx.PC.2011prices.USD.PPP	Divide by PPP deflator 2011 = 1.26	40
61A	OpEx latrine cleaning		27
61B	OpEx latrine disinfection		40
61C	OpEx latrine other		2
	Sum.Opex.2010prices	Sum.Opex. (61) multiplied by 12 to obtain yearly amount	53

	OpEx.PC.2011prices.cedis	Divide per HH size + Multiply by 2011 multiplier 1.36	53
	OpEx.PC.2011prices.USD.GDP	Divide by GDP deflator 2011 = 1.51	53
	OpEx.PC.2011prices.USD.PPP	Divide by PPP deflator 2011 = 1.26	53
62A	CapManEx desludging		0
62B	CapManEx replacement vent pipe		0
62C	CapManEx repairslab		0
65	Payment per public toilet per visit		93
66	Number HH members that use public toilet		93
	Toilet tariff per person per year.cedis.2010	1 Pesewa = 0.001 cedi Assumption each user uses 4 times per day Only multiplied by the HH members reported using the toilet and not all the household members	93
	Toilet tariff per person per year 2011prices.cedis	Multiply by 2011 multiplier 1.36	93
	Toilet tariff per person per year 2011prices.USD.GDP	Divide by GDP deflator 2011 = 1.51	93
	Toilet tariff per person per year.2011prices.USD.PPP	Divide by PPP deflator 2011 = 1.26	93

4.5 Economic costs

4.5.1 Mozambique

To calculate household economic costs the following variables have been analysed:

- Time spent on one round trip to the primary water sources, dry and wet seasons (including queuing/waiting time). This time was derived from asking households how many minutes were spent to go to the source, the waiting time and the time to return from the source (time per round trip including queuing). There might be recall bias using this method, but it does capture queuing or waiting times which can be significant.

- How many round trips the household undertakes per day/per week. There are two sources in each season, a primary and a secondary or alternative source.
- Two proxies for costing time were calculated. A lower band of 30 percent of Mozambique GNP (World Bank databank) and as higher band of 30 percent of the minimum wage for agriculture in 2010 (Hanlon, 2013). The reason for the choices of the different proxies used is explained in the literature review (2.1.2.4).

The average salary in 2010 for unskilled labour in the informal sector in Mozambique can be used as an even lower band but no relevant studies were found which could provide an amount for the calculations.

Therefore the amounts per hour to value time used were:

- The lower band is measured with the GDP per capita in Mozambique, which in 2010 was US$ 387 annual, US$ 32.25 per month and 30 percent of that amount is US$ 9.675 per month or US$ 0.06 per hour (assuming 20 working days and 8 hours a day).
- The upper band is measured with the minimum wage for agriculture in Mozambique. In 2010 it was 1692 meticais per month which is equivalent to US$ 49.82 and 30 percent of that amount is US$ 14.946 which translates into US$ 0.093 per hour (assuming 20 working days and 8 hours a day).

This study recognizes the value of time lost from daily activities, whether productive working time, school time, or leisure time. With the principle of applying a non-discriminatory perspective on people's time and its value to the overall economy, the author of this thesis will use the same value for each unit of time spent by women, men and children (Bittman and Ironmonger, 2011).

The distances reported to return from the source were generally a couple of minutes lower than distances to go to the water source. Usually it would be the other way around, given the carry load, unless terrain is mostly going up on the way to water point – unlikely in hydro-geological terms. It is also not very realistic that households can report time in less than 5 minutes intervals and therefore such level of detail in answering the question is "strange". Minutes spent per round trip have been organised in intervals and all the amounts reported higher than 500 minutes (about 8 hours) were considered highly improbable and removed.

No in-kind contribution has been reported or collected from the questionnaires. Therefore the time spent is the only component which is part of the economic analysis.

For sanitation, the questionnaires were not designed to gather information to allow for the analysis of economic costs, but analysis of existing data allows drawing some conclusions. Halfway through the data collection it was noted that very few households were reporting financial costs spend building their traditional latrines. The Mozambique team decided that if the households responded that they had zero financial costs, the enumerators asked what would be the market value of the labour employed as well as if materials would be need to be bought.

4.5.2 Ghana

For water, in Ghana a similar approach was taken to calculate economic costs. Time spent per round trip including queuing and waiting time was calculated from households recall times. For the Ghana sample no number of roundtrips per day or information concerning the dry and wet season was available for this question.

Two proxies were used for costing time: a lower band 30 percent of Ghana GNP (World Bank databank) and a higher band of 30 percent of the minimum wage for agriculture in 2010. The annual GDP per capita provides a higher amount than the minimum wage and therefore the bands were reversed.

The amounts per hour to value time used were:

- Upper band: annual GDP per capita in Ghana in 2010 was US$ 1,100 (Jerven and Duncan, 2012), and 30 percent of that amount translates into US$ 27.5 per month or US$ 0.17 per hour (assuming 20 working days and 8 hours a day).
- Lower band: Ghana has a single minimum wage. The minimum wage for agriculture in Ghana in 2010 was 3.11 Ghana cedis per day (Asamoah, Ansah, Anchirinah et al., 2013) which is equivalent to US$2.17 and 30 percent of that amount translate into US$0.081 per hour (assuming 8 hours a day).

In the Ghana sanitation questionnaire there are no questions concerning the time spend building own latrines and toilets or local materials used. The questionnaires captured purely the financial transactions. As a result an economic cost analysis for sanitation in the Ghana sample is not possible.

4.6 Data analysis on service levels

Data analysis was done for the criteria that describe a service from a human rights perspective see literature review chapter 2.3. For water services: water accessibility, perception of safety (quality), quantity, continuity (reliability), affordability and acceptability. There are many more criteria which can be applied. These were chosen for analysis because they represent the minimum criteria that need to be met for a service to be considered a service from a human rights perspective. Some of them are also reflected in lower and middle-income country norms (Moriarty, Batchelor, Fonseca et. al, 2011).

Additionally, at about 50 meetings and training courses that took place between 2009-2013 face to face with senior experts in the Americas, Europe, Africa, Asia and Australia, the author has asked the following question to the training participants: “If you could only choose three indicators of a water service which ones would you choose?”. The top four answers in 100% of the cases are: access, quantity, quality and reliability. There are two additional indicators which are also mentioned with some votes which are “affordability” and “adequacy”. These indicators match to a large extend the human rights proposed indicators for water services and there is enough data in the surveys to complete the analysis.

For sanitation services the human rights framework refers to access, acceptability, affordability, safety and continuity. Given the data available in the surveys, cleanliness and level of maintenance were analysed as the best proxies available to the criteria concerning safety and continuity. For defining a sanitation service, it has been more difficult to reach a consensus among sector experts on the minimum indicators of what constitutes a service. The most commonly cited in training events include: a facility that provides no contact with human faeces, that provides privacy to those that use it, that is clean and odour free and faeces are safely disposed of. These do not match exactly the human rights framework.

Each of the criteria has been correlated and analysed for the rural/peri-urban division, the type of water or sanitation facility, the wealth status of households and the capital and recurrent expenditures. When possible, criteria has been correlated with each other such as quantity and distance for instance.

4.6.1 Access to water sources

Distance and time were used to measure accessibility. As such, two methodologies have been used for collecting the data:

- Method 1: Distance measured using straight line metres (with GIS) for the primary source in the dry season. Additionally, in Mozambique household were asked to indicate the distance per round trip with intervals for remaining sources.
- Method 2: Asking households to report the time spent arriving at the source, waiting in queue or for water to be available and the time spent returning home. Further, for Mozambique questions were asked about the type of recipients used, and how many round trips were done per day or per week.

Both methodologies have their pros and cons. When time is reported by households, recall bias can take place, but this method takes into account queuing times which can be significant as well as difficulties with the terrain and the drudgery of carrying weights (and often children). The GIS measurement in metres (and reported distance intervals) is more comparable across different contexts and easier/cheaper to collect, but it does not take into account either queuing times or natural terrain barriers which might make the walk to and from longer.

The analysis of the results from using both methodologies is interesting in itself since it can tell us if a straight line GIS measurement can be a good proxy for the distance or time spent collecting water per round trip.

The histograms with the data from the Mozambique sample for the two possible methods provide some similarities between the distance in metres and the overall time reported by households including queuing. Using Pearson's correlation there is a statistically significant relationship between distance and the reported time with queuing (R^2=11.7%, P=34.2%, CI=[.261,.418]. s=.000) and even higher correlation without queuing (R^2=15.4%, P=39.3%, CI=[.300,.489]. s=.000).

Comparing distances with time reported for the primary source in the dry season, the results achieved using both methodologies and the measurement of time quoted in the literature of 10 minutes per Km carrying 20 litres in uneven terrain seems an unrealistic conversion (Table 27). Using a broader band of 30 minutes per Km provides the results in Table 28.

Table 27 Comparing time and distance per round trip collecting water (conversion: 10 minutes per 1.000 meters)

Distance from water point in meters (for round trip distances double)	Method 1	Time equivalence per round trip as reported by HH	Method 2 without queuing	Method 2 with queuing
Less than 250 meters	34.6%	Less than 4 min	11.8%	4.5%
Between 251 - 1500 meters	58.7%	Between 5-30min	68.0%	16.2%
Between 1501- 3000 meters	5.7%	Between 31-60 min	16.8%	31.0%
More than 3000 meters	1.0%	More than 60 min	3.4%	48.3%
N	1221		1123	1123

Table 28 Comparing time and distance per round trip collecting water (conversion: 30 minutes per 1.000 meters)

Distance from water point in meters (for round trip distances double)	Method 1	Method 1 (Sum)	Time equivalence per round trip as reported by HH	Method 2 without queuing	Method 2 with queuing
Less than 100 meters	28.3%	28.3%	Less than 4 min	11.8%	4.5%
Between 101 - 250 meters	20.2%		Between 5-30min		
Between 251 - 500 meters	24.6%	57.2%		68.0%	16.2%
Between 501 - 1000 meters	12.4%				
Between 1001 - 2000 meters	8.5%	14.5%	More than 31 min	20.2%	79.3%
More than 2000 meters	6.0%				

Using the results from the more realistic conversion of 30 minutes per 1.000 meter, it can be seen that using method 1 (reported distance/GIS measurements) provides a more “rosy reality” than method 2 (reported time) with or without queuing. In fact, it appears that while using reported distance 28.3% of households would be spending less than 4 min per round trip to access water while using the reported overall time only 4.5% of households would fall under this category.

Since the methods are correlated, the following equation for Mozambique might be a proxy transformation from accessing time using straight line metres or collecting detailed time from households (Figure 8).

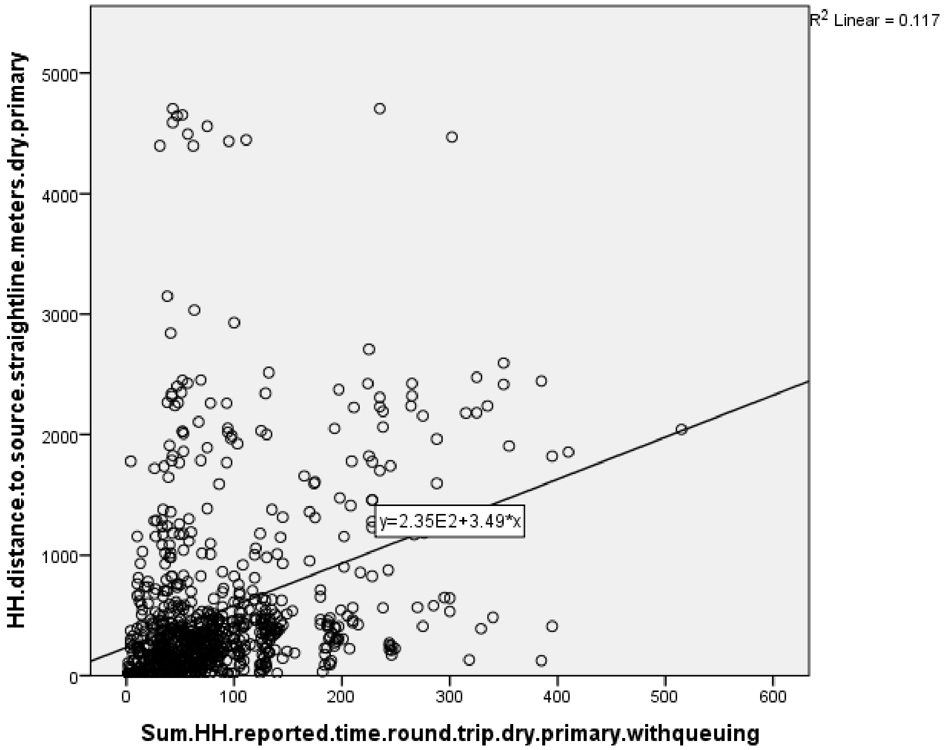


Figure 8 Relationship between reported distance per roundtrip and straight-line GIS distance to source (in metres, Mozambique)

For Ghana, there are only 204 data points for reported time to travel and queue at the source and the relationship with the distance measured using straight line GIS is not statistically valid (Figure 9). Distance does not seem to have influence on the reported time per round trip, but the respondents are concentrated in the “less than 100 minutes” interval and if comparing the same interval with Mozambique then there is also less obvious correlation.

Concluding, distance is not a very useful indicator for access because it masks the difficulties in the terrain and the queuing times. Reported time is a more useful indicator, but the data collection needs to include separate questions for going to the source, waiting and returning. When recall times are an issue, answers formatted as time intervals will probably provide most accurate approximation. Finally, if equivalences need to be made between time spend in round trips carrying water and distance, using 30 minutes per kilometre is more realistic than 10 minutes.

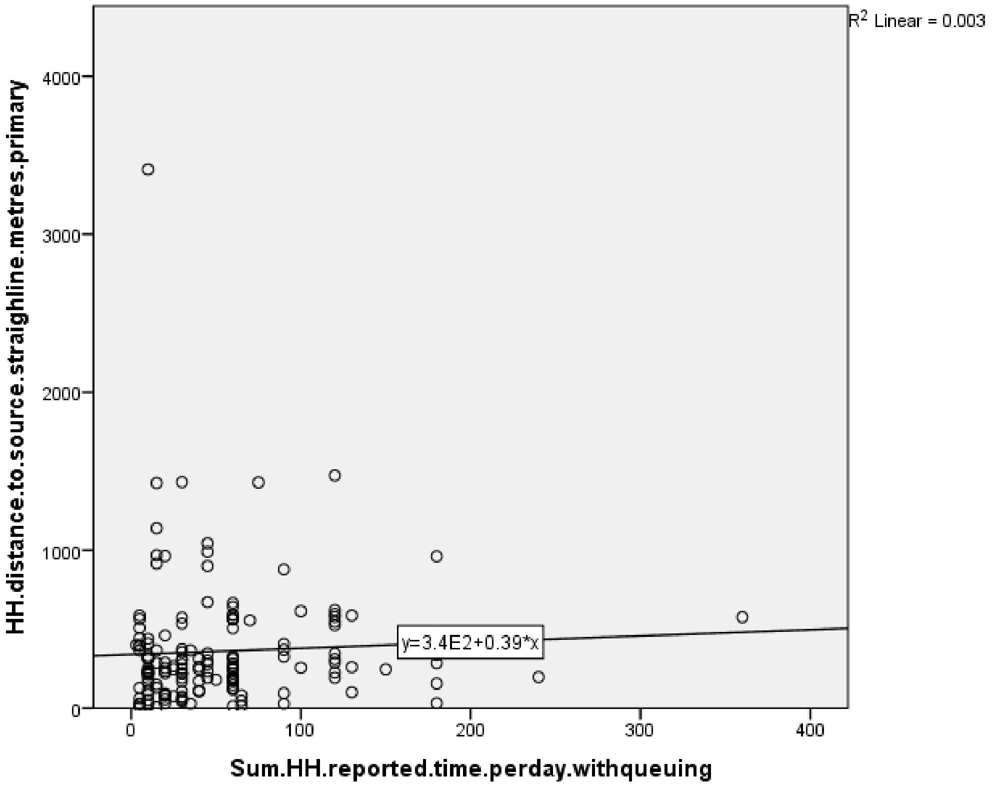


Figure 9 Relationship between reported distance per roundtrip and straight-line GIS distance to source (in metres, Ghana)

4.6.2 Access to sanitation facilities

Both questionnaires asked if households had access or were using toilets and what type of latrines or toilets were accessed. The Mozambique questionnaire asked additionally about their location and how many families were sharing the facilities. Enumerators observed if the latrines were being used or not, but it was not possible to determine if all members of the household were using them and if they were accessible by the elderly or disabled household members.

4.6.3 Quantity of water

The survey for Mozambique was the most complete. For the overall quantity a household collects several elements needed to be taken into account: when do the households collect water (daily, weekly or household tap), the number of round trips per day and per week (which have been converted into roundtrips per day) and the amount of 20 litre containers or the quantity (in m^3) measured with the water meter.

The variables have been converted into daily amounts and divided by the household size to obtain the litres per day per person:

- Total litres per person per day from containers source $_x$ = Number of roundtrips per day source $_x$ * number of containers source $_x$ * 20 litres / N household members
- Total litres per person per day from metered tap source $_x$ = m^3 per month source $_x$ * 1000 litres / 30 days / N household members

Statistically calculated outliers were identified and amounts above 100 litres per person per day per source have been removed. The distributions of the litres accessed by containers were very different from the distributions of the litres accessed through metered tap and therefore most of the analysis was done separately for each data set except overall totals on litres per person per day. For the final correlation with costs, the total litres per person per day have been averaged between the two seasons.

In the analysis, the resulting amounts reflect the standard 20 litre containers and what seem like "peaks" in litres at 20 intervals are actually resulting from the calculation basis. Therefore the litres have been converted into intervals to avoid erroneous conclusions.

The Ghana survey asked simply about the quantity per household per day that was collected from the formal and informal sources as well as vendors. Answers for non-metered water are less reliable than the Mozambique sample given the issues with recall bias. Even although quantity of water consumed is generally higher when compared with Mozambique, three extreme outliers were removed.

4.6.4 Water quality (perception)

In Mozambique and Ghana, given the remote locations of parts of the sample it was not physically possible to collect water samples and get them on time to be analysed in a laboratory (only available in the capital cities). The team realised the limitation and therefore no conclusions can be made on water quality apart from the type of source accessed, household perception and if water testing had been done when the water facilities were installed.

Questions analysed for the primary sources in the dry and wet season include:

- If a water quality test had been done at least once to the main source (triangulated with local officials) or never;

- The user perception on the water quality and the reasons for the choices;
- If water was treated by the households and how it was treated (Mozambique only).

Additionally, as a proxy indicator the type of source can be used. A service can be considered "safer" if the water source is considered improved and "less safe" if the source is considered unimproved (Keyser et al, 2013; WHO, 2000). Improved sources include boreholes with handpumps, standpipes and other piped schemes. Unimproved sources include open wells, ponds, rivers, etc.

4.6.5 Reliability of water facilities

The measurements in the samples concerning water reliability are different per country. In Mozambique the sample contains questions such as "Are problems with the source resolved quickly?" and "What are the main issues that need to be solved?" In Ghana the questions are "How reliable are the point sources accessed by the household?" followed by six answer possibilities such as "system works all the time"; "system works most of the time and occasional breakdowns are quickly repaired"; "system has broken down and has never been repaired (or has never worked)", etc.

Ideally, for both countries the questions should have also included: "How many times has the main source been completely broken down the last month?" and "For how long?".

4.6.6 Reliability of sanitation facilities

In Mozambique, for the reliability and safety of the sanitation facilities, enumerators observed the state of maintenance of the superstructure as well as the level of cleanliness inside the latrines and toilets. In Ghana, opinion was asked about satisfaction with latrine cleanliness (when using public toilets and neighbours toilet).

4.6.7 Acceptability of water facilities

Given all the aspects considered in the literature review, acceptability can be best measured with an indicator which measures the satisfaction of customers: "How acceptable/satisfied are you with your water or sanitation service?" and "What is your opinion on the management of this source?" These questions were only made in the Mozambique survey, but for both countries there are several related questions concerning the reliability of the systems such the perception on quality and aspects to improve in the service which are good proxies for acceptability.

4.6.8 Acceptability of sanitation facilities

For sanitation, the acceptability can be measured in the Ghana survey by the reasons that respondents answered on why they did not use latrines.

Dignity and privacy requirements have not been accessed by the survey in none of the countries and further conclusions cannot be drawn.

4.6.9 Affordability of water and sanitation to households

The initial proposal from Roaf (2005) was to analyse the percentage of household expenditure on drinking water by persons living below the country poverty line. Hutton (2013) has added additional possibilities including different costs components.

With the available data it is possible to calculate for the whole population and per wealth status the following affordability ratios for water and sanitation:

- Capital expenditure (one time) per person as a proportion of the per capita expenditure per day * 365 (Mozambique);
- Operational expenditure (per year) per person as a proportion of the per capita expenditure per day * 365 (Mozambique);
- Overall payments made for water per person as a proportion of the per capita expenditure per day * 365 (Ghana);

4.7 Household socio-economic analysis

4.7.1 Background to wealth status data in the country samples

The first step in the socio-economic analysis concerned the identification within the sample of who are the poor and the non-poor households in each of the countries. For this division, first an indicator had to be chosen for identifying who are the poor and secondly, a "poverty line" had to be defined to categorise the households in each of the poverty intervals.

As described in chapter 2.1.2 in the literature review which analyses which poverty measurements are used globally, the choice of indicators is particularly sensitive and influences the results in defining who is poor and who is less poor.

For the Mozambique dataset four methodologies and respective indicators were used to identify which methodology was the more appropriate to divide the households into poverty categories. The four different methodologies described in the literature in chapter 2.2 were applied to the dataset: reported income, reported expenditure, household perception of poverty and asset ownership. Poverty differentiation was one of the last sample criteria and mostly used within the communities which had already been selected for other reasons explained in the sample chapter (3.3.1). The research teams did not agree with one measurement and about 40% of the household survey was related with wealth indicators which reflect to some extent the four international methodologies used. However, the data collection was not designed specifically to analyse which of the four methodologies would be better, but simply for the research teams to agree post data collection, and based on local consultation, on which would be the best indicators to segregate the households as poor or non-poor.

In Mozambique household data has been collected to allow four different ways to divide households in socio-economic categories. The dataset will be analysed using each of these, in the following chapters:

- Household reported income (using intervals) and primary and secondary sources of income;
- Household reported expenditure (last 7 days, last 30 days and last year) on: food, transport, social events, rent, school and education, health, electricity (or charcoal, wood or gas) and other;
- Household reported and observed assets: electricity, radio, TV, mobile phone, fixed phone, fridge with freezer, wristwatch, bicycle, motorcycle, cart with animal traction, truck, motor boat and material used in the construction of the roof, material used in the walls of the house;
- Household reported poverty level compared with neighbours.

For the Ghana dataset, only during the pilot exercise data was collected for the first three approaches to categorise households. The team choose to select a fifth approach specific to the Ghana context and based on the main activity of the head of the household.

The analysis of the dataset using each of the groups of indicators above will provide a different answer on which households are relatively poorer in the sample. For the purpose of this thesis the interest is in analysing the result of poverty measurement in Mozambique using the four methodologies to decide which set of indicators will be used for dividing the samples into poorest, poor and non-poor. This chapter describes that process and the results.

4.7.2 Mozambique

4.7.2.1 Mozambique national and international poverty lines

In 2008, the National Statistics Institute has conducted the Mozambique National Family Budget Survey (GoM 2010). The report analysed poverty using among others household expenditure patterns. The national poverty line was 18.4 meticais per day per capita in 2008 (US$ 0.76) which was obtained by summing the food poverty line with non-food poverty line reflecting the minimum expenditure needed to meet food and non-food needs. The food poverty line (which indicates the poorest) was calculated at 13.6 meticais per day per capita in 2008 (US$ 0.56). In 2008, 56.9% of the population was living below the national poverty line in rural areas while 49.6% in urban and 54.7% at national level.

The international poverty line in 2008 was 1$ per person per day which is equivalent to 24.3 meticais in 2008. In Mozambique, 45% of the population was under the international poverty line (GoM, 2010) (Table 29).

Table 29 Mozambique national and international poverty lines

Extreme poverty line (to meet nutritional requirements)		
2008 report per day per adult	13.6 Meticais	US$ 0.56
2010 calculations per HH per month	2302 Meticais	US$ 68
National poverty line (to meet food and non-food consumption)		
2008 report per day per adult	18.4 Meticais	US$ 0.76
2010 calculations per HH per month	3013 Meticais	US$ 89
International poverty line		
2008 calculation per day per adult	24.3 Meticais	US$ 1
2010 calculations per HH per month	4114 Meticais	US$ 121

Source: Adapted from GoM (2010) using USD GDP in the databank.

4.7.2.2 Poverty analysis using households reported income intervals

In the household survey, households were asked to report on income intervals. The non-response rate on the income was overall 39.5%. Given this high (but not uncommon - Garn, Isham, and Kahkonen, 2002) rate, it is interesting to note that 27% of the overall sample reports less than US$ 44 (1500 meticais in 2010 prices) per household per month or $.29 per person per day (average hh size of 5 persons). This figure increased to 47.1% if only considering the respondents in rural areas.

Although the reported income intervals do not match exactly with the national and international poverty lines broadly, from the 60% of households that answered the question, the vast majority of the population in the sample is below the international poverty line and the national poverty line. A high percentage of the population is even further below the national food poverty line (Figure 10).

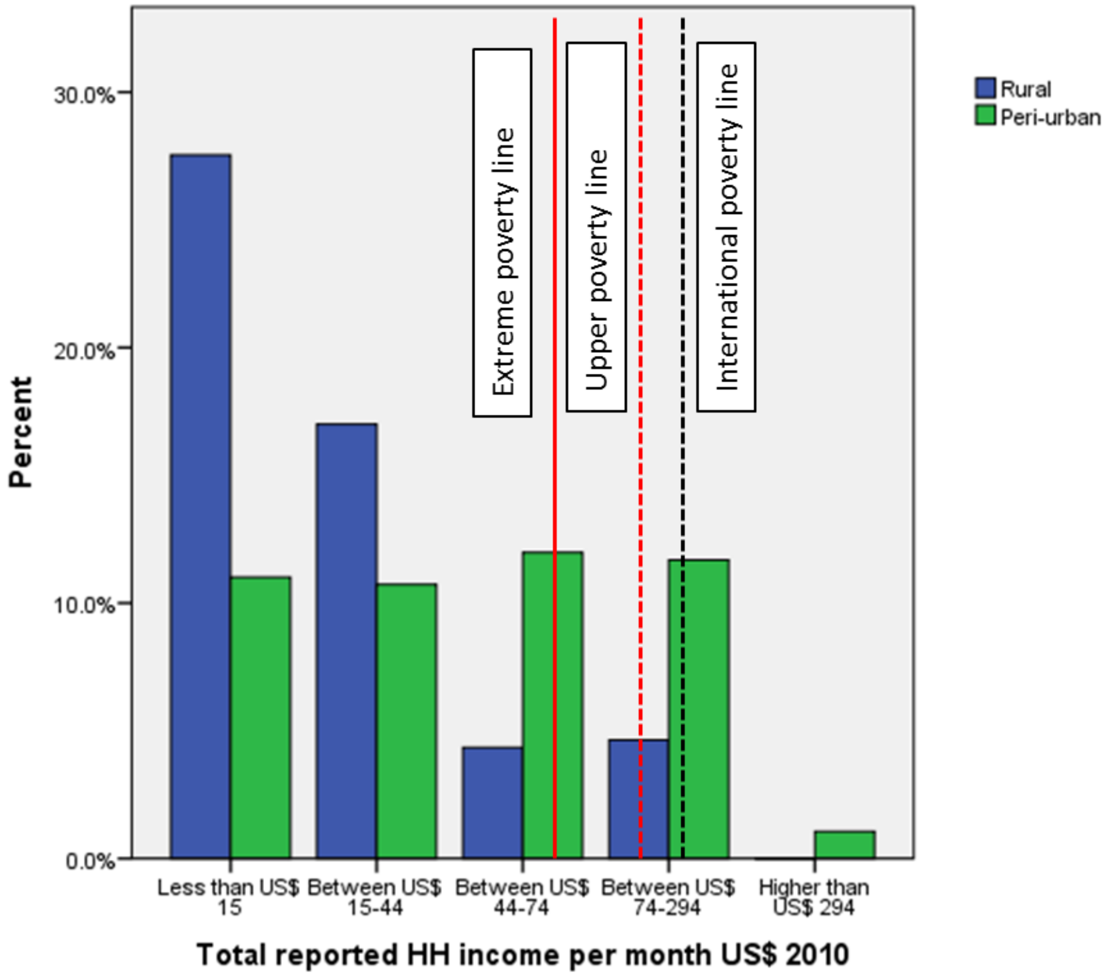


Figure 10 Reported household income per month

The main reported sources of household income are agriculture (67% for the rural respondents) and fix salary or permanent labour (39% for the peri-urban respondents) Figure 11.

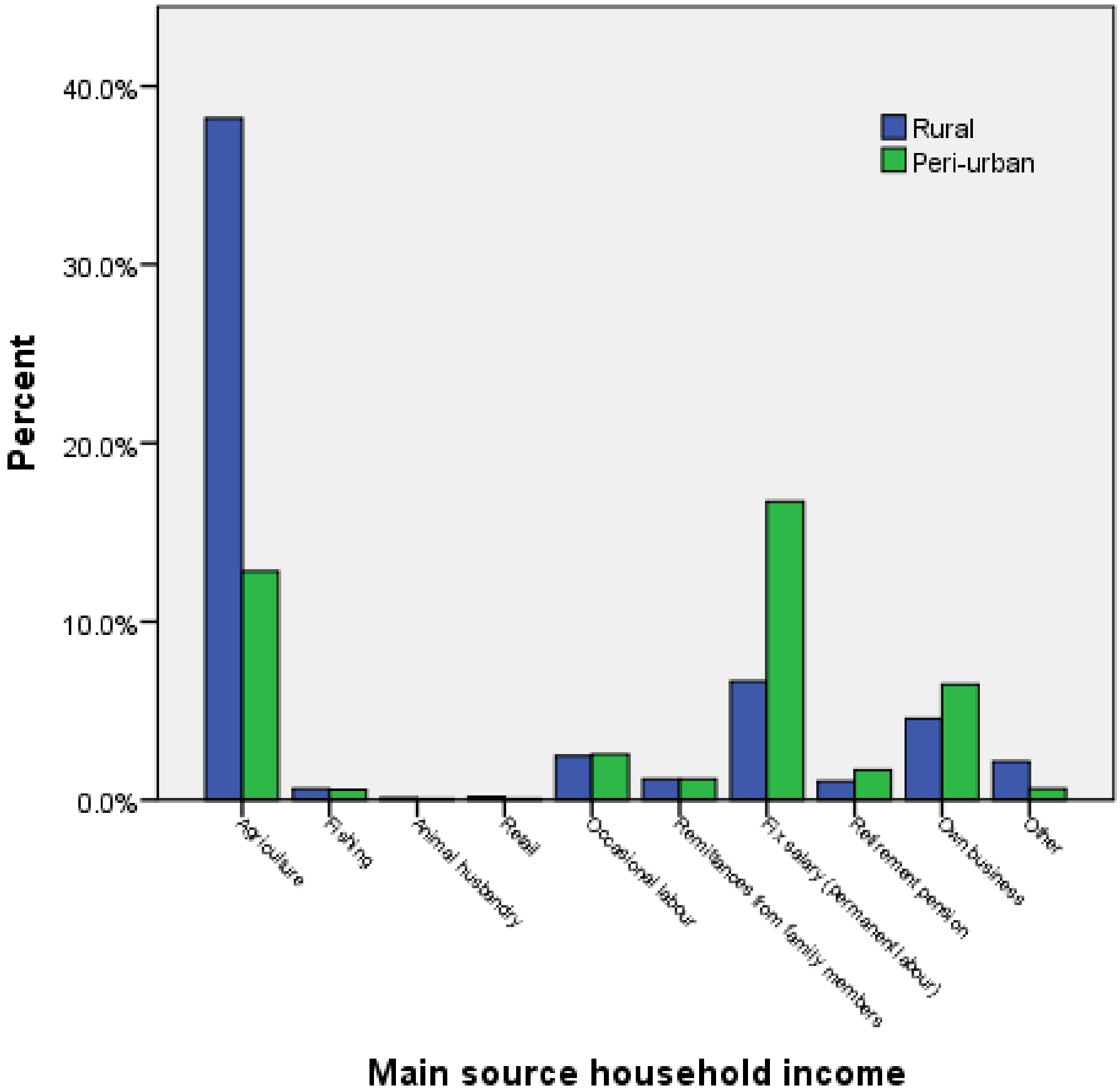


Figure 11 Reported household main source of income per month (%)

4.7.2.3 Poverty analysis using household reported expenditure

Households have reported expenditure on food, transport, social events (for the last 7 and 30 days), rent, education, health, electricity/charcoal/wood/gas (for the last 30 days and the last 12 months) and other expenditure. The household expenditure was then converted to daily per person expenditure and converted to 2008 prices for comparison with national and international poverty lines (Table 30). Using this methodology 82.6% of the sample is below the national poverty line and 87.9% is below the international poverty line, with the vast majority still under the national food poverty line (74.2%) although there are differences between rural and peri-urban areas which will be further analysed in the next chapter (Figure 12).

Table 30 Reported expenditure per capita and poverty lines (2008)

Poverty lines 2008	Meticais per person per day	Frequency	Percent
National food poverty line	13.6 or less	1270	74.2%
National poverty line	13.7 - 18.4	145	8.4%
International poverty line	18.5 – 24.3	91	5.3%
	24.4 or more	177	10.3%
Missing		27	1.5%
Total		1710	100%

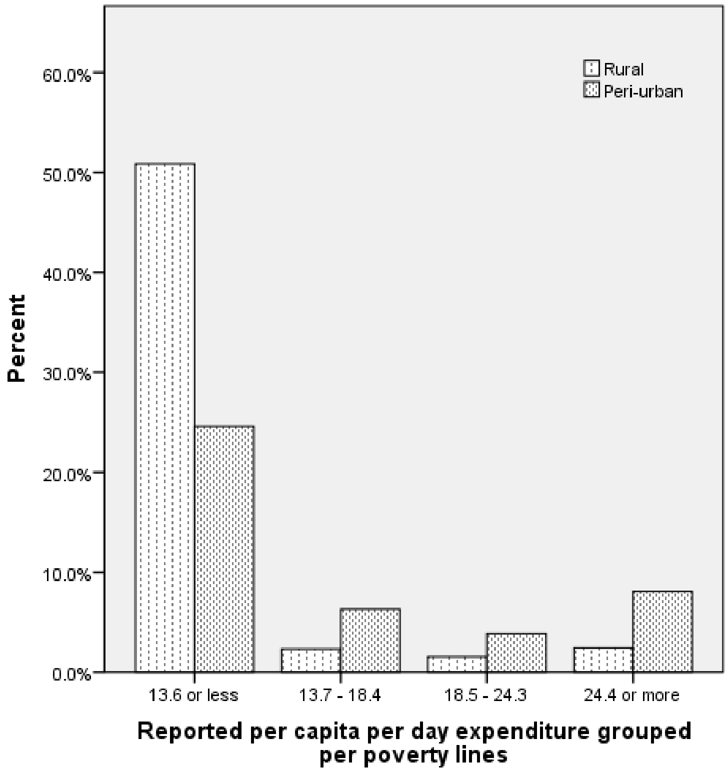


Figure 12 Comparison of reported expenditure rural and peri-urban with national and international poverty lines

The median of the sample for both rural and urban household size is 5 which match with the national household size (GoM, 2008). The analysis confirms the theory that the analysis done per household does not capture economies of scale (see chapter 2.2.3.3). Larger households have higher reported expenditure, but they also have less expenditure on a per capita basis (Deaton, 1997) Table 31.

Table 31 Reported expenditure per capita per size of household

	Expenditure reported per household per month grouped (meticais, 2010)				
	499 or less	500 to 1499	1500 to 2499	2500 to 9999	10000 or more
Mean HH members	4	5	5	6	7
	Expenditure reported per capita per month grouped (meticais, 2010)				
	99 or less	100 to 299	300 to 499	500 to 1999	2000 or more
Mean HH members	5	5	5	4	3

For comparing this methodology (reported expenditure) with the previous methodology (reported income), the expenditure was transformed into the same categories as reported income and it can be observed that reported income intervals are lower than the reported expenditure (Deaton, 1997) but not consistently. This comparison also confirms that income variables have more missing observations than the reported expenditure (Garn, Isham, and Kahkonen, 2002).

4.7.2.4 Poverty analysis using households reported poverty level

The question asked in the questionnaires was “how do you rate your household compared with your neighbours” (Table 32). The non-response rate was high (27.6%). Unfortunately there was not a question on how the households rated themselves which makes it impossible to create categories. A correlation was attempted with the reported expenditure with inconclusive results. This analysis was therefore not pursued further.

Table 32 Opinion of perceived household poverty compared with neighbours

Poverty status when compared with neighbours	Count	Percent
Poorer	256	15.0%
Same	596	34.9%
Less poor	386	22.6%
NR	472	27.6%

4.7.2.5 Poverty analysis using household assets

In the questionnaire, several assets and dwelling characteristics were checked during the household interviews. The frequency table (Table 33) provides an overview of the sample characteristics.

Table 33 Frequency table for household assets

Assets	Rural	Peri-urban
Electricity	37	277
Radio	537	467
TV	59	263
Mobile phone	164	376
Fixed phone	3	6
Fridge with freezer	12	133
Wristwatch	178	190
Means of transport	**Rural**	**Urban**
Bicycle	360	176
Motorcycle	34	39
Cart with animal traction	17	3
Truck	15	23
Motorboat	12	2
Dwelling characteristics	**Rural**	**Urban**
Roof material: grass/thatched/palm	762	315
Roof material: zinc sheets	207	391
Wall material: Adobe blocks or sticks	744	335
Wall material: Concrete block or brick	122	292

To be able to understand which groups of assets explain the dataset a Principal Component Analysis was applied using the methodology set in Fields (2013).

Step 1 consists of an initial check on adequacy of the sample by using the KMO test and scanning the R-matrix. The Kaiser-Meyer-Olkin measures the sampling adequacy and the recommendation is to have 10 times as many participants (1710) as variables (16), which this sample fulfils. KMO varies between 0 and 1. A value close to 1 indicates that patterns of correlation are compact and factor analysis should provide reliable factors. Values greater than .8 are very good. The first test with all the 16 variables above provided a .828 KMO.

The scanning of the R matrix allows checking the correlation coefficients between pairs of variables. If correlations are too high (>.9) or too low (<.3) then they need to be removed. Not surprisingly (given the low frequencies), the variables radio, fixed phone, wristwatch, bicycle, motorcycle, cart with animal traction, truck, motorboat were all eliminated given the consistent values under .3. Additionally the variable on the roof material made with grass was also removed as it had a value above .9. The new KMO test with the remaining 7 variables is .862 which is better than the previous score.

Step 2 is the main analysis: factor analysis and extraction using Kaiser's criterion, scree plot and parallel analysis. From running the analysis two factors have been extracted one related with "Key household assets" and another one related with "Materials used in walls and roof" (Table 34).

Table 34 PCA: Pattern matrix with factor scores

Extraction Method: Principal Axis Factoring	Factor	
Rotation Method: Oblimin with Kaiser Normalization	1	2
L02.C.HH.assets.TV	.854	
L02.A.HH.assets.electricity	.851	
L02.F.HH.assets.fridgefreezer	.731	
L02.D.HH.assets.mobilephone	.518	
HH.assets.walls.adobeblocks.sticks.fromM2		.961
HH.assets.walls.concreteblock.brick.fromM2		-.770
HH.assets.roof.zincsheets.fromM1		-.644

Step 3 involves checking the reliability of the analysis by using Cronbach's alpha for each factor. Reliability is used to measure the consistency of a measure. For "Key household assets" Cronbach's alpha is .83 which indicates a good reliability.

In conclusion, a principal axis factor analysis was conducted on the 7 variables with oblique (direct oblimin) rotation. The Kayser-Meyer-Olki measure verified the sampling adequacy for the analysis, KMO=.86 and all the KMO values for individual items were all well above .5. An additional analysis was run to obtain eigen values for each factor in the data. Two factors had eigen values above 1 and in combination they explained 63.4% of the variance in the data. The scree plot showed the two point of inflection that justify the extraction of the two factors. Factor 1 represents key assets within the households and factor 2 the materials used in the walls and roof (Fields, 2013).

Having defined the indicators which could be used to measure poverty levels within the households, it is not clear how to define the poverty lines based on the assets and any division chosen based on these factors would be arbitrary (ie. considering non-poor those households that had all the assets extracted above, or only a few of those).

4.7.2.6 Conclusion on indicators and measurement of poverty in the Mozambique sample

There are pros and cons of using either one of the four methodologies with the existing data in the sample. The most robust method for categorising household socio-economic categories which also allows for comparisons across countries is based on the household reported expenditure. There are still constraints with using this method with this sample because the questionnaires were administered only once (usually the same households are visited twice in a year for an ideal application of the methodology to avoid problems related with recall periods), price lists were not collected, nor disaggregated food consumption items. Further, it is well known that people cannot recall purchases long after they have been made (Deaton, 1997). Recall periods over two weeks tend to result in downward biased estimates and in the questionnaire there were recall periods of one month to one year.

However, comparatively, the problems with the other three methodologies were more severe:

- For reported income, the non-response rate was very high (40%);
- In the qualitative analysis of poverty, the surveys did not ask households how they rated their own household which makes it impossible to divide in categories;
- For the reported assets, although some of the assets could be used as proxy indicators for poverty, the cut off points chosen for poverty categories would be rather arbitrary and international comparisons would be difficult.

Having decided on the indicator – reported household expenditure – it was necessary to decide on a cut-off point – or the point where households are categorised into poor and non-poor. The households were assigned to these categories by using international and national poverty lines. This has indicated that the majority of the households surveyed were either poor or very poor making further analysis not very interesting independently of the indicators and cut off points used.

The purpose of this thesis is to compare broadly, among countries, the expenditure and services received by the poor compared with the non-poor within the sample and not to identify exactly which households are poor and which ones are not. As such, it has been decided to "cut" the sample data by looking at the frequency distribution of household reported expenditure as explained in the findings chapter.

The most relevant conclusion is that although the findings and analysis will constantly refer to the differences between the poor and non-poor within the sample, the large majority of the households in the sample used in this thesis are considered very poor at international and national level.

4.7.3 Ghana

4.7.3.1 Ghana national and international poverty lines

In Ghana, the official poverty lines date from 2006 in a report issued by the Ghana Statistical Service in 2007 and have been updated in a more recent report by Osei-Akoto and Gottmann (2010) (Table 35). The incidence of poverty was found to be highest by far among food crop farmers and becomes more pronounced using measures which take account the depth of poverty.

Table 35 Ghana national and international poverty lines

Extreme poverty line (per adult per year, to meet nutritional requirements)		
2006 report	288 New Ghana Cedis	US$ 314
2009 calculations	411 New Ghana Cedis	US$ 292
Upper poverty line (per adult per year, to meet food and non-food consumption)		
2006 report	370 New Ghana Cedis	US$ 404
2009 calculations	556 New Ghana Cedis	US$ 395
International poverty line		
2009 calculation	643 New Ghana Cedis	US$ 456

Source: Adapted from Akoto and Gottmann (2010) using USD GDP in the databank.

Expenditure and income information from the households was collected for the pilot. Similarly to Mozambique, the reported income is lower than the reported expenditure (comparative statistics in Table 36). In the pilot it was noted that collecting expenditure would take an additional 30 minutes at a minimum per survey and under advice from the statistics institute, and for measurement at country level, the main activity of the head of household was considered a good proxy for dividing the sample into “poor” and “non-poor”.

Table 36 Statistics reported expenditure and reported income during pilot data collection

		Reported expenditure per person per year US$ 2009	Reported income per person per year US$ 2009
N	Valid	65	66
	Missing	1274	1273
Mean		624.31	709.15
Median		503.19	371.63
Std. Deviation		455.955	770.392
Percentiles	25	332.73	154.57
	50	503.19	371.63
	75	721.99	946.81

The question asked in the questionnaire was “What is the main economic activity of the household breadwinner? (as the main livelihood)”. The response categories were:

- Public sector employment
- Private formal employment
- Private informal employment
- Cash crop farming
- Food crop farming
- Non-farm self-employment
- Unemployed
- Other

By considering that the poor are those which main activity is food crop farming then 36.7% of the sample can be considered poor (the average for Ghana in 2005/6 was 43% for extreme poor and 46% for poor). Another possibility is to consider that the very poor are the households which main activity is food crop farming, the poor those that cultivate cash crop farming and everyone else is considered non-poor.

To test this assumption an analysis was done on the expenditure reported during the pilot data collection. The pilot data was collected in the Greater Accra Region where households are in general more affluent compared with the remaining regions in the country (N=66). The results show that, in the absence of other data, broad equivalences can be made between the main economic activity of the head of the household and the socio-economic status (Figure 13): those who farm food crops are closer to the extreme poverty line and, those that farm cash crops are closer to the upper poverty line.

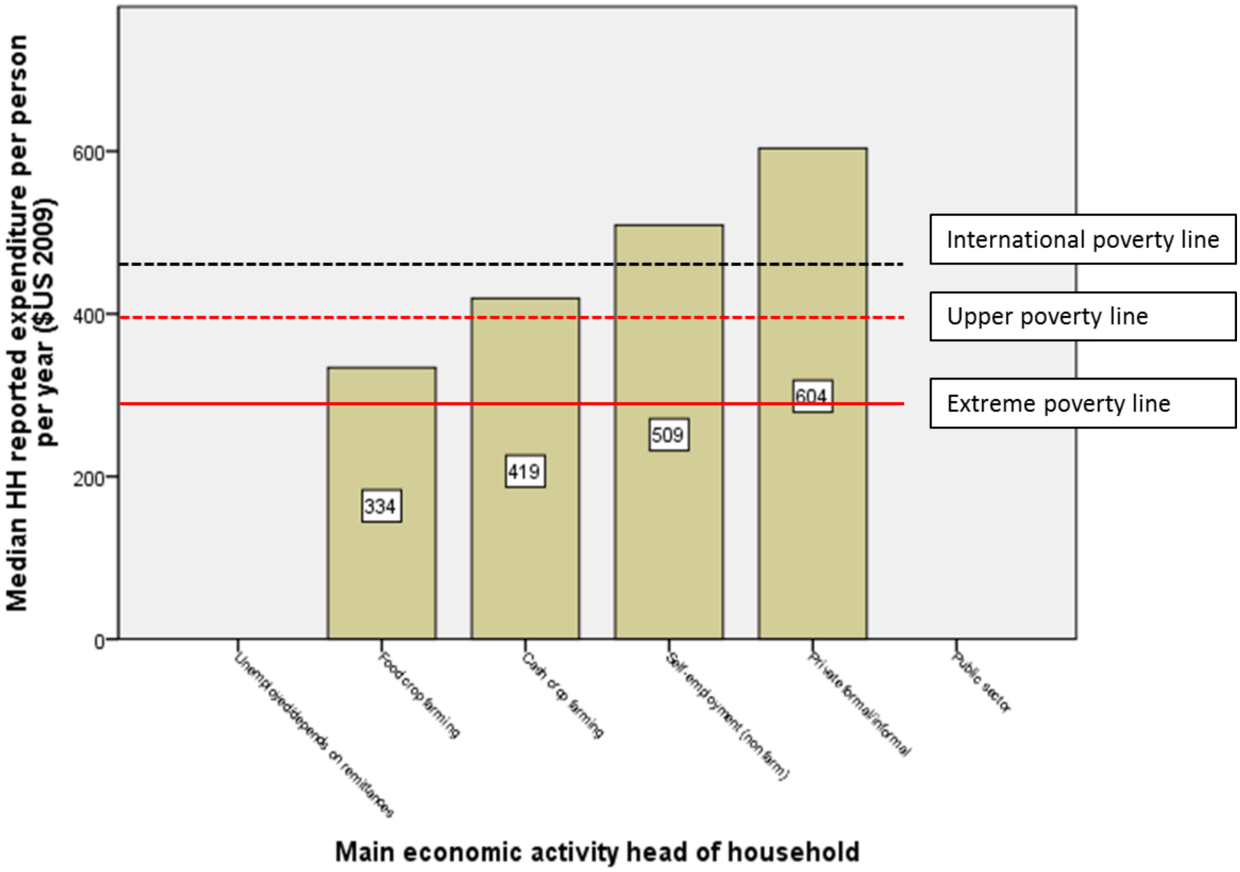


Figure 13 Poverty status against HH reported expenditure

4.7.3.1 Conclusion on indicators and measurement of poverty in the Ghana sample

For the whole sample, only the activity of the head of household is available as a proxy indicator for socio-economic activities. This means that although an analysis can be made for comparing costs and service levels received by the different categories of the population, there are some limitations:

- Because the poverty categories are categorical in nature, they can only be matched with the national or international poverty lines (which are numerical) under the assumptions that the expenditure reported from the 66 respondents in the survey is somehow similar to the remaining expenditure in the survey or slightly higher;

- The correlation analysis between poverty and service levels will be less robust because categorical variables will be used
- Affordability analysis (which is based on expenditure) will be less robust

This choice of poverty indicator is relevant for national level analysis but it impacts on the comparison of the dataset with the Mozambique dataset. Broad equivalences can be made but results need to be interpreted with caution when discussing the poor and the non-poor across the two countries.

4.8 Conclusions on overall cross country comparability

The Ghana questionnaire was much shorter than the Mozambique one. Additionally, context-specific changes and adaptations of the questionnaires lead to non-comparability of some parameters being studied. Even the way the same questions were presented in the questionnaire had impact on the amount and quality of the responses.

There are issues with non-comparability across the two countries concerning the poverty analysis, the distinction between wet and dry season, and the financial and economic costs for water supply. This chapter discusses each of these and the implications for the analysis.

In the Mozambique sample it was possible to divide the population in three distinct socio-economic groups based on reported household expenditure. In the Ghana sample, the household expenditure was collected only during the pilot trial and the only indicator that can be used to categorise the household's level of poverty is the activity of the head of household which according to the Ghana Statistical Institute is a good proxy for poverty. The main issue is that it is not possible to make an international comparison based on indicators which are so country specific: those that are considered non-poor in Mozambique are still considered very poor in Ghana.

The answers in the Ghana survey for the wet and the dry seasons do not vary much. This makes sense for most of the water provided through piped systems. The author of this thesis cannot judge the validity of the answers for the non-piped and informal sources. Either there are not many differences in the water accessed in the different seasons in Ghana or the reliability of the answers is doubtful. Most of the analysis for the Ghana dataset was therefore done for the whole year with no disaggregated seasonal analysis.

The financial costs are different in nature in the Mozambique and in the Ghana sample. The poorer and more rural population in the Mozambique sample has contributed for capital expenditure and almost does not pay for maintenance or for tariffs of point sources. In the better-off Ghana sample, it's the opposite. Households have contributed minor amounts to the construction of the point sources through the village water committees and have to pay to access water from formal and informal sources.

In the economic cost analysis for Ghana, for the time that households spend per day, it is unclear how many round trips are made and therefore the calculations are only considering one roundtrip per day. Additionally, the Mozambique sample has collected the time that households take to access formal and informal sources, while the Ghana sample addresses time to formal sources only.

The economic cost analysis for sanitation is only possible for Mozambique because contributions in kind where not collected in the Ghana sample.

In conclusion, the impossibility of comparisons derives mainly from less information available in the Ghana sample. The critical data which is available to achieve the objectives of the thesis is, with some limitations, comparable among the two countries.

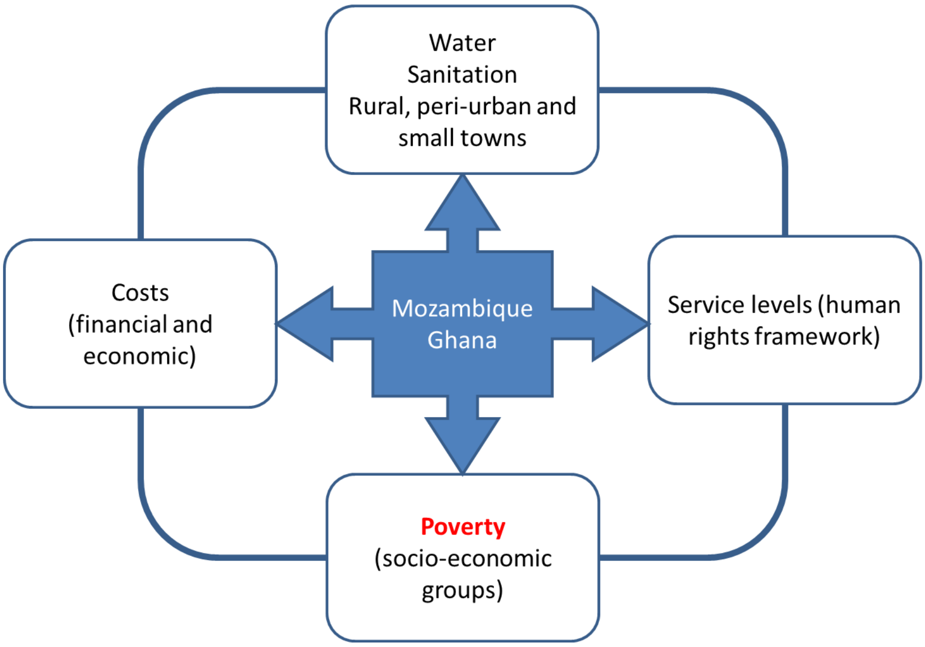
5 ANALYSIS AND DISCUSSION

This chapter analyses and discusses the findings from applying the methodologies and approaches set in the previous two chapters to provide an answer to the main research question and the two hypothesis:

Can low-income rural households pay for water supply and sanitation services? Hypothesis 1: Low income rural households cannot pay for the construction and maintenance costs or/and tariffs are too high. Hypothesis 2: Low income rural households can pay for improved water and sanitation but are not prioritising to do so.

The chapter starts by describing the household sample from a wealth perspective and describing the characteristics of the low-income households. This analysis is followed by a description of the water sources and uses in both countries. The financial and economic household expenditure are analysed per socio-economic categories (and compared with the grey literature and benchmarks available in the sector). The same analysis is done for sanitation. The final chapters measure the service levels using the indicators proposed in the human rights framework and summarise the poverty analysis. Further details of the analysis can be found in Appendices B to H.

5.1 Socio-economic categories in the household sample



One of the sub-questions of this thesis is to analyse if costs and service levels vary with household-economic status and to what extent. For this purpose, which impacts on the overall analysis, the sample had to be carefully divided into socio-economic categories. The majority of the 3049 respondents to the survey are very poor, or poor, from either a national or international perspective.

For Mozambique, four methodologies were used to analyse the poor and the non-poor in the sample (N=1710). Similarly to the findings of the literature, reported expenditure was the most robust methodology with the available indicators to divide the sample in three socio--economic categories. The conclusion is that 82.6% of the households in the sample are below the national poverty line and 87.9% are below the international poverty line, with the vast majority under the national food poverty line (74.2%). This has indicated that the majority of the households surveyed in Mozambique were either poor or very poor. Looking back, maybe this is one of the reasons for the other methodologies not providing robust results: because all the methodologies which are not based on reported expenditure do not provide enough granularity when the sample households are all too poor (or too rich).

For Ghana, the only indicator available across the whole sample (N=1339) to categorise the households was the activity of the head of the household. Being a farmer of food crops is an accepted broad equivalence to being poor compared with all other possible activities. Based on this indicator the sample was divided into poor and non-poor.

In the pilot data collection for Ghana (N=66), expenditure was collected and broad equivalences could be made with the household activity even although the pilot data was collected in a comparatively richer peri-urban area in Accra Metropolitan area (Photo 6). Nevertheless, compared with the Mozambique data set, the sample in Ghana is overall less poor (

Table 37). The poor in Ghana, with a reported household expenditure of US$ 0.93 (median, 2011 GDP prices) per person per day are better off than the least poor in the Mozambique sample (median US$ 0.82).

Photo 6 Peri-urban areas: greater Accra region.

Photo credit: Peter McIntyre

Table 37 Comparing household socio-economic categories in Mozambique and Ghana

	HH reported expenditure per capita per day (median) US$ 2011 GDP	
	Mozambique	Ghana
Poorest	.13	
Poor	.38	0.93
Least poor/non-poor	.82	1.42

The most relevant conclusion is that although the findings and analysis constantly refer to the differences between the poor and non-poor within the sample, the large majority of the households in the sample used in this thesis are considered extremely poor at international and national level (Mozambique) and poor (Ghana). (See Figure 14, Figure 15).

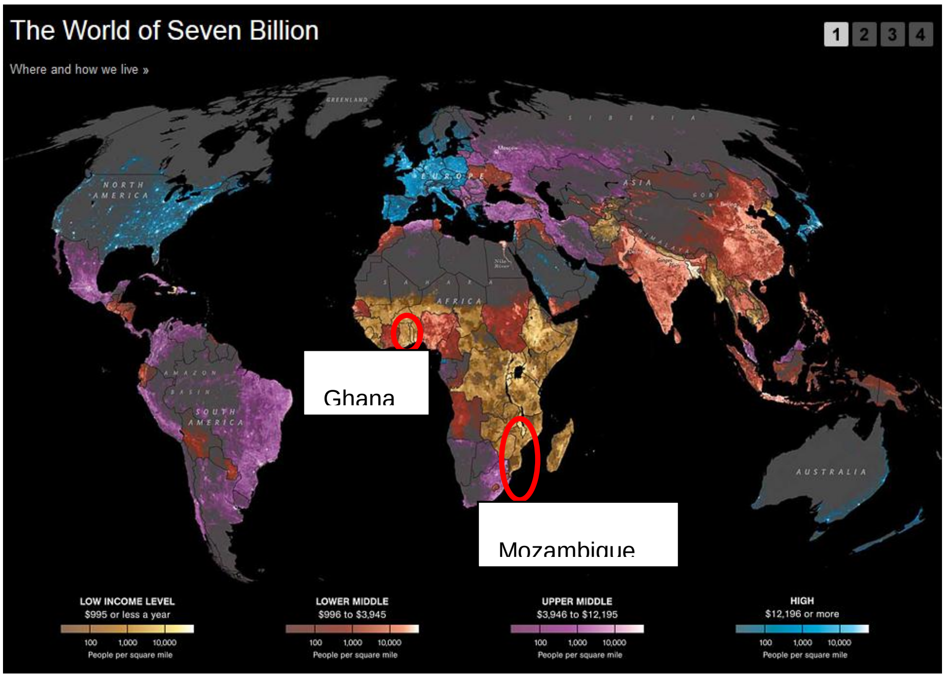


Figure 14 The World Seven Billion colour coded per income level with highlight Ghana and Mozambique with the relatively the lowest income level

Source: Adapted from National Geographic, 2014

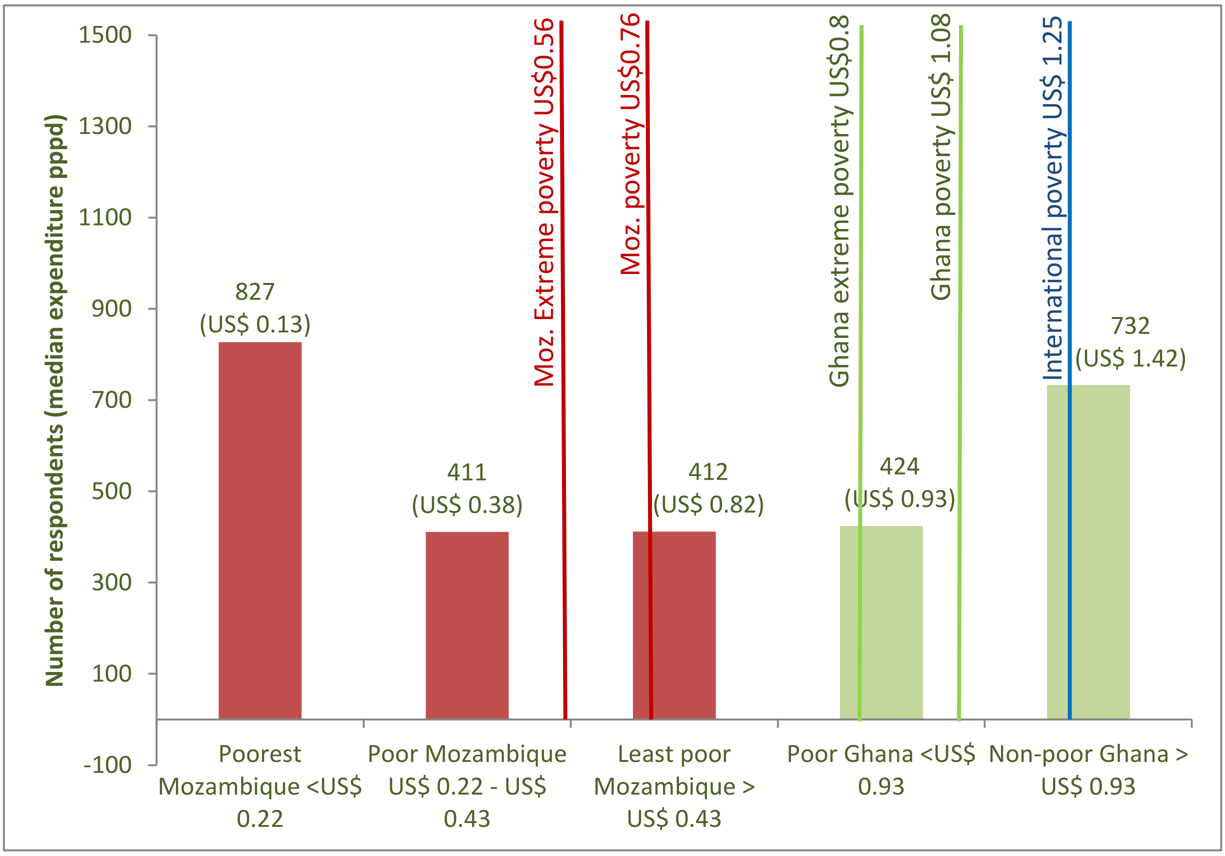
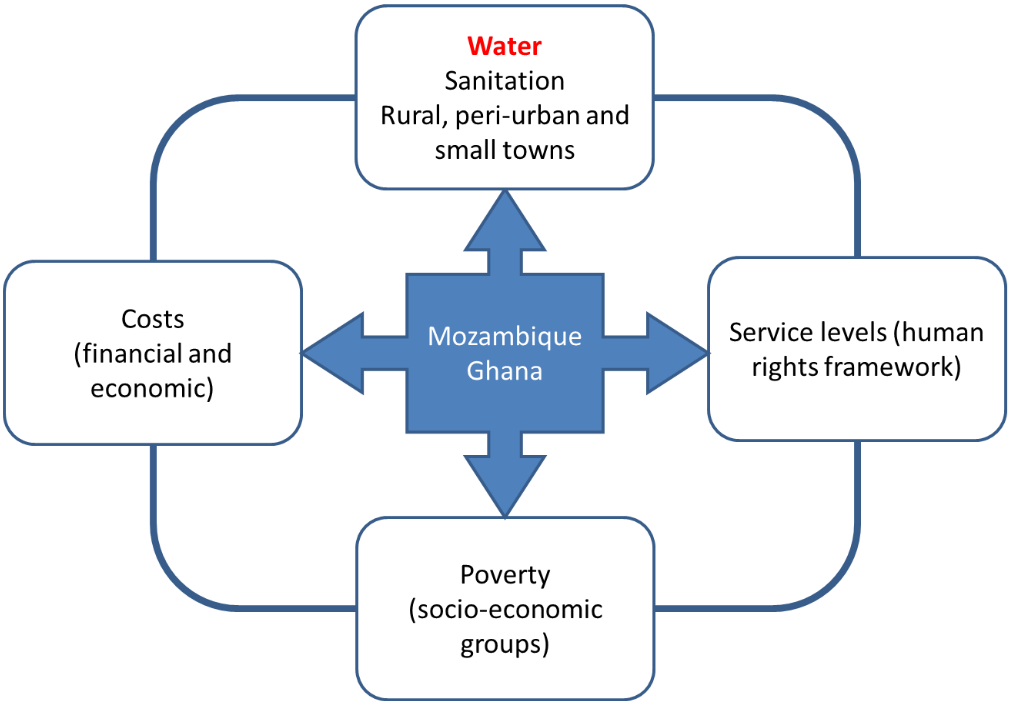


Figure 15 National and international poverty lines, Mozambique and Ghana sample

5.2 Water sources and uses



5.2.1 Mozambique

The sample households both in rural and peri-urban areas access more than one water source in the dry and in the wet season. In Mozambique the dry season takes place between April and September (6 months) and the wet season between October and March. The access to more than two sources is slightly higher within the population living in rural areas (Table 38) and the least poor depend slightly less on more than two sources (Table 39).

Table 38 Sample population access to water sources in rural and peri-urban areas Mozambique

	Rural (%column)	Peri-urban (% column)
One source	538 (55.0%)	474 (64.8%)
Two sources	425 (43.5%)	231 (31.6%)
Three sources	14(1.4%)	21 (2.9%)
Four sources	1(0.1%)	6 (0.8%)

Table 39 Sample population access to water sources per poverty status

	Poorest (%column)	Poor (%column)	Least poor (% column)
One source	475 (57.4%)	227 (55.2%)	269 (65.3%)
Two sources	323 (39.1%)	175 (42.6%)	140 (34.0%)
Three sources	23 (2.8%)	8 (1.9%)	3 (0.7%)
Four sources	6 (0.7%)	1 (0.2%)	0 (0.0%)

Noting that the absolute numbers need to be interpreted cautiously (the sample has more rural and poorest than peri-urban and least poor), to check for correlations, Kendall's tau test was used among the most likely non-parametric variables: poverty, rural/peri-urban, costs and types of sources.

Poverty status was significantly related to whether the household was located in a rural or peri-urban area (Kendal's tau correlation coefficient = 38.4%, CI [.344,.426], p=.000) and the total number of sources was also significantly related to whether the households were in rural or peri-urban areas (Kendal's tau correlation coefficient = 8.0%, CI [-.128,-035], p=.001).

Photo 7 Borehole with handpump, Mozambique.

Photo credit: Peter McIntyre

The primary water sources in the dry season include informal sources, protected and unprotected wells, boreholes fitted with hand pumps (Photo 7), and piped schemes grouped as described in Table 40. To note is the high percentage of the population accessing boreholes with hand pumps at 38.9% (664) and those accessing potentially unsafe sources 30% (512) in both urban and peri-urban areas.

Table 40 Primary sources dry season rural and peri-urban areas

Grouping for analysis	Source from questionnaire	Rural	% of overall sample	Peri-urban	% of overall sample
Informal	River water, stream, lake, pond	150	8.8%	41	2.4%
	Rainwater (Photo 8)	8	0.5%	3	0.2%
Well	Unprotected well	182	10.6%	128	7.5%
	Protected Well	42	2.5%	16	0.9%
Borehole and hand pump	Borehole	521	30.5%	143	8.4%
Piped scheme	Stand pipe (Photo 9)	72	4.2%	164	9.6%
	Neighbours tap	3	0.2%	162	9.5%
	Yard tap (Photo 10)	0	0.0%	71	4.2%
	Household tap (Photo 11)	0	0.0%	4	0.2%

Photo 8 Rainwater structure and tank, Inhambane Province, Mozambique.

Photo credit: Catarina Fonseca

Photo 9 Paid standpipe, Inhambane Province, Mozambique.

Photo credit: Catarina Fonseca

Photo 10 Yard tap with meter, Mozambique.

Photo credit: Catarina Fonseca

Photo 11 Elevated and ground reservoir feeding small piped systems in Inhambane, Mozambique.

Photo credit: Catarina Fonseca

Most of the rural population water is provided through boreholes and hand pumps while in peri-urban areas piped schemes predominate (Figure 16). Within the socio-economic categories the poorest and the poor access water through boreholes with handpumps while the least poor receive water primarily through piped schemes (Figure 17).

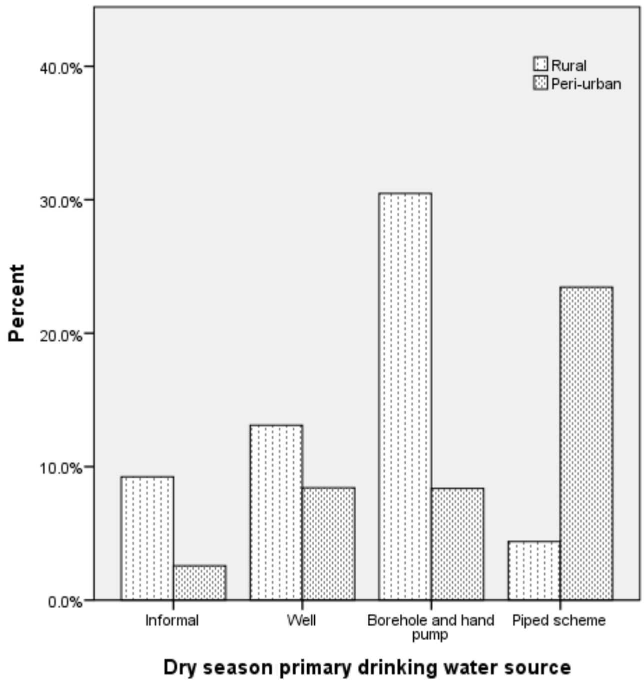


Figure 16 Primary drinking water sources in the dry season rural and peri-urban areas

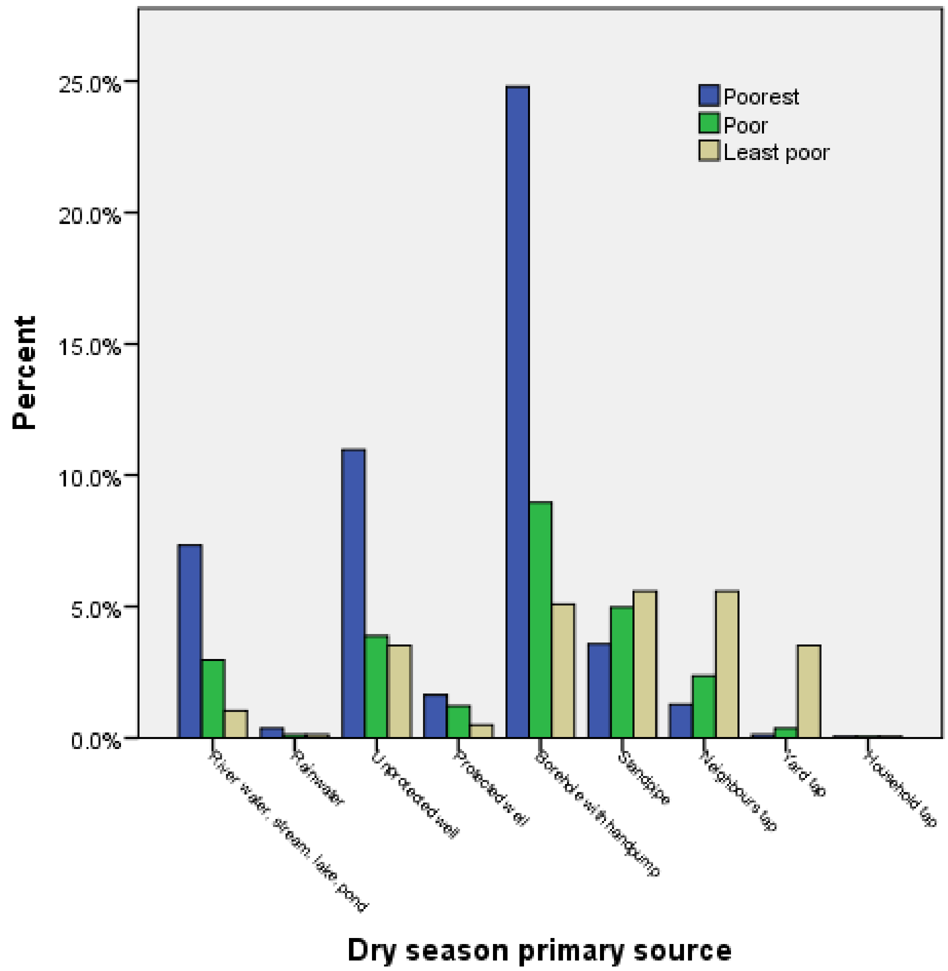


Figure 17 Primary drinking water sources, dry season per poverty status Mozambique

The main reasons for using each of the sources is mainly because the water is of good quality and the source is conveniently closer to the household, but for using alternative sources in both seasons the fact that the water is free, the availability of water and low queuing times become important factors (Figure 18). In the wet season, for a minority of households the use of a second source is motivated by the desire or need to use rainwater.

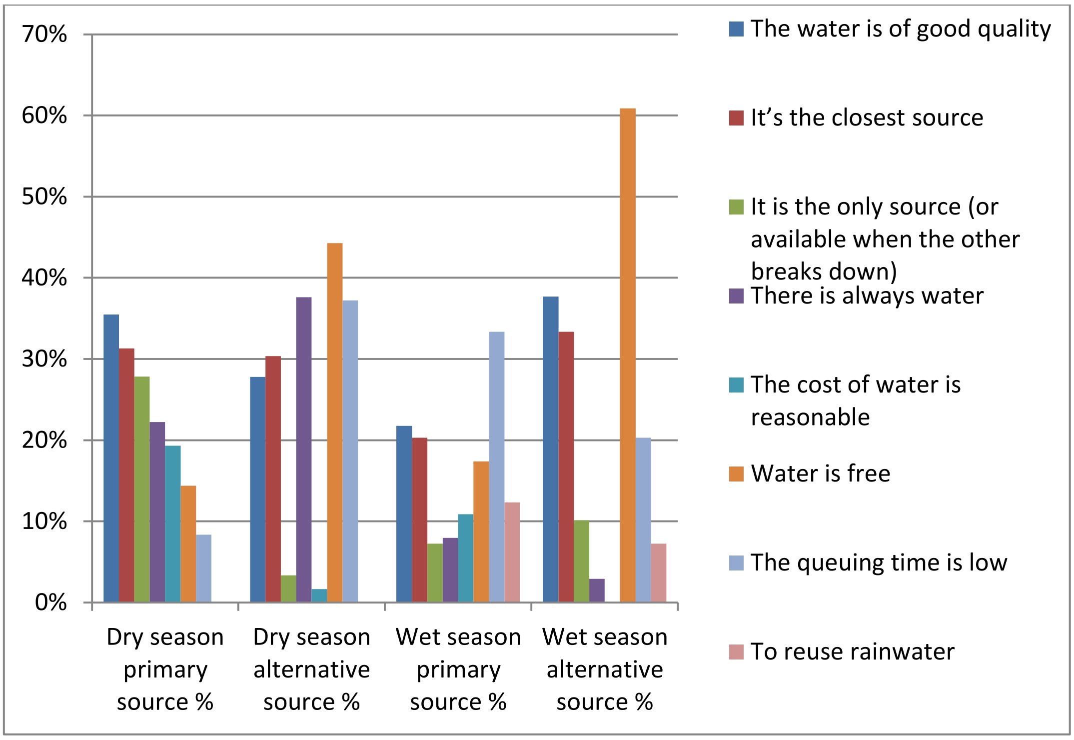


Figure 18 Reasons for using water sources dry and wet seasons (%)

5.2.2 Ghana

Households in Ghana access on average one formal source and one alternative source (Figure 19), but 19,3% (259) accesses more than two formal sources. Additionally, 67% (898) have a rainwater harvest system and 58% (788) access other informal sources such as shallow water, ponds and river water. From these, 29 households access more than two additional informal sources (Photo 12). Purchasing water from vendors is common to 17.9% (240) of the households. The differences between wet and dry season are not marked enough in the answers to the survey and therefore the remaining analysis will be done combined for both seasons.

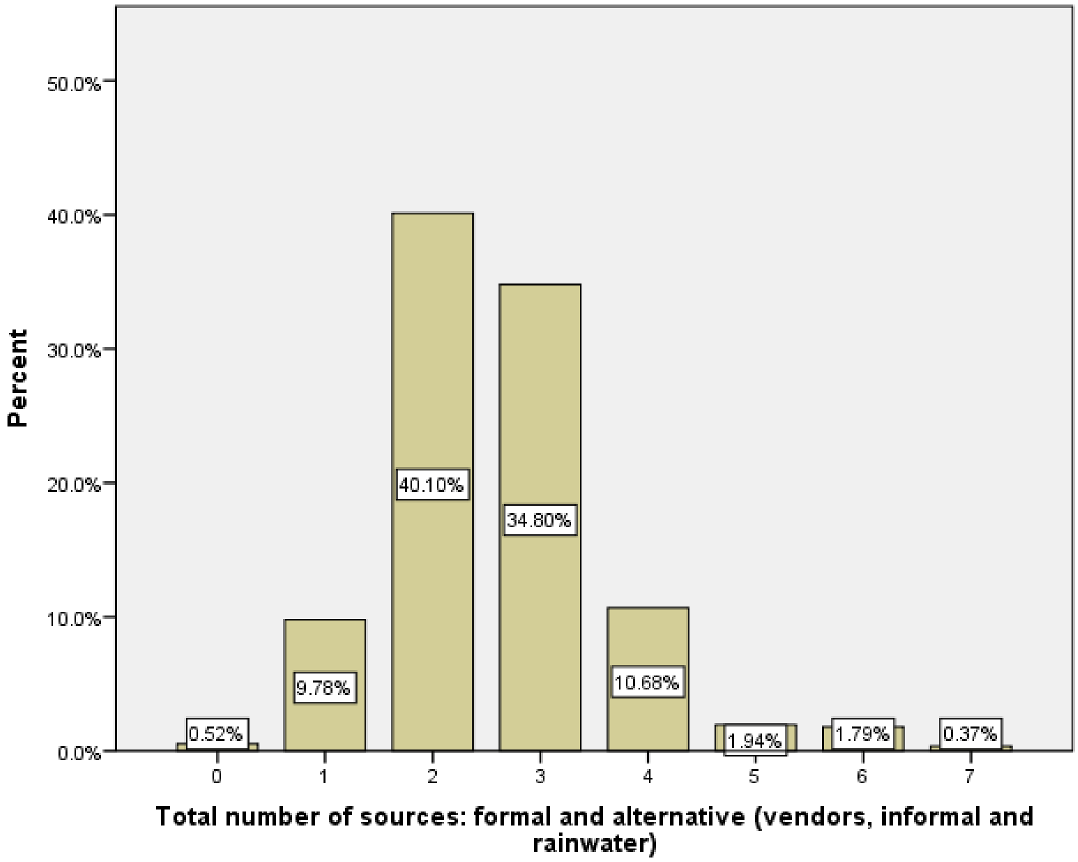


Figure 19 Number of water sources accessed year round, Ghana

Even in peri-urban areas and small towns households are generally accessing more than one source but more than four sources are accessed by rural households (Table 41).

Table 41 Sample population access to water sources in rural and peri-urban areas Ghana

	Rural (%column)	Peri-urban (% column)	Small town (% column)
No source/answer	6 (0.6%)	NA	1 (0.4%)
One source	73 (7.1%)	11 (16.7%)	47 (19.5%)
Two sources	**397 (38.5%)**	**41 (62.1%)**	**99 (41.1%)**
Three sources	**369 (35.8%)**	13 (19.7%)	**84 (34.9%)**
Four sources	132 (12.8%)	1 (1.5%)	10 (4.1%)
Five sources	26 (2.5%)	NA	NA
Six sources	24 (2.3%)	NA	NA
Seven sources	5 (0.5%)	NA	NA

Photo 12 Collecting water from pond, informal source, North Ghana.

Photo credit: Peter McIntyre

Similarly to Mozambique, the primary formal sources accessed are, in rural areas almost exclusively boreholes and hand-dug wells with handpumps. Public standpipes, household connections and yard standpipes are almost exclusive to peri-urban and small towns (Figure 20). Informal sources are only accessed in rural and in small towns, not in the peri-urban areas (Figure 21).

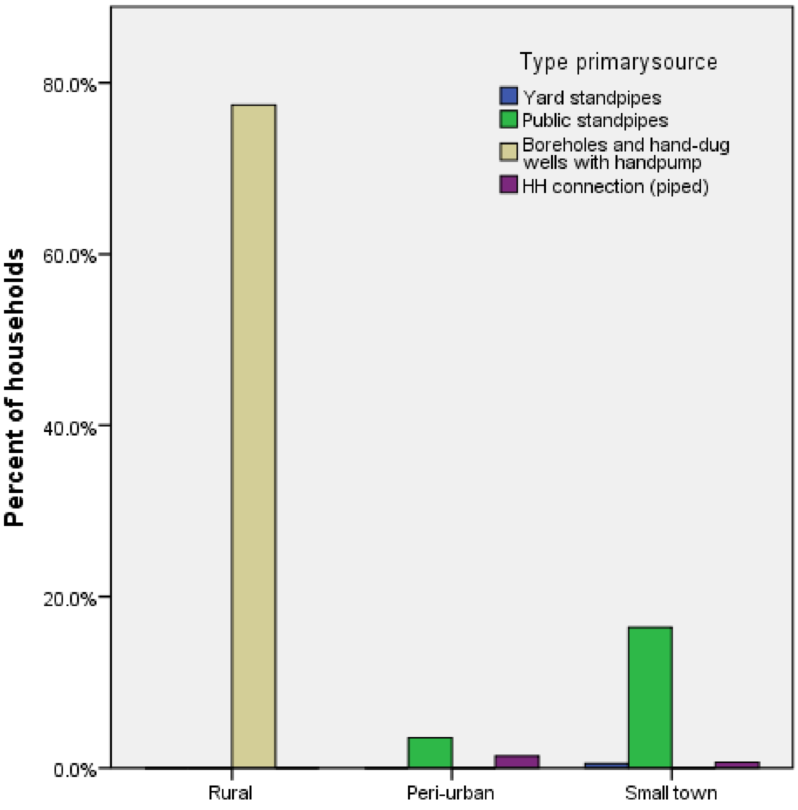


Figure 20 Primary formal source in rural, peri-urban areas and small towns, Ghana

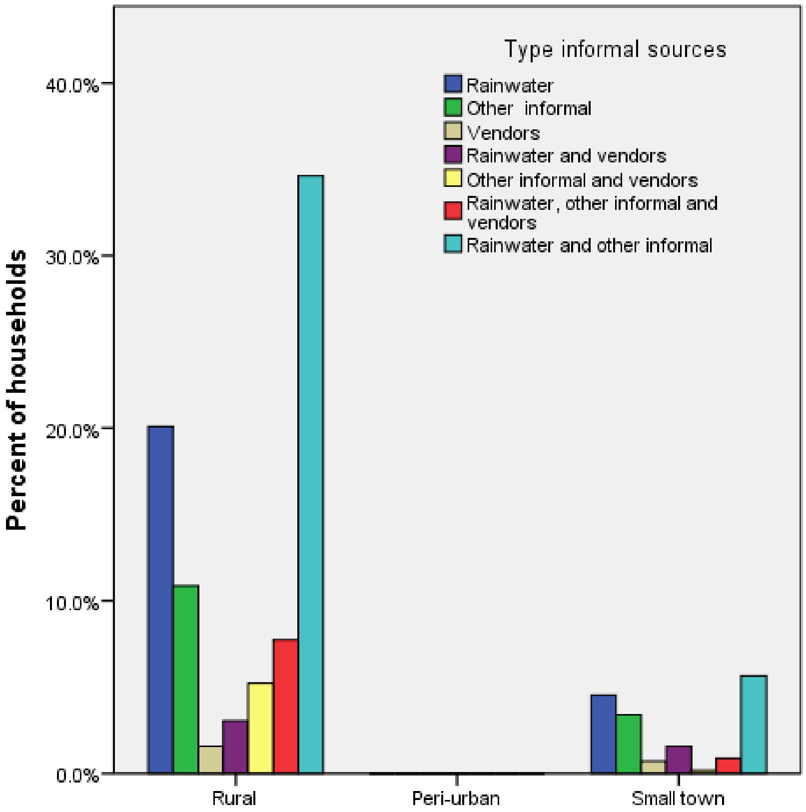


Figure 21 Informal sources in rural, peri-urban areas and small towns, Ghana

When analysing sources per socio-economic categories, there is less distinction in the Ghana sample compared with the Mozambique sample. Both the poor and non-poor access boreholes with hand pumps, public standpipes and additional informal sources. Yard standpipes and household connections are almost exclusively accessed by the non-poor (Figure 22).

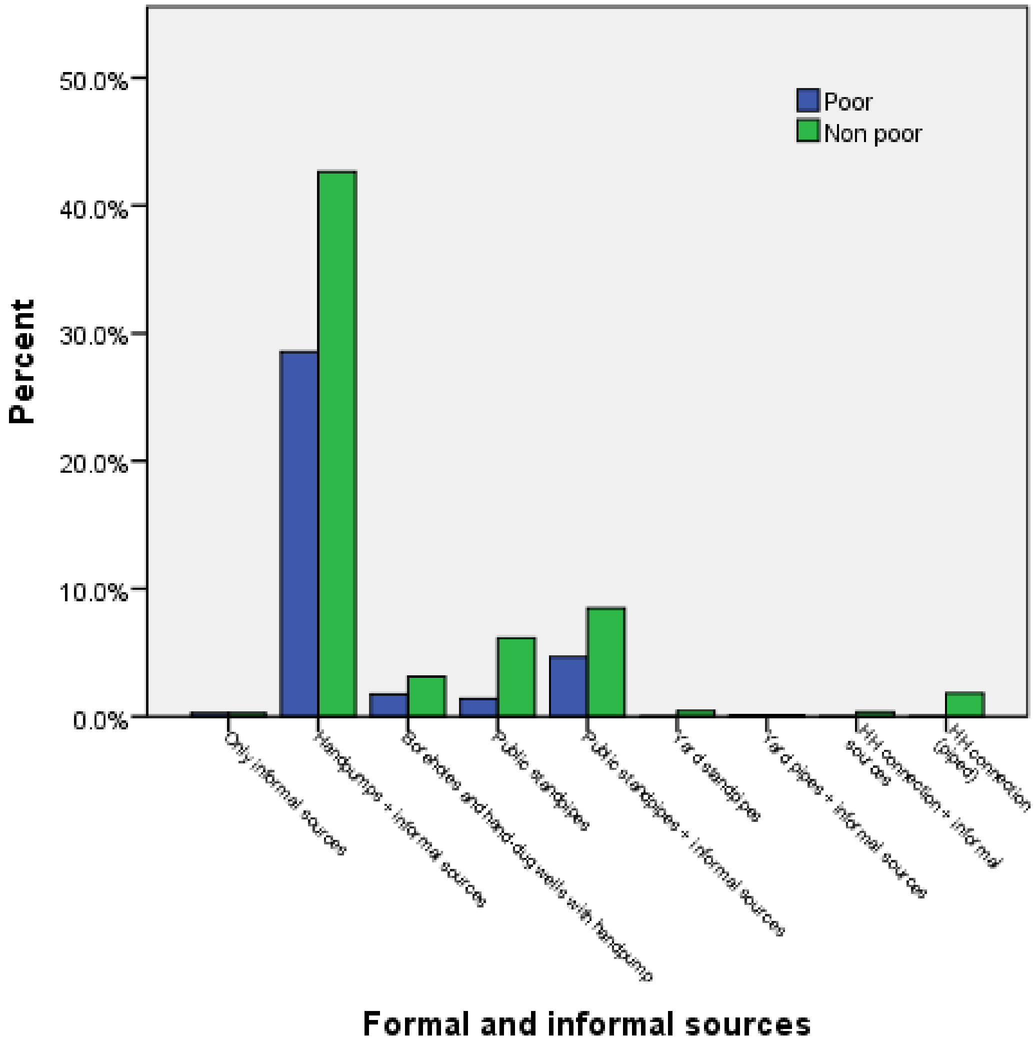


Figure 22 Formal and informal sources per poverty status Ghana

The main reasons for using the formal sources are proximity of the source to the household followed by perceived quality (Figure 23). The reasons for not using these formal sources relate to taste or because they are broken (Figure 24). The main reason for not using more informal sources is mostly because households are getting the desired quantity from existing sources (Figure 25).

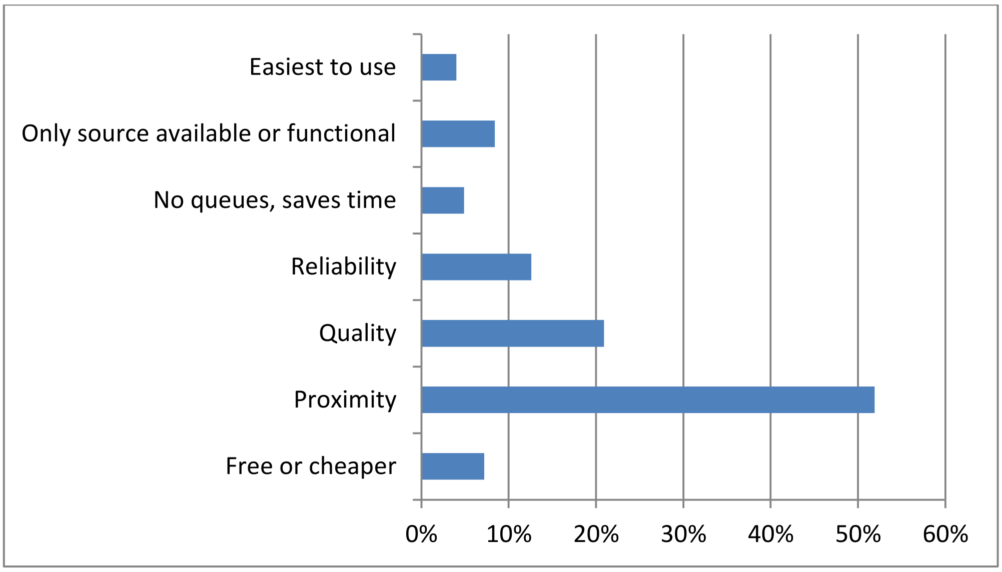


Figure 23 Reasons for using formal sources, Ghana

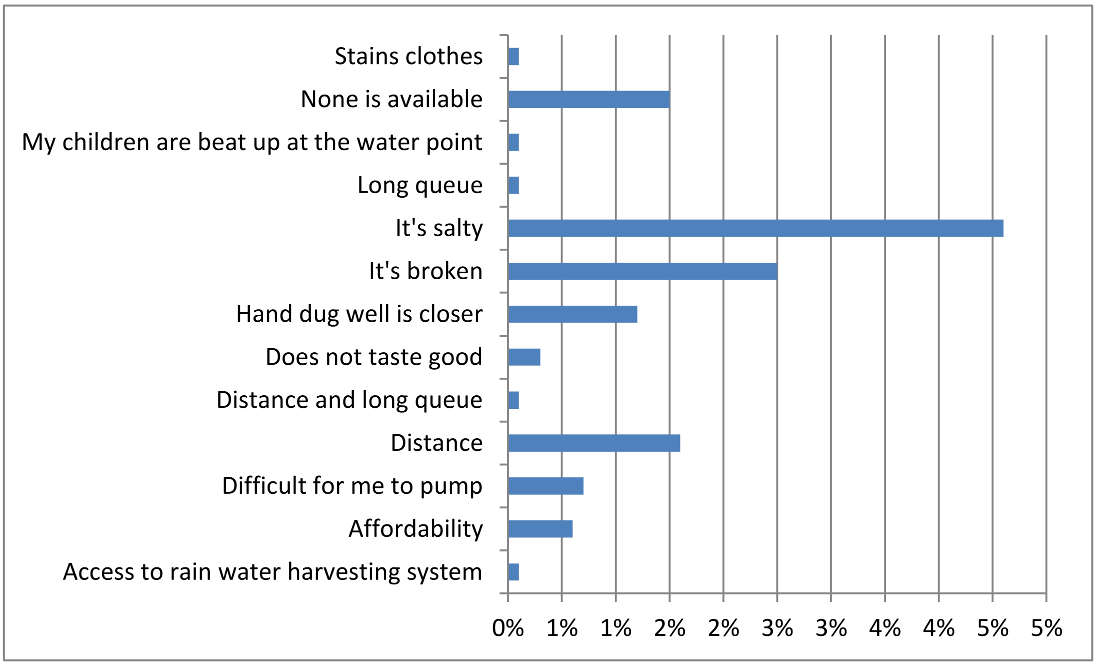


Figure 24 Reasons for not using formal sources, Ghana

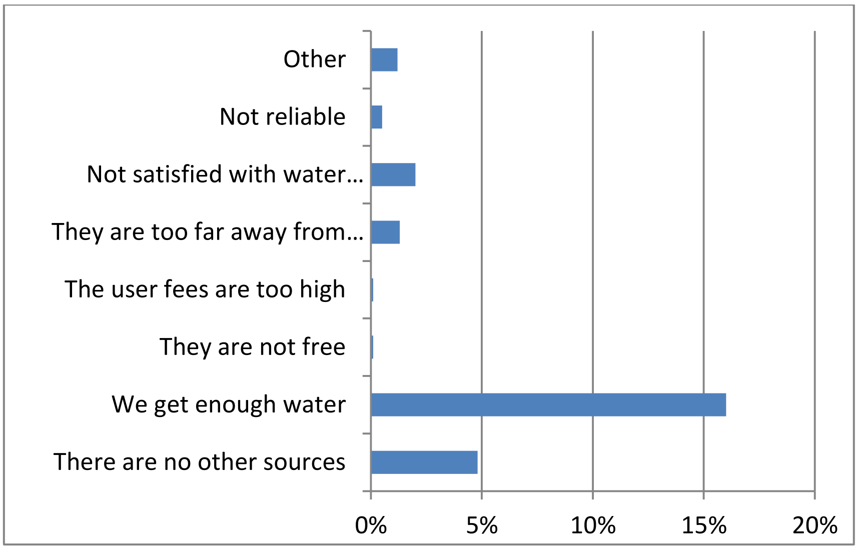
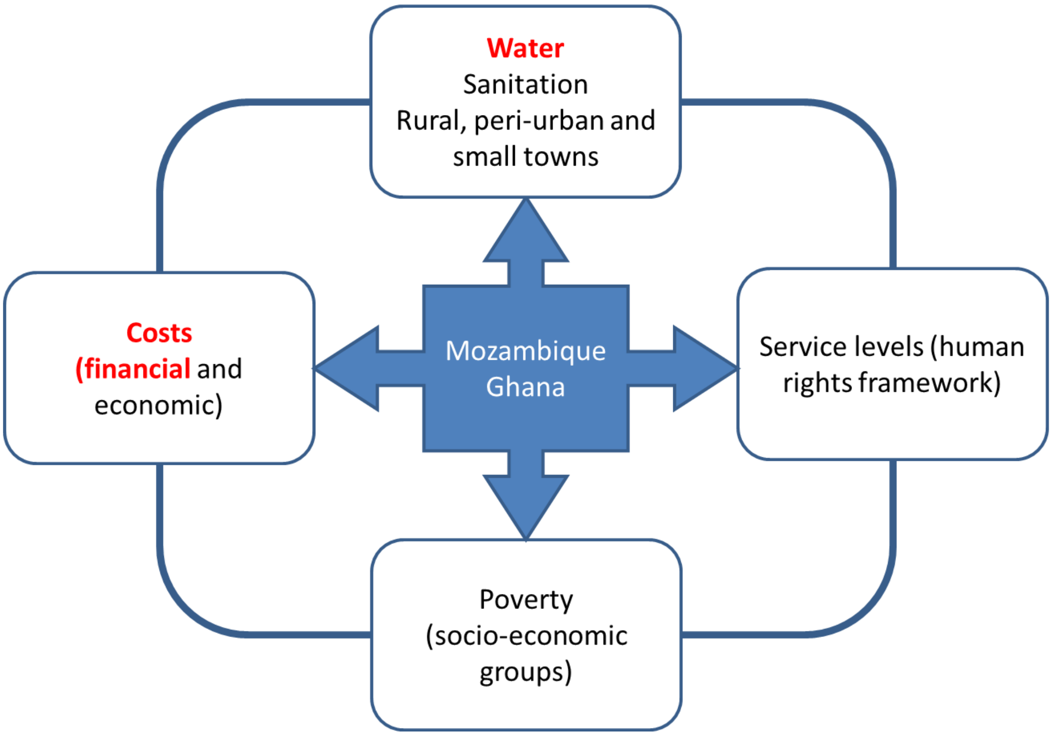


Figure 25 Reasons for not using informal sources, Ghana

5.3 Households financial expenditure and costs for accessing water

This chapter is key to answer the research question as it identifies the financial costs to households to reach their present level of water services in Mozambique and Ghana. It compares the findings from the two countries with the findings from the literature review and the cost benchmarks from WASHCost.



5.3.1 Comparison of the survey results in Ghana and Mozambique

Households in Mozambique and Ghana are accessing multiple formal and informal sources in the wet and dry seasons for multiple purposes: domestic uses and productive uses as well. Capturing the financial expenditure from households for all the sources met with different degrees of success.

In Mozambique the expenditure on the construction and maintenance of formal and informal water sources was captured both for the dry and the wet seasons. The payment of user charges in the form of tariffs to access water was not captured fully. These are limited to some peri-urban areas.

In Ghana, the costs paid to access water have been fully captured for formal and informal water sources, but the more random and smaller contributions to the water and sanitation committee for the construction and maintenance of the infrastructure was not disaggregated per household or captured in the household surveys. The findings presented will therefore need to take these limitations into account.

In Mozambique, one-off capital expenditure for the whole sample is US$0.5. CapEx for households living in rural areas which is lower than for households living in peri-urban areas ($0.43 and $6.70 USD 2011 prices per capita respectively). Expenditure for the construction of own facilities, such as yard taps, is higher than the contributions to the communal systems which are mostly boreholes with hand pumps and hand-dug wells. In Ghana, villages have to contribute a percentage of the costs required for the construction of infrastructure (up to 250 cedis or US$ 165 in the sample), but the specific amount that each household has contributed was not captured in the survey.

In Mozambique maintenance was reported at only US$.09 per person and not reported for Ghana. This means that one-off expenditure for major maintenance either did not take place in both countries or if it took place households have not contributed/reported the repairs. Given the interviews with the communities and the district officers both situations are happening in both countries. When the formal primary source is broken, which was reported by several households, other formal and informal sources are used to meet the required quantity per household until the formal source is repaired by the district officers or in some cases by trained water and sanitation committees.

Overall OpEx is US$ 1 and it is higher in rural areas ($1.25 USD 2011 prices per capita per year) when compared with OpEx in peri-urban areas ($0.90). This is partly explained by the annual operational expenditure with informal and unsafe sources for water treatment and paid transport (which is not taking place with the formal sources. The closer the primary source from the household, the higher are the number of roundtrips per source indicating that households are valuing proximity above quality and then, those than can, spending more on Opex for water treatment rather than accessing or paying for OpEx for communal boreholes maintenance (which are further away from the household).

In Mozambique, initial household investments in rainwater appear to diminish drastically as the households have more income, while investments in yard taps, unprotected (nearby) wells and household taps increase (Figure 26. Even though the sample is small (N=60), the poorest spend less on operational expenditure ($0.56) when compared with the poor ($0.9) and the least poor ($1.08).

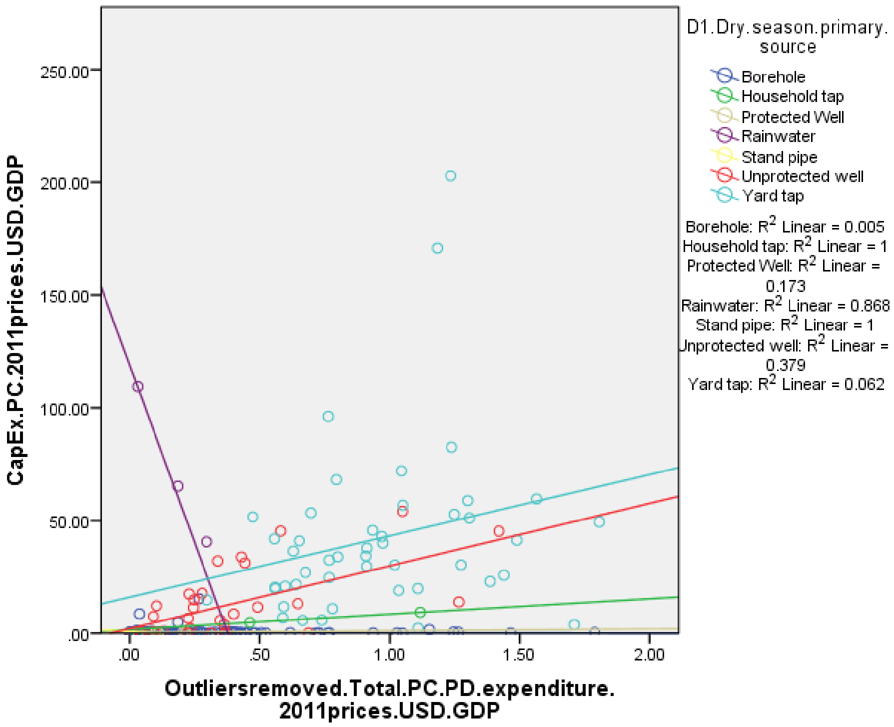


Figure 26 Capital Expenditure per primary water sources and household wealth status, Mozambique

In Ghana this analysis is not possible but may reflect a different model: capital expenditure is the responsibility of the Community Water Supply Agency and the district authorities which install externally funded formal sources (mainly boreholes with hand pumps for rural areas and public stand posts for peri-urban areas). Most households have to pay a fee to access these formal sources but also the informal sources in the peri-urban areas which include vendors. The fees are supposed to pay for the operators and for the minor maintenance of the formal sources and provide a return on capital to the private vendors.

In Ghana, the annual recurrent payments for water are higher in peri-urban areas (media $1.53 USD 2011 prices per capita per year) when compared with rural ($0.54) or small towns ($0.41). As mentioned in the sample description, the official small towns in Ghana are mostly more compact rural areas and the analysis confirms this assumption. The non-poor are spending more than the poor.

In both countries the opinion from households on the user charges and financial contributions towards the formal sources is very similar. The majority of households find them acceptable (Figure 27, Figure 28).

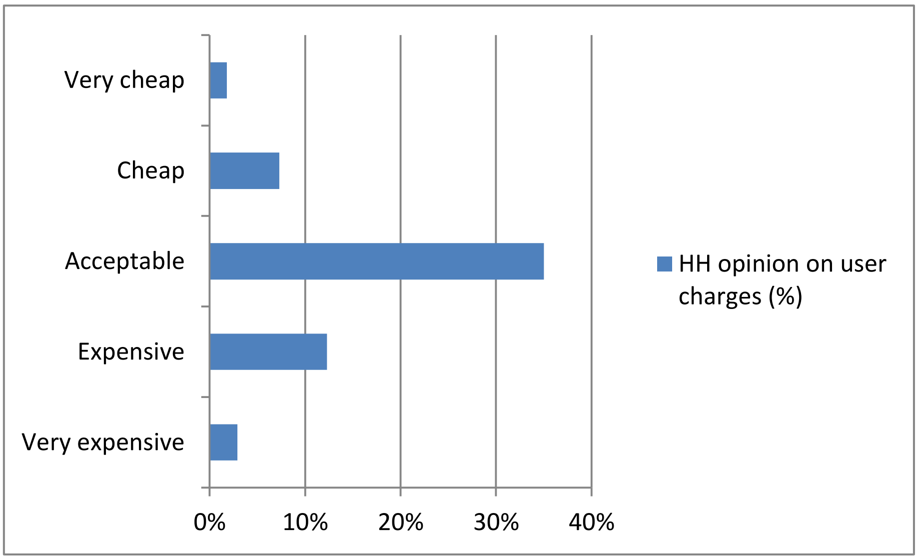


Figure 27 Households' opinion on user charges, Mozambique

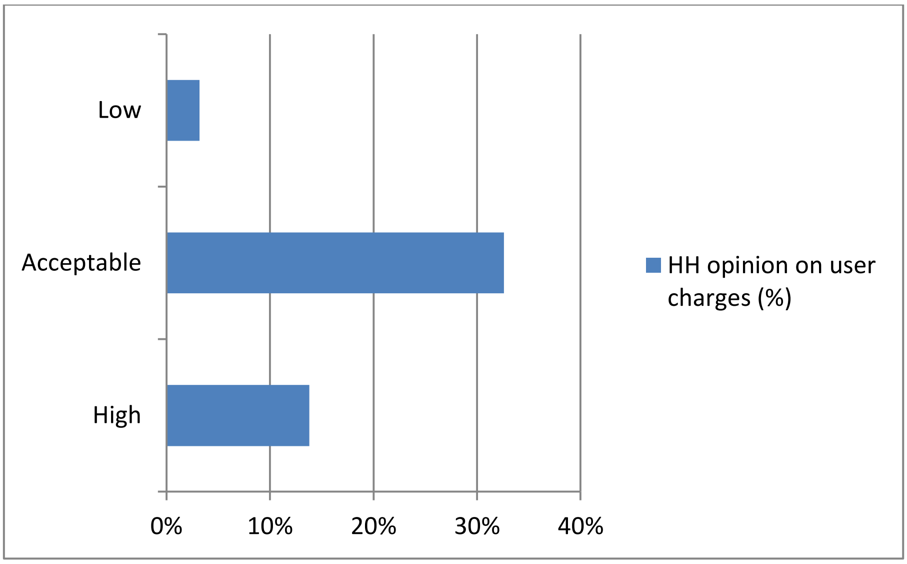


Figure 28 Households' opinion on user charges, Ghana

The first main set of conclusions therefore confirms hypothesis 2 for water services:

1) Low income rural households are paying for improved water;
2) Even within a very poor subset of the general population there are significant differences in the capital expenditure, operational expenditure and payments by the different socio-economic categories. The poor spend less than the non-poor. As will be seen in the service level analysis chapter, the services delivered are also higher for the non-poor. Small increments in household wealth are therefore having a large impact on the choices of where households collect their water, on the expenditure for water services and the quality of the services received and
3) Annual, recurrent operational expenditure (Mozambique) and user charges (Ghana) are higher for non-communal systems even if these are not formal systems. In other words, as income rises, households are paying and investing most in water sources closer to their homes and/or non-communal sources.

There are several papers which have concluded that the household choices for improved water sources increase with income and household expenditure (as well as education level) (Madanat and Humplick 1993; Larson, Minten, and Razafindralambo 2006; Nauges and Strand 2007; Nauges and Whittington, 2009).

The confirmation of hypothesis 2 has serious implications for models and approaches to service delivery for rural areas which are based on the provision of communal boreholes with hand pumps and which are dependent on household contributions towards maintenance. In these models, sustainability is based on the assumption that as long as communities have been involved in the construction of the handpump and trained in their maintenance, they will feel "ownership" and take care of the infrastructure.

The sample data analysed shows that although communal boreholes and hand pumps are often the primary (and only) formal sources, as soon as other sources are available nearby, even if of poorer quality and higher cost, households will choose them, favouring proximity. As wealth increases, payment for water provision through a communal borehole with handpump does not increase because households will prefer other sources (Figure 29). Besides proximity, time spent queuing is very high for the communal sources in both countries (chapter 5.4). There is another aspect that supports hypothesis 2: the expenditure from the households in Mozambique that reported having their own individual sources, known in the sector as "self-supply". The 85 households in Mozambique that reported self-supply had spent US$ 11.78 on capital expenditure (median, USD 2011 prices per capita) which is much higher than the median for the whole sample (US$ 0.5) but then were spending less (US$ 0.78) than the overall sample on operational expenditure (US$1).

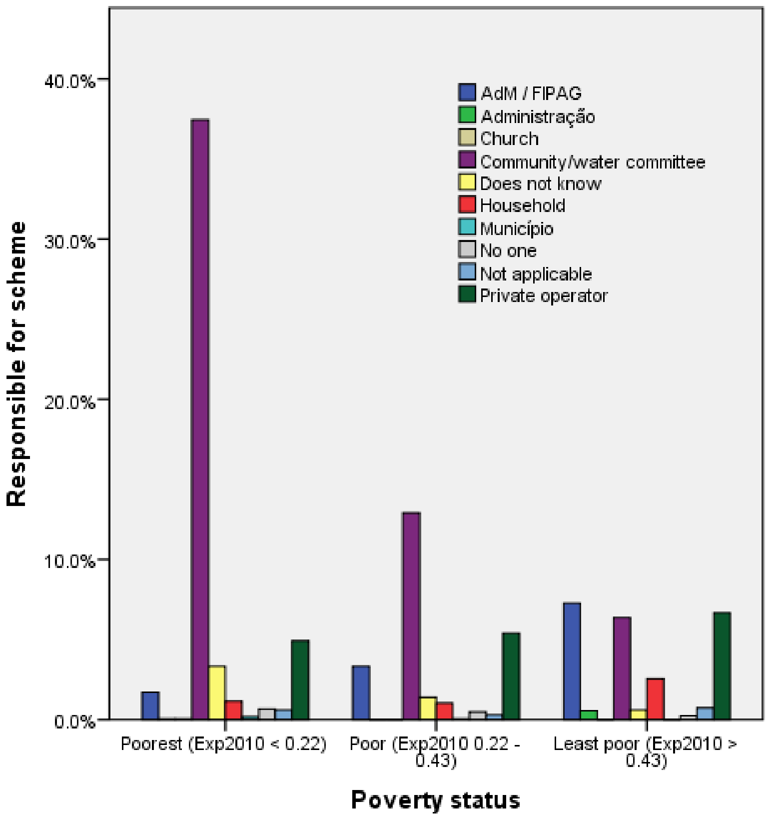


Figure 29 Responsibility for main water source per poverty status, Mozambique

5.3.2 Comparison of survey results with the grey literature on financial costs

Household capital expenditure in Mozambique can be compared with the costs collected in the grey literature (chapter 4.1) and with the WASHCost benchmarks. In WASHCost, calculations were made for cost benchmark using data from four countries (including Ghana and Mozambique, Table 42). The calculations include only the costs to build and maintain facilities which are providing a "basic" or above, level of service (Burr and Fonseca, 2012).

Table 42 WASHCost benchmarks for water

Cost component	Primary formal water source	Cost ranges in US$2011 per person
Total capital expenditure	Borehole and handpump	20-61
	Small piped schemes (serving less than 500 people) or medium schemes (serving 500-5000 people) including mechanised boreholes, single-town schemes, multi town schemes and mixed piped supply	30-131
Operational and minor maintenance expenditure (per year)	Borehole and handpump	0.5 – 1
	All piped schemes	0.5 - 5

Source: Fonseca and Burr, 2012.

The results and comparisons are shown in Table 43 (in US$ GDP) and Table 44 (in US$ PPP). The advantage of the GDP analysis is that is presents the costs as they have been incurred by the families in Ghana and Mozambique. The PPP is being mainly used for checking the influence or impact of currency valuation and devaluation on costs when international comparisons are made.

For investments that rely mostly on the household expenditure such as rainwater harvesting and yard taps, the data collected from Mozambique is within the WASHCost benchmarks. However, for communal systems that are paid by other sources such as boreholes with hand pumps and standpipes the household expenditure reflects only a small part of the overall cost. For the household tap connections the expenditure reflects the connection to the main piped system where the overall cost is not burdened on the households.

Table 43 Capital expenditure water comparison (US$ GDP 2011)

	Total capital expenditure (per person)		Household capital expenditure (per person)	
	WASHCost benchmarks	Grey literature review (N)	Mozambique median (N)	Ghana median (N)
Rainwater harvesting	NA	16-167 (6)	52.9 (11)	NA
Unprotected well	NA	5-89 (8)	7.47 (310)	NA
Borehole and handpump	20-61	3-102 (22)	0.22 (664)	NA
Small and medium piped schemes	30-131	30-267 (11)	0.13 (236) Standpipe 34.09 (71) Yard tap 9.30 (4) HH tap	NA

The analysis done using the purchasing power parity shows that the financial costs across all the water sources is lower than the benchmarks (Table 44) but the main reason to use the PPP is to make comparisons among countries which in this case is not possible.

Table 44 Capital expenditure water comparison (US$ PPP 2011)

	Total capital expenditure (per person)		Household capital expenditure (per person)	
	WASHCost benchmarks	Grey literature review (N)	Mozambique median (N)	Ghana median (N)
Rainwater harvesting	NA	47-356 (6)	21.18 (11)	NA
Unprotected well	NA	5-89 (8)	3.04 (310)	NA
Borehole and handpump	20-61	3-238 (22)	0.08 (664) 3.04 (310)	NA
Small and medium piped schemes	30-131	64-268 (11)	0.04 (236) Standpipe 11.12 (71) Yardtap 3.42 (4) HH tap	NA

The same comparisons with the grey literature and the WASHCost benchmarks were done for the household expenditure on minor maintenance (OpEx) for Mozambique and for the recurrent household payments in Ghana.

The grey literature review with operational costs is based on a very small sample. The amounts in the literature are lower than the WASHCost benchmarks for boreholes and handpump. The OpEx for small pipes systems in the grey literature is within the WASHCost benchmarks but it is slightly higher for medium piped schemes.

Using the GDP USD (Table 45) the household expenditure is within the WASHCost benchmarks, which is not surprising since the operational expenditure in Mozambique is being supported in its totality by households. The interesting finding is that the household payments to access water in Ghana are within the WASHCost benchmarks and lower than the OpEx being paid in Mozambique. Households in Ghana are paying less for accessing a similar or better service which is provided through a payment system. Using the PPP USD (Table 46), the Mozambique OpEx is even more expensive than the regular payments of households in Ghana.

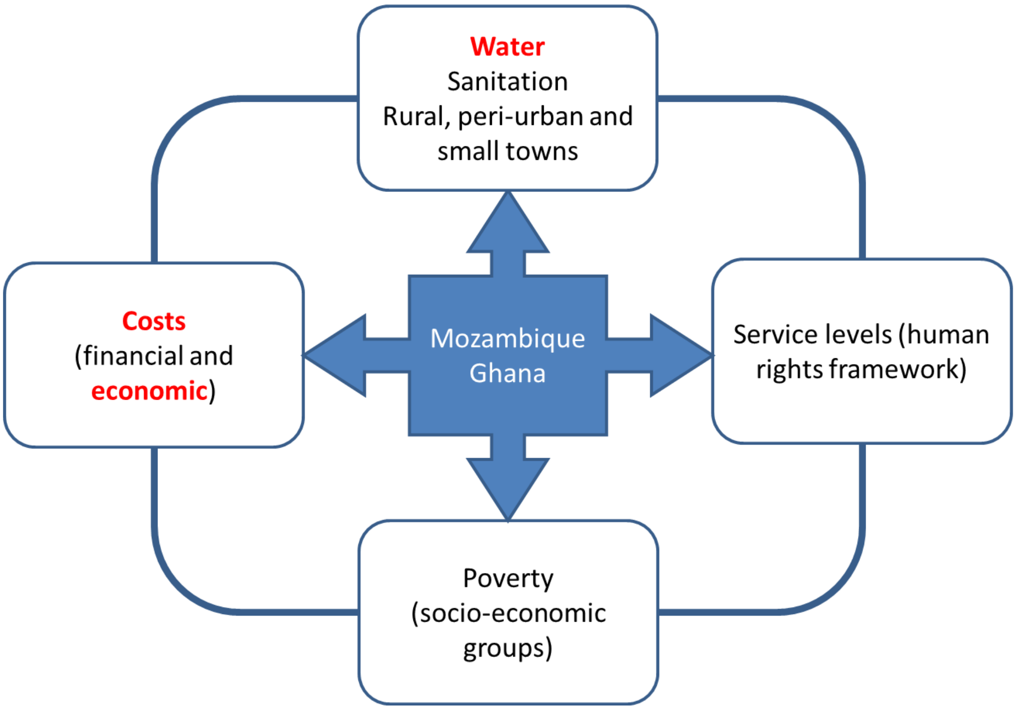
Table 45 OpEx & water payments US$ GDP 2011 (median per person, per year)

	OpEx		HH OpEx	HH payments
	WASHCost	Grey literature (N)	Mozambique (N)	Ghana (N)
Rainwater harvesting	NA	0.5-2.4 (4)	NA	NA
Unprotected well	NA	0.2-0.6 (3)	1.3 (310)	NA
Borehole and handpump	0.5 – 1	0.2-0.3 (4)	0.91 (664)	0.54 (1032)
Small and medium piped schemes	0.5 – 5	0.6-1.2 (3) Small 2.5-16.8 (4) Medium	1 (236) Standpipe 0.91 (71) Yard tap	.45 (266) .45 (7)

Table 46 OpEx & water payments US$ PPP 2011 (median per person, per year)

	OpEx		HH OpEx	HH payments
	WASHCost	Grey literature (N)	Mozambique (N)	Ghana (N)
Rainwater harvesting	NA	0.5-5.1 (4)	NA	NA
Unprotected well	NA	0.2-0.6 (3)	2.38 (310)	NA
Borehole and handpump	0.5 – 1	1.2-0.8 (4)	1.67 (664)	1 (1032)
Small and medium piped schemes	0.5 – 5	0.6-1.2 (3) Small 5.4-16.8 (4) Medium	1.83 (236) Standpipe 1.67 (71) Yard tap	.83 (266) .83 (7)

5.4 Household economic costs on water supply



This chapter attempts to answer the final sub-question of the research and identify the non-financial contributions (time and in-kind) of households to reach their present level of water services and compare with findings from the literature review.

The household survey was not designed to collect economic costs. For the economic cost analysis it was only possible to cost the time that households spend per round trip, including queuing. It was not possible to value the in kind contributions or the times spent digging during the construction of the water systems (Photo 13).

In Mozambique, the median time per round trip including queuing to access the primary formal source in the dry season is 60 minutes, in Ghana it is 24 minutes only for accessing the formal sources. In Mozambique the median across all sources, formal and informal, is 31 minutes. The poor spend more time than the non-poor collecting water in both countries because their main sources are communal sources which are further away or more crowded.

Photo 13 Community contributes to digging a piped scheme, Mozambique.

Photo credit: Catarina Fonseca

In Mozambique there are considerable time savings (45-60 minutes) when accessing non-communal formal sources such as yard taps and neighbours taps (Figure 30). In Ghana the time savings are up to 35 minutes per trip for those that use boreholes with hand pumps compared with the households using public standpipes (Figure 31).

Churchill et al, (1987) has reported that in Mozambique, time savings resulting from new wells averaged 1.75 hours a day (approximately half of the former hauling time from rivers and ponds). It can be seen above that the time can be even further reduced once households access water closer to their homes.

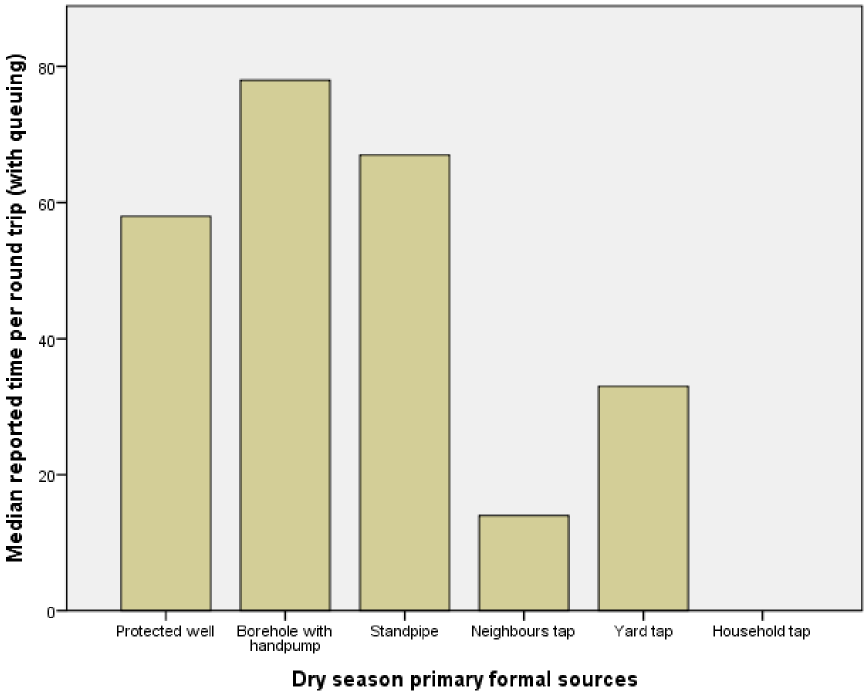


Figure 30 Median time spend per round trip, formal primary sources, Mozambique

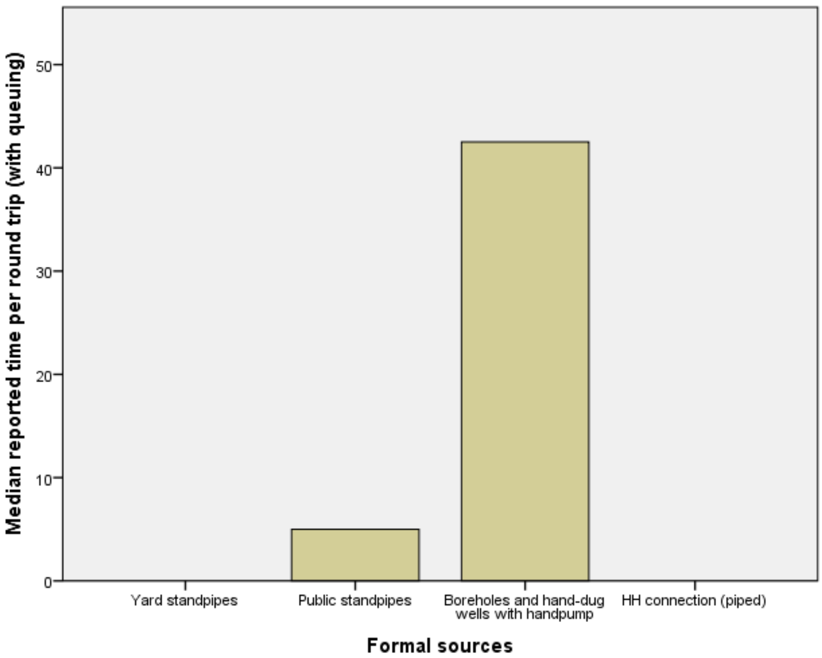


Figure 31 Median time spend per round trip, formal sources, Ghana

In both countries, queuing is mostly experienced in the communal sources: boreholes and hand-dug wells with hand pumps and public standpipes and therefore correlated with rural and small-towns respectively (Figure 32, Figure 33).

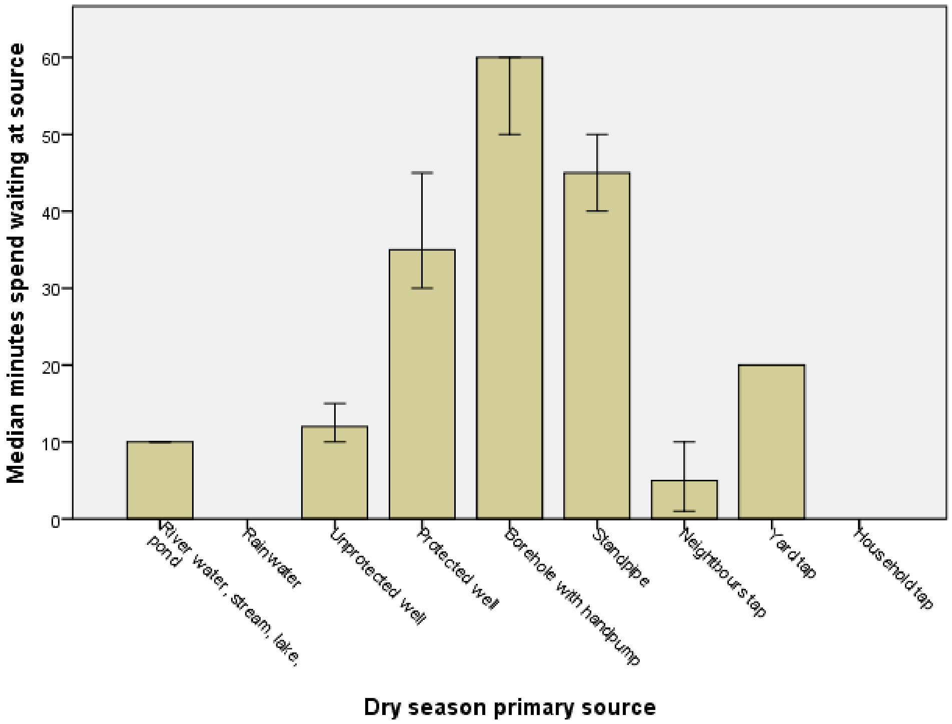


Figure 32 Minutes (median) spent waiting per primary source in the dry season per trip, Mozambique

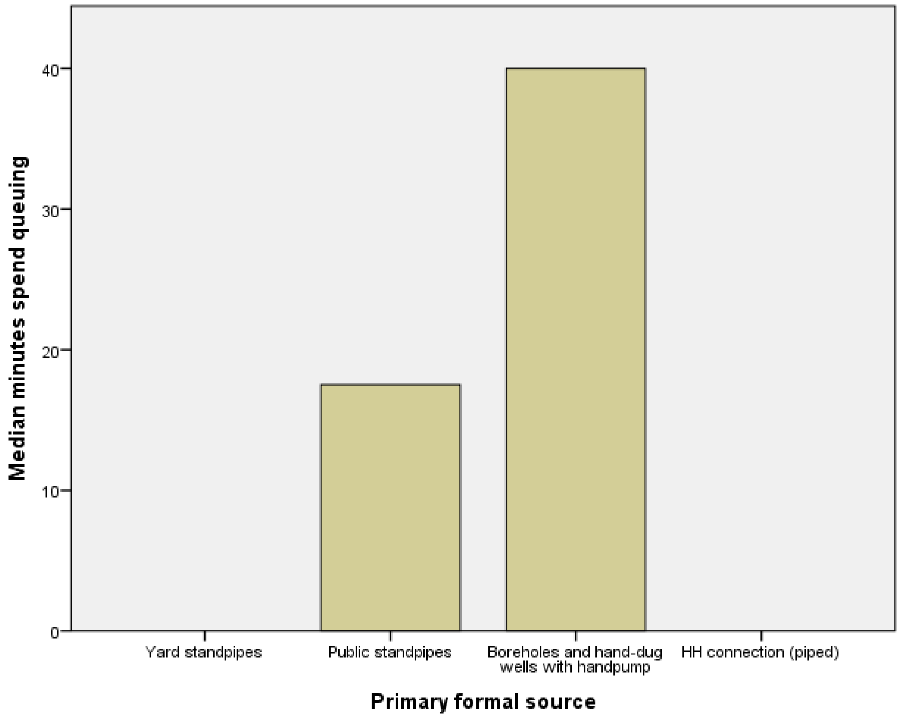


Figure 33 Minutes, (median) spent queuing for formal sources, Ghana

The final step for valuing time took into consideration the lower and upper values described in chapter 4.5.2. Reporting on the time per household per day is more reflective of the fact that it's the same person collecting water for the household and therefore her time needs to be costed fully. Even if in Mozambique the cost of time is lower, because households travel and wait longer when compared to Ghana, the amounts are higher.

Table 47 Economic cost of time spend per household per round trip for accessing formal water sources US$ 2010

	Per household/ day Mozambique (N valid = 1113)		Per household/roundtrip/day Ghana (N valid = 204)	
	Lower band	Upper band	Lower band	Upper band
Mean	$.18	$.28	$.06	$.12
Median	$.14	$.22	$.03	$.07
Standard deviation	.185	.289	.07	.14

When a monetary value is applied to the time spent, to calculate the economic costs per water source, household contributions increase slightly but do not change the results dramatically (Table 48).

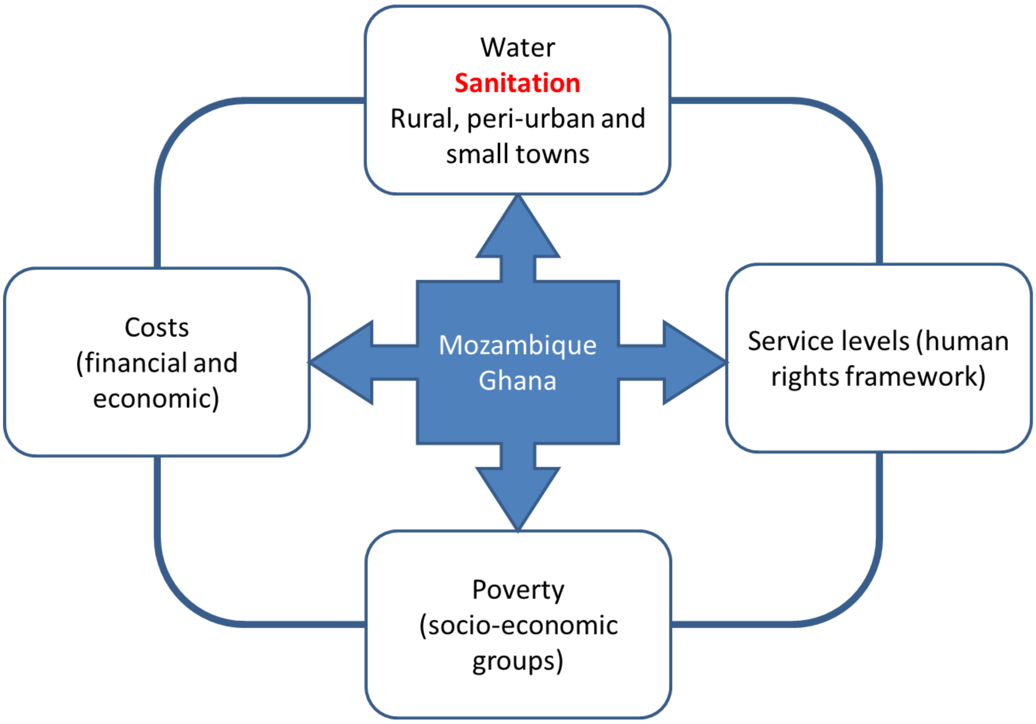
Table 48 Economic cost (time) added to regular expenditure and water payments comparison US$ GDP 2011 (median per person, per year)

	Mozambique HH time	Ghana HH time
Rainwater harvesting	.13	NA
Unprotected well	.17	NA
Borehole and handpump	.28	.12
Small and medium piped schemes	.27 Standpipe .32 Yard tap	.01

Churchill et al. (1986) mention that “when the value of time is taken into account, the rural poor of Africa and Asia are paying prices for water that are many times higher than what is being paid by their urban counterparts in both the developing and developed world” p73. The results from the analysis of the survey contradict this statement. This might result from the choice of values to cost household time. In economies where there are no monetary alternatives to women and children’s time, improvements in water services will bring above all more convenience and well-being.

5.5 Access to sanitation facilities

Similar to the water analysis in the previous chapters, the dataset for sanitation was analysed to answer the main research question in terms of access, service levels and costs to households.



5.5.1 Mozambique

In Mozambique, the vast majority of households (almost 90%) disposed of their excreta in what are considered unsafe sources (WHO/UNICEF, 2000), although many of those households separated the excreta using traditional pit latrines which are built by digging a hole in the ground surrounded by a sort of wall made of local materials (Photo 14). The traditional latrines walls are in the majority made of bamboo, reed or palm. A few (18) traditional latrines in the sample were observed not to have a fence. The walls of the toilets with septic tanks and the VIP latrines are built mostly with cement blocks (Photo 5). The improved traditional latrines also use cement or adobe blocks and some (19) use zinc sheets.

Most of the latrines considered safe are located in peri-urban areas. The 10 toilets with septic tanks using piped water and the 19 VIP latrines are exclusive to peri-urban areas. 12% of the households shared their facilities mostly with 2 or 3 families. Open defecation was also prevalent in peri-urban areas.

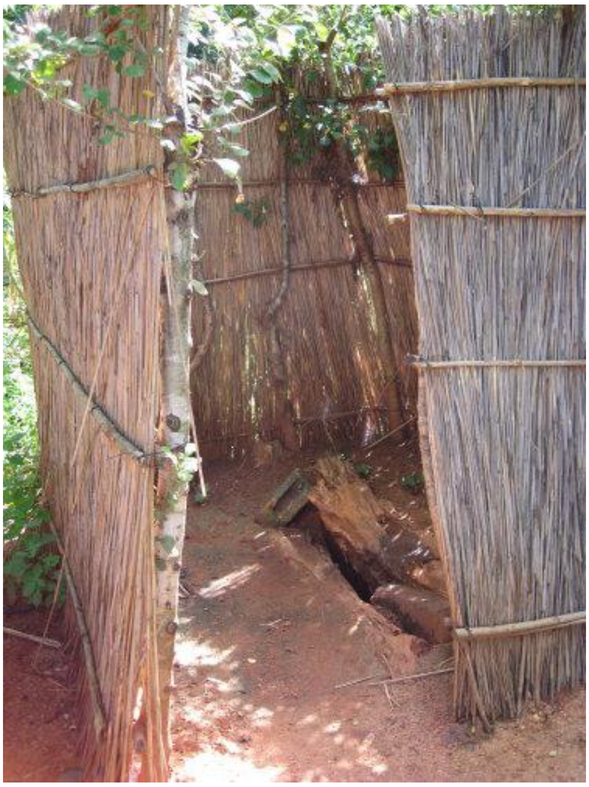


Photo 14 A traditional pit latrine in Mozambique.

Photo credit: Peter McIntyre

Photo 15 A VIP latrine in Mozambique, defined as having a ventilation shaft, ideally with a fly protector mesh on top

Photo credit: Arjen Naafs

There is a correlation between socio-economic categories and sanitation access. The poorest households in the sample use the unsafe sanitation latrines rather than improved latrines (Figure 34).

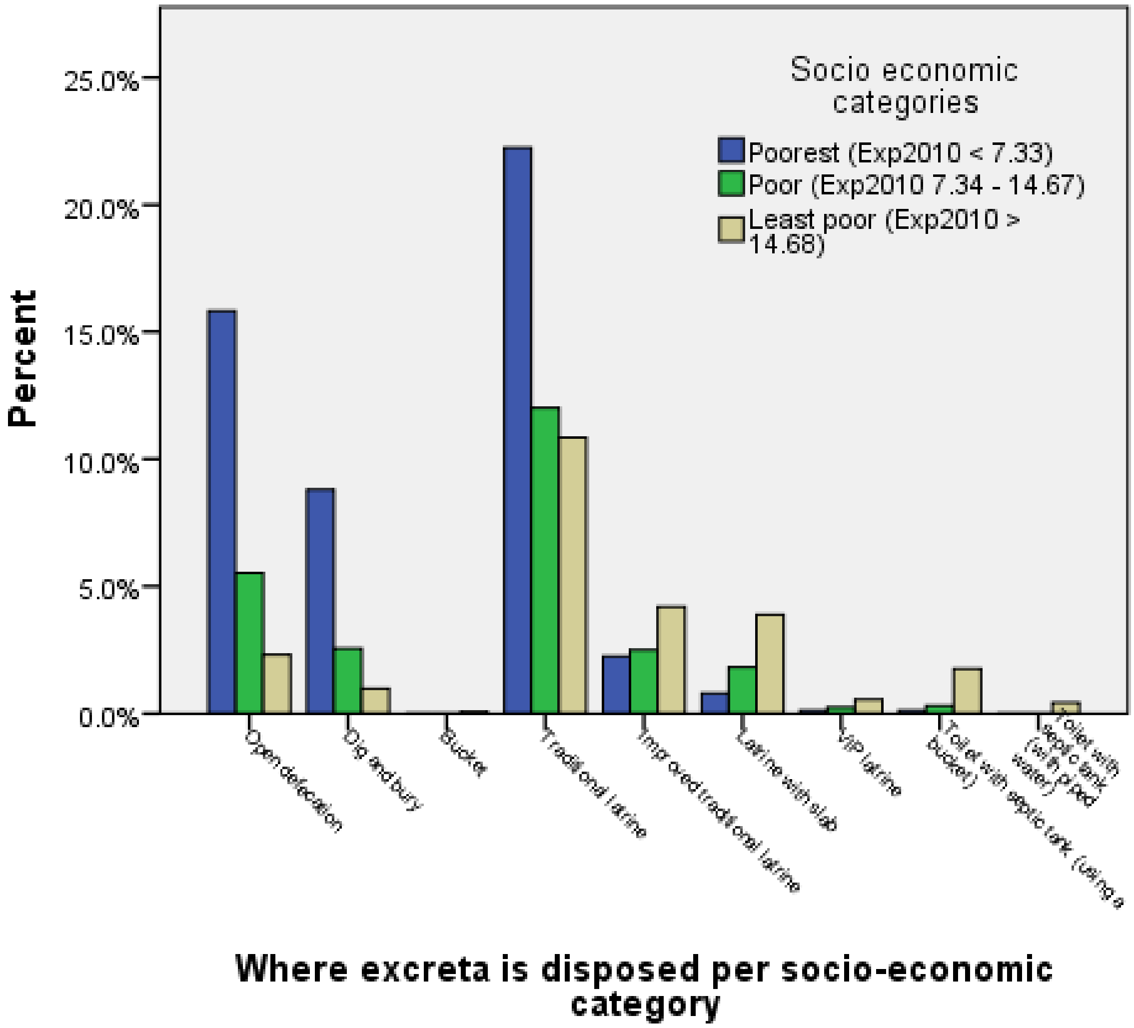


Figure 34 Excreta disposal per socio-economic category, Mozambique

5.5.2 Ghana

Estimates show that the wealth of households in Ghana continues to increase and is generally higher than in Mozambique. Nevertheless, a large majority of households in the sample does not have an a toilet (36%) but accesses either shared facilities or more "sophisticated" improved latrines which include VIP latrines, the Kumasi Ventilated Improved Pit and toilets with septic tanks. From those that access a facility for disposal of excreta, the most traditional facilities are located in rural areas, but can be equally found in small-towns and peri-urban areas (Figure 35). Twenty three respondents have reported not using their toilets, at closer analysis these are mostly VIP latrines (15) followed by traditional pit latrines (4).

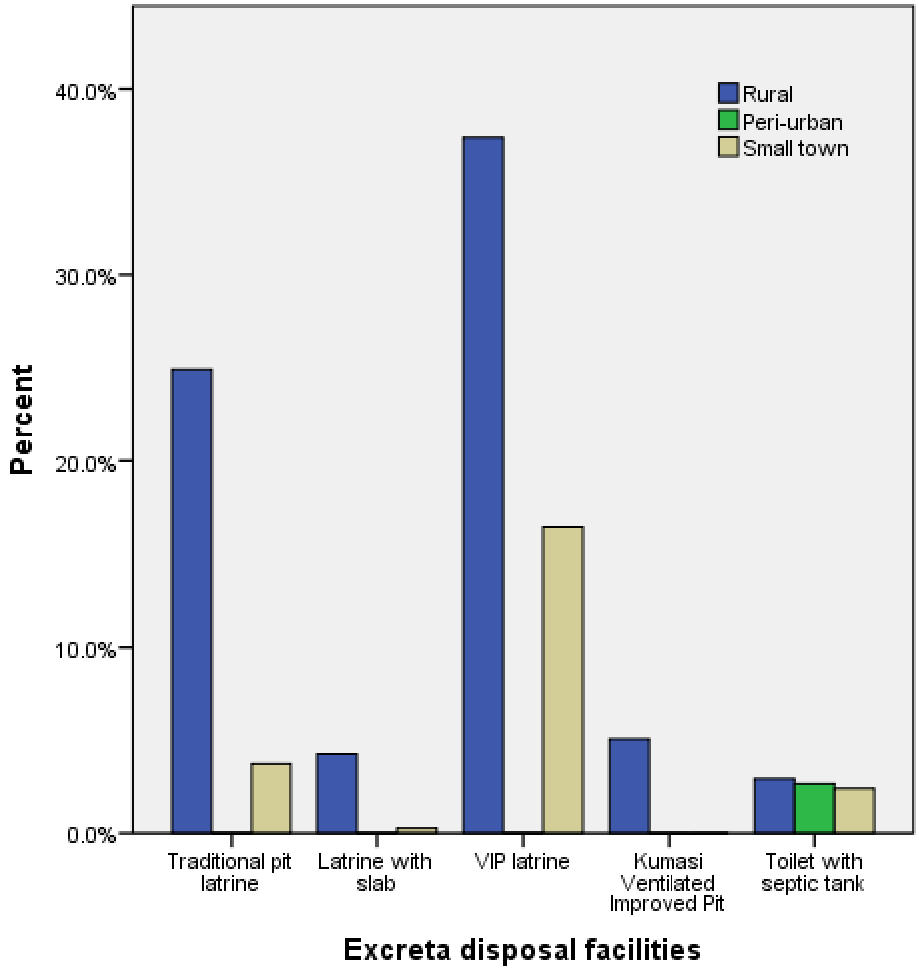


Figure 35 Excreta disposal facilities

There is a high number of respondents which report accessing public toilets. These are also located in rural areas where most of the times there are no public facilities or they are not accessed every time when needed. Because of the lack of the reliability of this data, these facilities, in line with international standards (WHO/UNICEF, 2000) will be considered unsafe.

The main reasons for households not building or using toilets include lack of affordability for the construction and because it's free to defecate in the open. Other reasons include no public toilet available or lack of comfort in the public toilet (Figure 36).

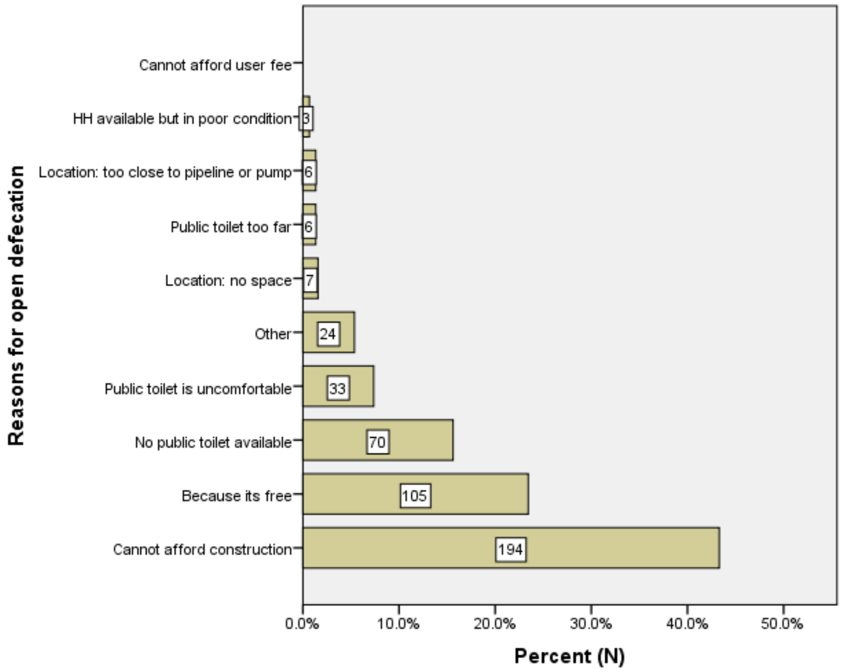


Figure 36 Reasons mentioned for not accessing toilets or latrines

The access to toilets by different socio-economic categories is not so marked as in Ghana. Nevertheless, it is the non-poor that access the most sophisticated Kumasi Ventilated Pit and the toilet with septic tanks (Figure 37).

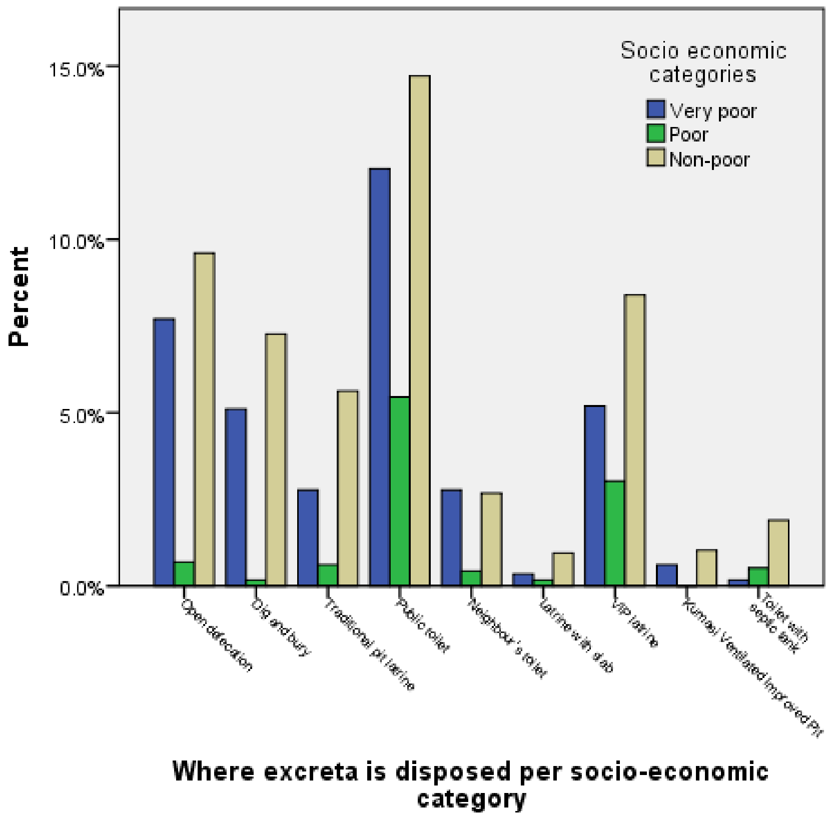
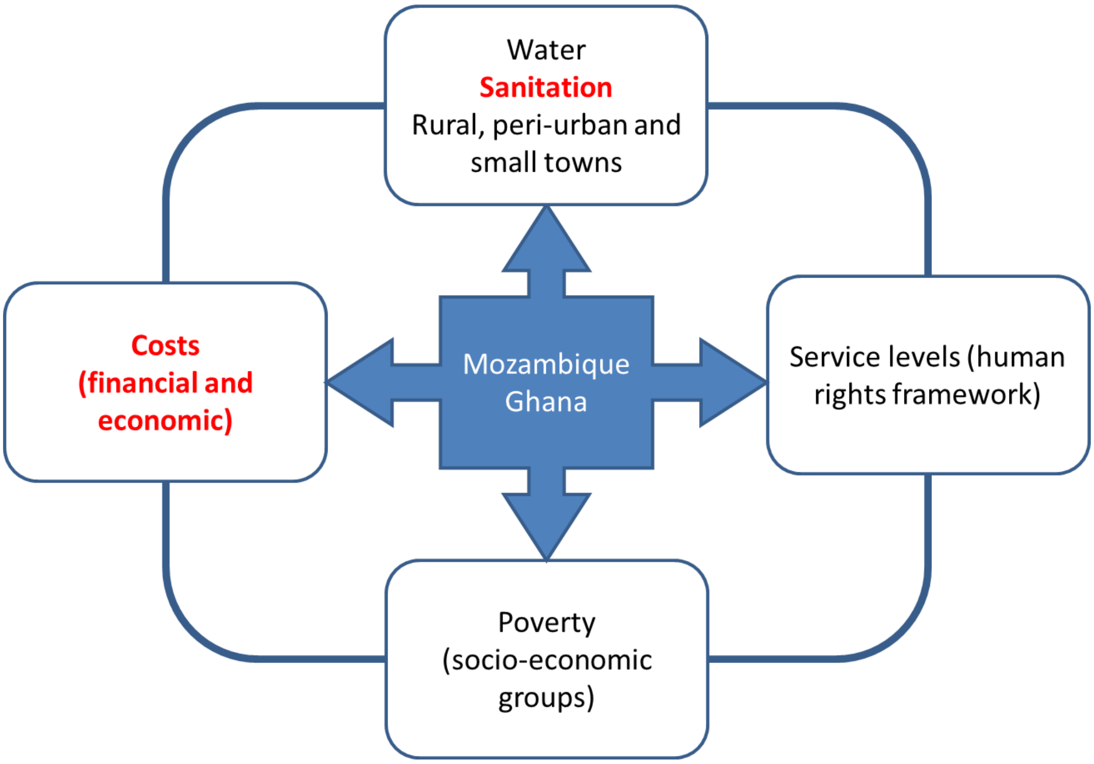


Figure 37 Excreta disposal per socio-economic category Ghana

5.6 Household financial and economic costs on sanitation

This chapter analyses the financial and economic costs to access sanitation services in Mozambique and Ghana to answer the research question. It compares the results with the literature findings and WASHCost benchmarks.



5.6.1 Capital expenditure

Household capital expenditure (calculated in total per person) for building latrines is generally higher in Ghana (median US$ GDP 17.06 / PPP 20.45) when compared with Mozambique (median US$ GDP 5.72 / PPP 9.31) this is mainly because the facilities in Ghana are being constructed with more robust materials (latrines with slabs, cement walled VIP latrines, Kumasi VIP latrines, etc.) compared with the sticks and clay of the traditional Mozambique latrines which mostly do not have a slab. The exception is the cost of the latrines with septic-tanks which are more costly in Mozambique than in Ghana.

The majority of the families in Mozambique that build traditional pit latrines used their own labour and materials which are not captured through financial transactions. However, since the question on time spent in construction and materials was not asked in the Ghana survey, no economic comparisons are possible.

Household capital costs for sanitation can be compared with the costs collected in the grey literature (chapter 4.1) and with the WASHCost benchmarks. In WASHCost, calculations were made for cost benchmark using data from four countries (including Ghana and Mozambique, Table 49). The calculations include only the costs to build and maintain facilities which are providing a "basic" or above, level of service (Burr and Fonseca, 2012). The results and comparisons are shown in Table 50 (US$ GDP) Table 51 (US$PPP).

For traditional pit latrines with impermeable slabs, the household expenditure in both countries is higher than the literature review and the WASHCost benchmarks. The benchmarks were built with the Mozambique and Ghana dataset but included also many data points for latrines in India which tend to be cheaper in $US GDP conversions. The household expenditure for pit latrines with impermeable slab, VIP types and septic-tank latrines are within the WASHCost benchmarks and the literature review. It narrows the ranges.

Table 49 WASHCost benchmarks for sanitation

Cost component	Latrine type in area of intervention	Cost ranges* [min-max] in US$ 2011
Total capital expenditure (per latrine)	Traditional pit latrine with an impermeable slab (made often from local materials)	7-26
	Pit latrine with a concrete impermeable slab, or VIP type latrine with concrete superstructures (with ventilation pipe and screen to reduce odours and flies)	36-358
	Pour-flush or septic-tank latrine, often with a concrete or brick-lined pit/ tank with sealed impermeable slab, including a flushable pan	92-358
Total recurrent expenditure** (per person, per year)	Traditional pit latrines with an impermeable slab (often made from local materials)	1.5-4.0
	VIP type latrines	2.5-8.5
	Pour-flush or septic-tank latrines	3.5-11.5

Source: Fonseca and Burr, 2012.

Table 50 Capital expenditure sanitation comparison (US$ GDP 2011)

	Total capital expenditure (per facility)		Household capital expenditure (per facility)	
	WASHCost benchmarks	Grey literature review (N)	Mozambique median (N)	Ghana median (N)
Traditional pit latrine with impermeable slab	7 – 26	26 (27)	54 (160)	76 (107)
Pit latrine with impermeable slab or VIP type	36 – 358	49 (10) rural 162 (4) urban	38 (115) – 100 (19)	50 (17) – 130 (203)
Pour flush or septic-tank latrine	93 – 358	69 (7) pour flush 144 98) rural 183 (4) urban	138 (40) - 201 (10) mainly peri-urban	86 (30) rural, peri-urban and small towns

The economic expenditure in Mozambique on labour and materials to build traditional pit latrines in rural low-income areas in Mozambique is estimated to be US$ 19 per household (US$ 3.8 per capita) per facility which would bring capital expenditure close to the Ghana expenditure. No data is available for maintenance related economic expenditure and no data at all on economic expenditure is available for Ghana.

The analysis using purchasing power parity shows that the currency in Mozambique has devalued more than the Ghanaian currency in relation to the dollar (in the last few years the opposite is happening but the dataset and calculations are prior to the significant inflation levels felt over the last two years in Mozambique). The costs are then generally higher for Mozambique when compared with Ghana as well as much higher than when compared with the grey literature review costs in US$ PPP (which suffers from methodological problems and therefore comparisons based on absolute amounts is questionable).

Table 51 Capital expenditure sanitation comparison (US$ PPP 2011)

	Total capital expenditure (per facility)		Household capital expenditure (median per facility)	
	WASHCost benchmarks	Grey literature review	Mozambique (N)	Ghana (N)
Traditional pit latrine with impermeable slab	7 – 26	27 (17)	95 (160)	90 (107)
Pit latrine with impermeable slab or VIP type	36 – 358	58 (10) rural 218 (4) urban	69 (115) – 183 (19)	60 (17) – 156 (203)
Pour flush or septic-tank latrine	93 – 358	73 (7) pour flush 181 98) rural 313 (4) urban	253 (40) – 368 (10)	104 (30)

5.6.2 Recurrent expenditure

The same analysis has been done for the recurrent expenditure (Table 52, Table 53). In Ghana no capital maintenance expenditure was reported on desludging, replacement of vent pipes or repairing the concrete slabs and operational expenditure is very small per person and much lower than the benchmarks or the grey literature review. However, in Ghana the amount per person per year expenditure on accessing public latrines (93 respondents) is US$ 6.57 (median) which is higher than the maintenance costs of own latrines and comes closer to the maintenance costs of the more sophisticated facilities in Mozambique. This amount is roughly US$ 0.02 per day which is a very small proportion of the extreme poverty line in Ghana.

Mozambique household's operational and maintenance expenditure are within the WASHCost benchmarks and the literature review except for the VIP latrines which show a higher maintenance requirement per person, per year.

In general, it can be noted that the capital maintenance, even though it is smoothed out per year (actually occurring in peaks, to replace a slab or to de-sludge a full pit) is as high or higher than the required minor operational maintenance, with exception of the traditional pit latrine in Mozambique, where most of the labour and materials are contributed by the households.

Table 52 Recurrent expenditure sanitation comparison US$ GDP 2011

	Recurrent expenditure (per person, per year)		HH recurrent expenditure (median per person, per year)	
	WASHCost benchmarks	Grey literature review (N)	Mozambique (N)	Ghana (N)
Traditional pit latrine with impermeable slab	1.5 – 4 (OpEx and CapManEx)	3 (6) OpEx 8 (6) CapManEx	3 (160) OpEx 1 (160) CapManEx	.14 (107) OpEx
Pit latrine with impermeable slab or VIP type	2.5 – 8.5 (OpEx and CapManEx)	4 (3) OpEx 17 (2) CapManEx	2 (115) OpEx slab 3 (115) CapmanEx slab 25 (19) OpEx VIP 22 (19) CapManEx VIP	.24 (203) OpEx slab
Pour flush or septic-tank latrine	3.5 – 11.5 (OpEx and CapManEx)	5 (4) Pour flush OpEx 9 (5) Septic tank Opex 16 (5) Septic tank CapmanEx	Septic with bucket 5 (40) OpEx 5 (40) CapManEx Septic with piped water 12 (10) OpEx 50 (10) CapManEx	.22 (30) OpEx septic tank

The analysis in US$PPP makes almost no difference except by increasing the costs proportionally in Mozambique (Table 53).

The most striking conclusion is that the results reflect the ability and willingness to pay for improved sanitation from a sample which is mainly constituted by the very poor according to the national food poverty line (in Mozambique) and the poor (in Ghana) thus also confirming hypothesis 2 for sanitation.

However, the fact that a traditional pit latrine with an impermeable slab cost US$ 54 (Mozambique median) and US$ 76 (Ghana median) per family surely prevents many to access sanitation facilities independently of any governmental promotion and demand creation facilitation. The food/extreme poverty line per capita per day in Mozambique was US$ 0.6 and in Ghana US$ 0.8. A traditional pit latrine with impermeable slab is therefore equivalent to about 3 months of salary for a very poor family in Mozambique and in Ghana. This might indicate that access to sanitation for the extreme poor might be unaffordable, pointing to hypothesis 1 for a sub-set of the population.

Table 53 Recurrent expenditure sanitation comparison US$ PPP 2011

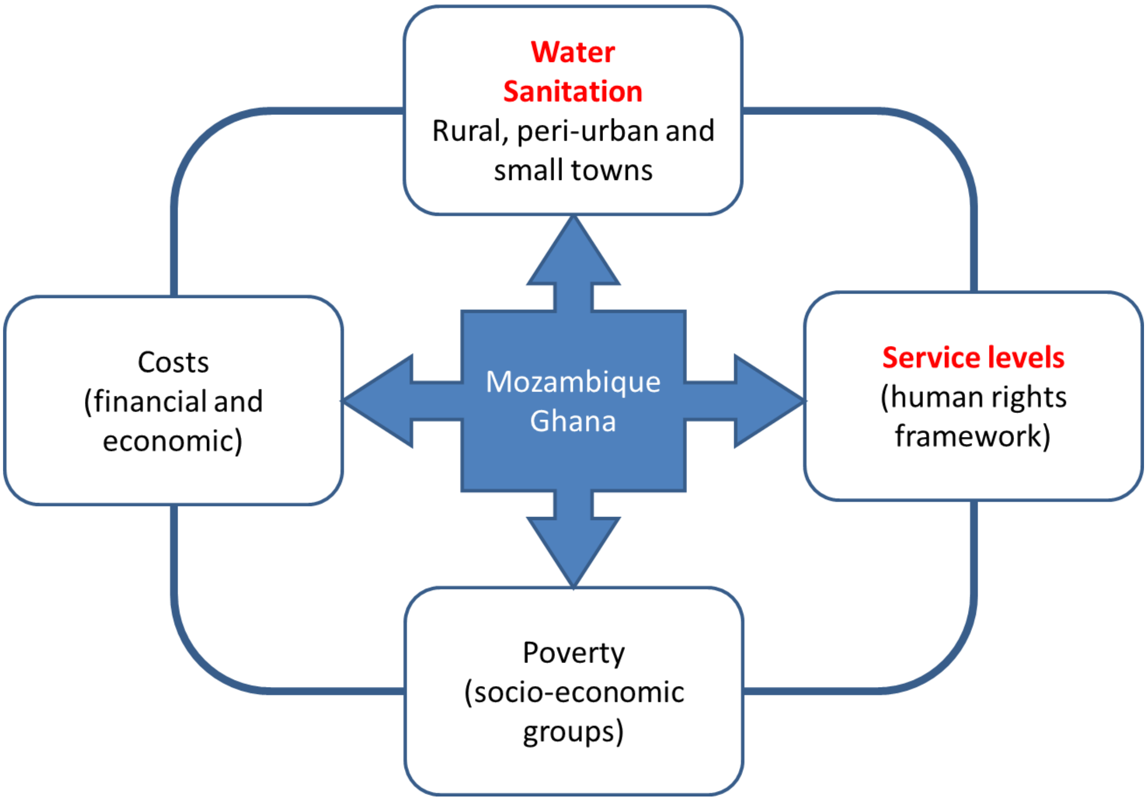
	Recurrent expenditure (per person, per year)		HH recurrent expenditure (median per person, per year)	
	WASHCost benchmarks	Grey literature review (N)	Mozambique (N)	Ghana (N)
Traditional pit latrine with impermeable slab	1.5 – 4	3 (6) OpEx 8 (6) CapManEx	6 (160) OpEx 1.5 (160) CapManEx	.26 (107) OpEx
Pit latrine with impermeable slab or VIP type	2.5 – 8.5	4 (3) OpEx 17 (2) CapManEx	5 (115) OpEx slab 5 (115) CapmanEx slab 45 (19) OpEx VIP 41 (19) CapManEx VIP	.43 (203) OpEx slab
Pour flush or septic-tank latrine	3.5 – 11.5	5 (4) Pour flush OpEx 9 (5) Septic tank Opex 16 (5) Septic tank CapmanEx	Septic with bucket 9 (40) OpEx 9 (40) CapManEx Septic with piped water 22 (10) OpEx 92 (10) CapManEx	.40 (30) OpEx septic tank

5.7 Service levels and the human rights framework

This chapter compares the service levels received by households with the standards proposed by the Human Rights framework and the findings in the literature. It provides a “measuring stick” for the level of services in the sample and a critical analysis of the indicators being proposed to measure the key criteria (see chapter 2.3):

- Accessibility to water and sanitation facilities
- Sufficient quantity to water
- Safe water (quality)
- Continuity in supply (reliability)
- Acceptability of water and sanitation facilities
- Affordability of water and sanitation services

This chapter presents separately the findings for each of the human rights criteria described in the literature chapter. Correlations have been assessed between each of the criteria (when it was logical to do so) and for the technologies, the rural/peri-urban divide, the wealth status as well as the capital and the capital maintenance expenditure. The details are in Appendix I.



5.7.1 Access to water facilities

For measuring access to water facilities using the proposed 'Post 2015 MDG' indicator in the human rights framework "formal source within 1,000 meters AND taking less than 30 minutes to meet their needs", in Ghana only 17% of the sample (N=228) would meet the and in Mozambique only 11% (N=192).

In both countries, households in rural and peri-urban areas are accessing more than one water source in the dry and in the wet season and a mix of formal and informal sources. More sources are accessed in rural areas compared with peri-urban areas. Formal sources in Mozambique are mainly protected wells and boreholes fitted with handpump. Public standpipes are most common for peri-urban. In Ghana with a sample that is less poor and more "urbanized", there are mote households with tap connections and yard standpipes, although the boreholes and hand dug wells fitted with hand pumps are also prevalent in rural areas.

The informal sources accessed by households in both the wet and the dry season in Mozambique are river water, streams, lakes, ponds, rainwater, and unprotected wells, in Ghana informal sources are mainly rainwater, vendors and sachet water but only in small towns and rural. The officially nominated small towns in Ghana in the sample are de facto more concentrated rural areas sharing many of the characteristics of rural areas in access to water and sanitation.

In Mozambique the access to more than two sources is slightly higher within the population living in rural areas and the least poor depend slightly less on more than two sources. In Ghana, even in peri-urban areas and small towns, households are generally accessing more than one source but more than four sources are accessed only by rural households.

In Mozambique the poorest and the poor access water through boreholes with hand pumps while the least poor receive water primarily through piped schemes. For Ghana there is less of a distinction between the sources accessed by the poor and the non-poor. However, only the non-poor access household tap connections and yard standpipes.

For both countries, water is collected mainly, 65%, by women, but in Ghana there is a high percentage of young girls and boys collecting water as well. For both samples only 3% of men collect water.

The distance to the formal primary source in Ghana is 169 metres (median) and in Mozambique 262 metres. About half the households in both surveys are less than 250 meters away from their main source, but 177 households in the Mozambique sample and 19 households in the Ghana sample are more than 1000 meters from their main formal source. Using only distance as an indicator does not reveal the real burden to the households that need to queue or wait for water to be available. Time is therefore an important component to measure access.

For both countries, boreholes with hand pumps are the most distant formal primary sources with a median of 334 metres in Mozambique and 197 metres in Ghana. Distance is higher in rural areas when compared with small towns/peri-urban areas.

In Mozambique, the higher the wealth status, the lower the distance to the primary formal source but in Ghana the wealth status does not influence the distance, maybe because the majority of the households, being better off, are selecting sources closer to their homes already.

Related to the previous finding, in Mozambique the closer the source, the higher the capital expenditure but there is no variation overall on operational expenditure. For Ghana, the median of water payments is higher for the sources less than 250 meters compared with the sources between 251-1000 meters.

In Mozambique the workload in collecting water is significant, the average number of roundtrips per day in the sample is 3 (if only using one source) or 6 (using two sources) in wet or dry season and carrying at least 20 litres per time. This level of detailed information was not collected in the Ghana sample.

In both countries, the main reasons for households to choose a specific formal source relate to proximity of the source and perceived quality of the water (even though formal water testing is not being done). Other factors include reliability of source, the taste of the water or because it is the only source available/functional at the time of the survey. Quantity does not seem to be a priority for any of the households or at least it was not mentioned in the survey given that households are getting the water required from many different sources for different purposes.

To note is the high percentage of the population accessing potentially unsafe sources 30% (512) in Mozambique and 60% in Ghana, both in rural and peri-urban areas. In Mozambique, important factors for using alternative sources in both seasons are the fact that the water is free, that there is enough water and there are low queuing times. In Ghana this question was not asked.

In Mozambique there is limited use of the primary formal water source for productive uses such as construction, beverage production or irrigation. In Ghana, a quarter of the sample uses formal sources for productive uses such as cooking and selling food. Non-poor households also use the water for livestock.

The first conclusion is that from a health perspective and global monitoring there is a tendency to acknowledge only one - and only the formal - source of water to households. From a Human Rights perspective this attempts to ensure that people are accessing at least one formal source within 1.000 meters from the household and taking less than 30 minutes to meet their needs. Research by Pickering and Davis (2012) suggest that reducing the time (and distance) for fetching water should be a priority for water infrastructure investments in Africa for reaping desired health benefits. From a health and development/ poverty reduction strategy the approach of only considering one formal source per household fails to acknowledge:

1) Health improvements will not be met because households access many other informal sources most of the time;

2) The real demand from households is for sources which are within their compound or households – even the poorest are already paying significant amounts to access non-communal water sources;

3) Households use water for multiple purposes (not only drinking) and different sources might meet different standards for the different uses.

The second conclusion is that, when comparing with the literature from the last 30 years, not much has changed. The same reports on distance, time and drudgery have been found in Mozambique and Ghana.

5.7.2 Accessibility (sanitation)

For access, the indicators proposed are accessibility within the household but also in workplaces and educational and health institutions and that the facilities are used by all: including women and children, the disabled and the elderly.

In both countries about 36% of the population in the sample is practicing open defecation. Additionally, in the Mozambique sample, the vast majority of households (almost 90%) disposed of their excreta in what are considered unsafe sources according to international standards. However, neither through the survey nor by observation was it possible to know if all the household members were using the facilities or if disabled members could assess the latrines.

In Ghana, similar to the problems mentioned in the Mozambique analysis, there are real issues with the reliability of applying indicators such as "use of latrines by all the members of the household". The questions can be asked, as was the case, but difficult to verify the reliability of the answers. Understanding which individuals within the household are accessing the facilities requires extensive and expensive observation methods to be reliable and accurate.

5.7.3 Quantity of water

In the human rights framework, between 50 and 100 litres of water per person per day are needed to ensure that most basic needs. In the survey, the (median) litres per person per day consumed are 33 in Ghana and 24 in Mozambique which are much lower than the proposed measurements. However, these averages hide the fact that the quantity consumed is highly dependent on the sources used by the households. Table 54 shows the differences per country and per source.

The main difference in quantity per person per day is between those that access communal sources such as boreholes and hand-dug wells, public standpipes or the neighbours tap and those that access private yard standpipes and household connections. Quantity doubles with the private access.

Table 54 Recurrent expenditure sanitation comparison US$ PPP 2011

	Mozambique		Ghana	
Primary formal source	N	Median litres per capita per day	N	Median litres per capita per day
Borehole with handpump	664	16	1032	24
Standpipe	236	20	266	24
Neighbours tap	165	20		
Yard tap	71	32	7	45
Household tap	4	56	28	45

The quantity of water per day per person is higher with shorter distances from the household to the source especially under 250 metres, after which there is a significant reduction in quantity. In Ghana, after 500 meters, quantity increases again and the explanation may lay in the fact that water is used for productive uses.

For both countries those in peri-urban areas access more water than those in rural areas. The poor access a lower quantity compared with non-poor. For Mozambique larger households are found to have greater water use and per capita consumption. The higher the perception of water quality, the higher the water consumed per litres per day. In Mozambique and Ghana, the litres used per day per person do not seem to impact on the uses.

Paying or spending on maintenance is linearly related with quantity. Households are getting less quantity from communal services and paying less, but those that can are investing in their own systems and increasing quantity and payments.

The turning point has been quantified earlier in Cairncross and Feachem (Figure 2) and in Bosch et al. (2002): when water sources are between 30 and 1.000 metres from the household (or roundtrips take between 5 and 30 minutes), the volume of water collected varies little, with a distance less than 30 meters the amount of litres increases and with a distance higher than 1.000 metres the amount of litres per capita per day decreases. The results from the survey, using no statistical transformations has found a much less linear relationship. Figure 38, Figure 39 and Figure 40 reproduced the results. One explanation is that the surveys from Ghana and Mozambique collected data from several sources and not only one.

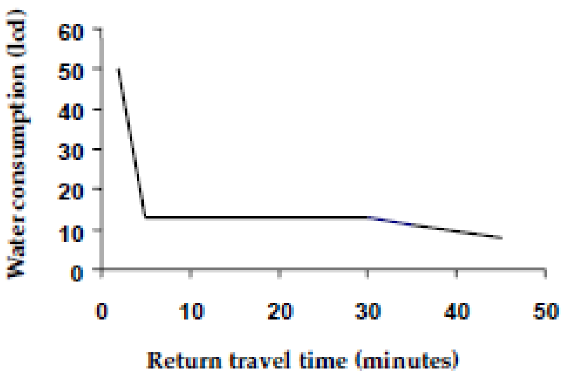


Figure 38 Water consumption and time – original from Cairncross and Feachem

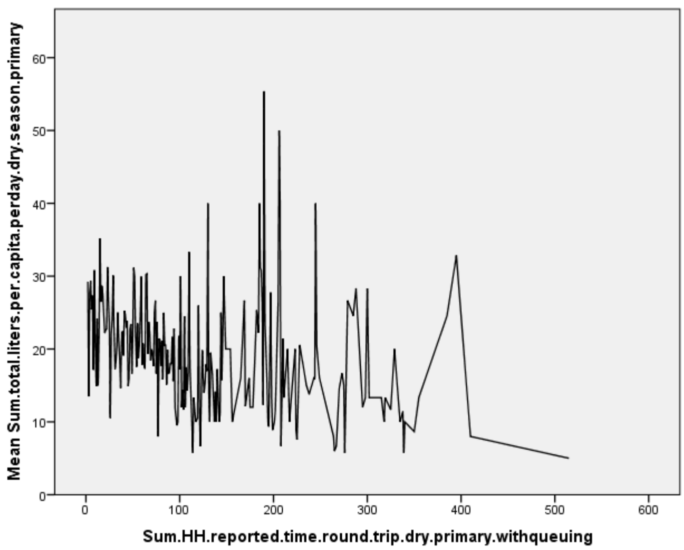


Figure 39 Water consumption and time – results from Mozambique survey

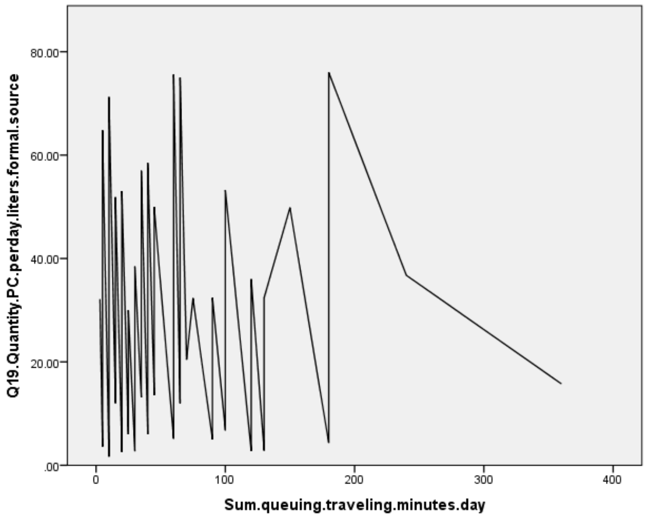


Figure 40 Water consumption and time – results from Ghana survey

5.7.4 Reliability of water sources

The fact that households are assessing many different sources points to the fact that most are not reliable. Either because they are not functioning or because they do not provide enough quantity or quality, it is not possible to point one reason.

In Mozambique, the only measurements of reliability in the sample are the questions "Are problems with the source resolved quickly?" and "What are the main issues that need to be solved?". The large majority of households (91.5%) consider that the problems with the source are solved quickly. Households mentioned that faster response to problems 9.6% (165), additional safe sources 4.9% (84) and improving the timing of supply 4.1% (70) are the main aspects that could be improved among a long list. Improving quality and safety and improving billing and transparency come as second.

In Ghana, the perception from households on reliability of the formal source is good. 52% (N=692) of the respondents say that the systems work all the time and 21% say that systems works most of the times and when it breaks repairs are done quickly (N=285). About 5% of the households reported that they had experienced prolonged breakdowns, or that the system fails during the dry season (Figure 41).

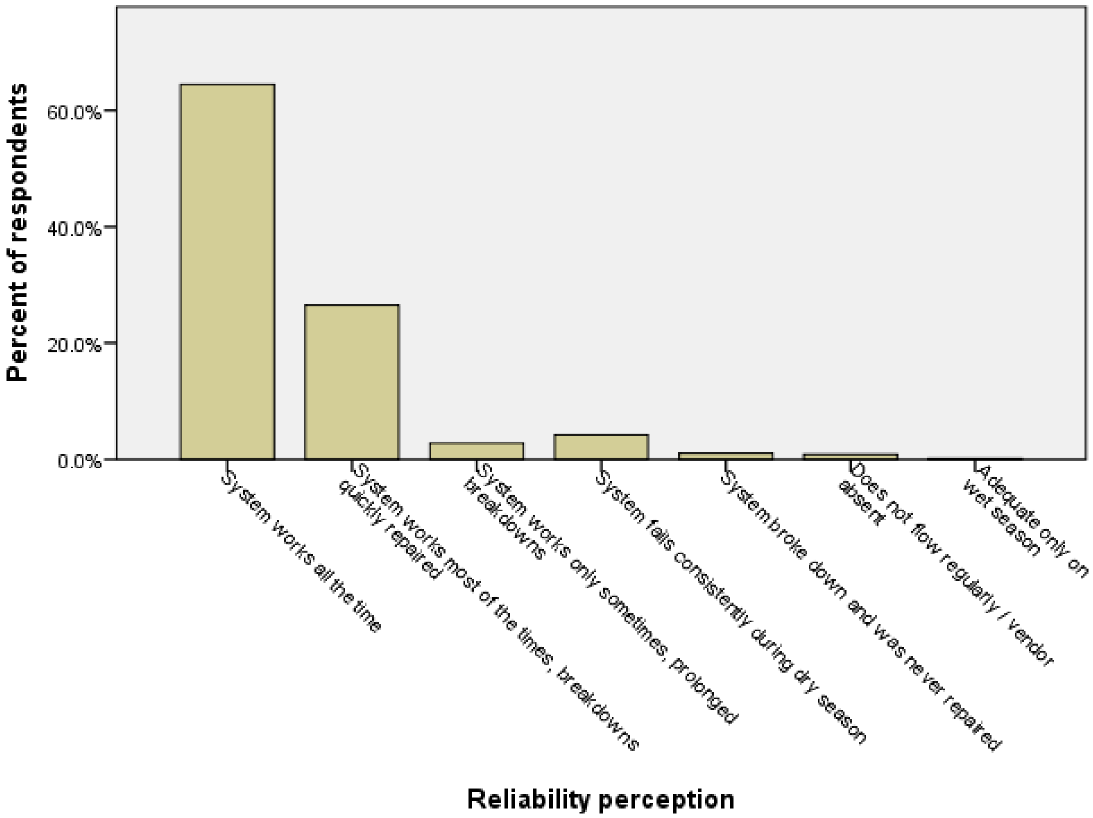


Figure 41 Reliability perception, Ghana

5.7.5 Reliability of sanitation facilities

In Mozambique, the only indication of safety, in the absence of standards that could be derived from the household survey, includes observing if the inside of the latrine was cleaned (Figure 42) and the status of the superstructure in terms of maintenance (Figure 43). This was only done in the Mozambique survey.

A high percentage of latrines (33.1%) have been considered dirty or very dirty and 19.6% of the latrines were in a poor or very poor level of maintenance which means that having access might impact on health given the lack of protection from microbial contamination.

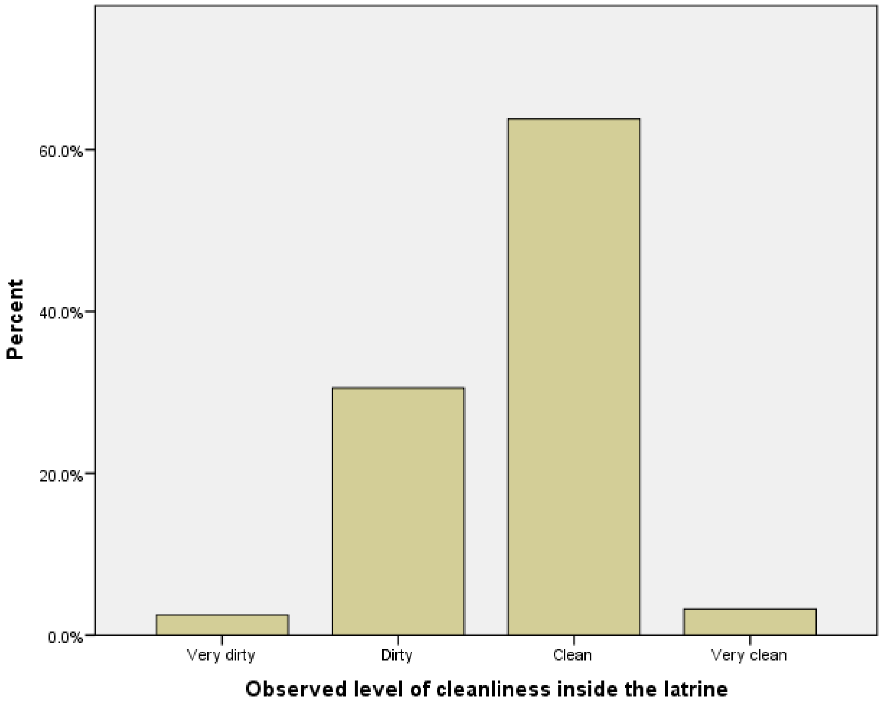


Figure 42 Level of cleanliness inside the latrine evaluated by the enumerator

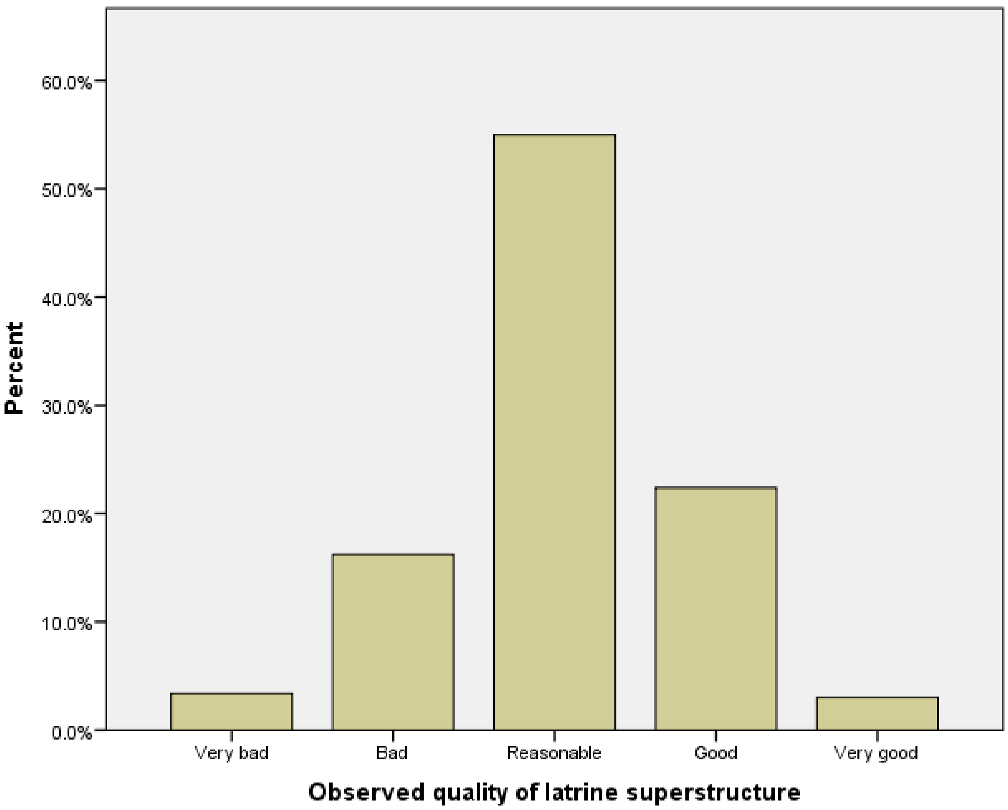


Figure 43 Status of maintenance level of the latrine superstructure evaluated by the enumerator

There was no correlation found between cleanliness and maintenance with the level of poverty or the type of facilities.

In Ghana, households were asked about their level of satisfaction and cleanliness with public toilets and with neighbour's toilets. From the 66 respondents (71% from those that reported paying public toilet fees), 61 said that the public toilet fee was acceptable and only 5 mentioned it was too high. The opinion on cleanliness of public toilets (N=114) and neighbours toilet (N=28) is overall "fairly clean".

5.7.6 Water quality (perception)

Water quality was done for the formal sources when they were built. There is no access to the results of such tests which is the indicator required in the human rights framework.

Applying the safer/less-safe approach (WHO/UNICEF, 2000), which groups technologies into "less safe" and "safer", in Mozambique, 70.2% of respondents would be considered to access a "safe" source and in Ghana, 86%.

The only questions in the survey that relate with quality and reliability concerned the perception of households. These might not be valid to measure the quality indicator but provides an idea of acceptability of the source.

For each of the countries, 65% of households find the water quality from the main sources acceptable. A higher percentage of users in rural areas perceive water having bad quality than in peri-urban areas. The higher the water quality is perceived, the higher the water consumed per litres per day and the closer is the source.

5.7.7 Acceptability

Acceptability as criteria is more qualitative in nature compared with criteria such as quantity and quality for instance and a function of existing/non existing supply alternatives. Someone may not be satisfied with something, but as there are no better options it is still seen as acceptable. The main challenge of using acceptability as criteria for monitoring services delivered at global level is that all the other indicators to monitor water services (access, reliability, quantity, quality, etc.) are all related to "acceptability". For instance, if consumers/international community say that more than

30 minutes for a round trip to collect water is substandard according to the criteria of accessibility, then we are saying that this is not-acceptable.

Additionally, there is not a normative definition for acceptability or consumer satisfaction. There is not a norm that says that "at least x% of the users need to be satisfied with the service provided". Using a global norm for acceptability would mean breaking it down in components such as "acceptability of water quality", "acceptability of tariffs", "acceptability of water quantity", etc. This is can be done for each of these criteria if we use a 'progressive realization' of "service delivery" criteria, from no service/not acceptable all the way to a high service/acceptable. But defining a homogeneous system at international level for users' needs perceptions and priorities for what is acceptable is not possible.

However, "acceptability" can be very useful at country level, as a quick sample-based exercise, to test whether the existing norms for setting service levels do indeed reflect users' desires/expectations. For example, we might discover that "75% of users surveyed felt that the 'basic' level of service that they receive is unacceptable" – and that might trigger a national discussion about what does constitute an acceptable basic level of service triggering service improvements. But, as a regulator, it would be extremely difficult to measure acceptability in a sufficiently objective way to make it a useful management tool for ongoing monitoring systems.

Acceptability criteria could also be used to add the consumer perspective and unpack some of the other more quantitative indicators. At a service provider level, it can be a first indicator of a system starting to fail before it is too late. For instance to measure water quality, it could be used together with water testing to check consumer satisfaction with taste, colour, hardness (if the water is too hard, it doesn't boil so quickly and the soap is not foaming so nicely when bathing) and smell. But these indicators are very context specific and should be best selected / developed with users, as they know what matters to them.

For Mozambique, in addition to the quality perception and reliability, about 80% (1351) of respondents think that the management of the scheme in the dry season is very good and 15% (264) think it's acceptable.

The main entity responsible for the management of the water sources are the community and its water committees in 56.3% (963) of the sample, a private operator

17.1% (293), FIPAG/AdM[9] 12.3% (171) and the households themselves 5% (85) for the dry season. In the wet season the sources are mainly managed by the community (16.1%) and a private operator (3.1%). There is no correlation between the perception on management and who manages the scheme.

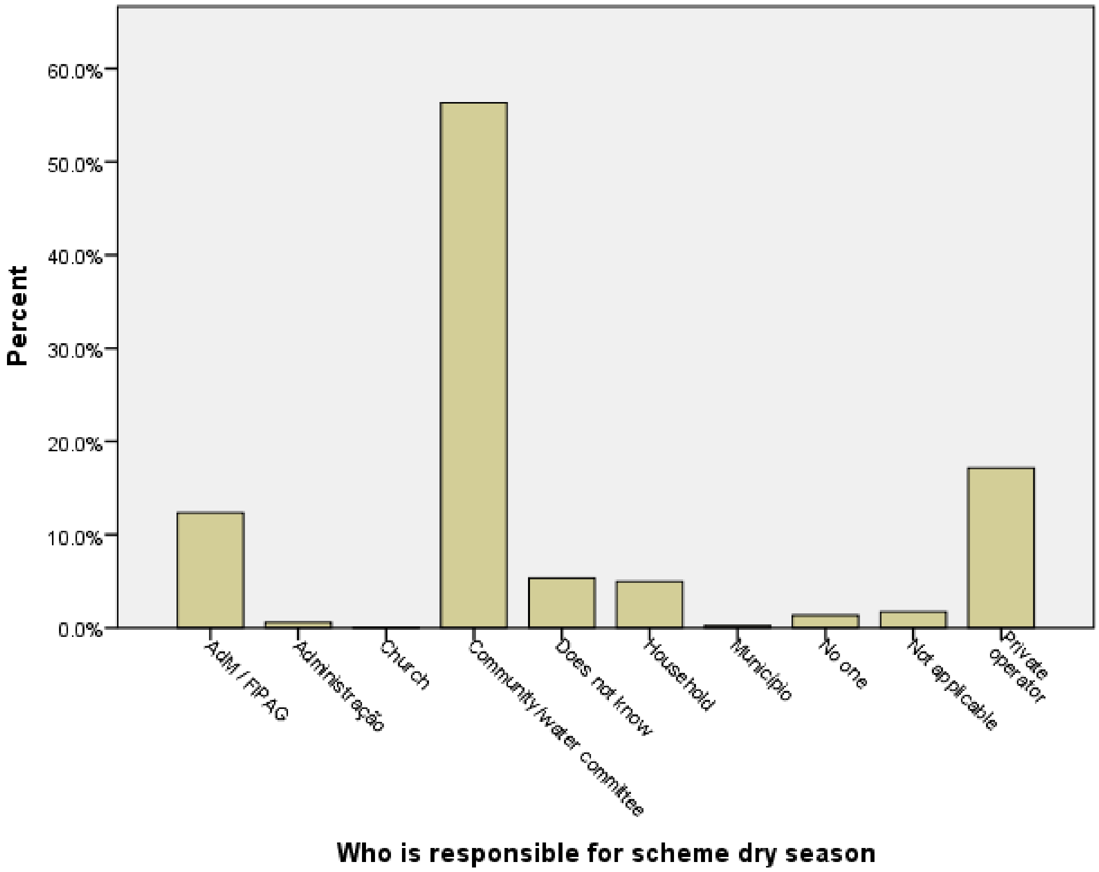


Figure 44 Management of water source, dry season, primary source

For sanitation, the fact that households are using a toilet does not answer the question as to whether the facilities are acceptable. Dignity and privacy requirements have not been assessed, neither which households members were using the latrine. There are no questions in the Ghana survey to discuss acceptability further.

5.7.8 Affordability of water facilities

In Mozambique, the financial costs (OpEx and CapEx) for water for the households below the national poverty line are about 2% of their overall household expenditure per year which is within the international benchmarks. Tariffs and CapManEx have

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9 FIPAG is the water authority for the urban population which delegates the management to the water utility Águas de Mocambique (AdM) as operator.

not been captured and would be additional costs. However, Figure 27 on household opinion on user charges shows that 15.2% of the sample population considers them expensive or very expensive.

The national poverty line in Mozambique in 2008 was US$ 0.61 per person per day. Analysing affordability from different perspectives provides the following results (Table 55).

Table 55 Affordability analysis for water, Mozambique

		N	Mean (%)	Median (%)	Std. Deviation
CapEx for undefined number of years as proportion of HH expenditure per year	Total population	211	13	1	74.47
	Population below national poverty line	153	15	1	87.27
OpEx per year as proportion of HH expenditure per year	Total population	55	.67	0	.99
	Population below national poverty line	23	1	1	1.44

For Ghana, the expenditure of households were not collected except for the pilot area and the affordability analysis based the activity of the head of the household cannot be made.

5.7.9 Affordability of sanitation facilities

In Mozambique capital expenditure per person represent about 3% of the yearly per capita expenditure and 1% for the recurrent costs (Table 56).

Table 56 Statistics on sanitation affordability Mozambique

		CapEx as proportion of overall household expenditure	OpEx and CapManEx as proportion of overall household expenditure
N	Valid	321	159
	Missing	1389	1551
Mean		.0504	.0412
Median		.0305	.0123
Std. Deviation		.05724	.08690
Minimum		.00	.00
Maximum		.40	.66

There were 31 instances where recurrent expenditure was higher than 5% of overall household expenditure spread across the different type of sanitation facilities and the different socio-categories, but 115 instances where capital expenditure was higher than 5%, reaching at times 40% of overall household expenditure. There is no correlation between the households that invest higher percentages of their income in sanitation facilities and the socio-economic categories, but expenditure has some correlation with the type of facilities chosen.

In Ghana overall household expenditure has only been collected for the households in the pilot data collection therefore the affordability analysis had been only done for that subset of the sample (N=65) and provides only two valid results (having a toilet and reporting financial expenditure) both at 4%. If broad equivalences are made with the median expenditure reported per main activity of household, the results show (that Capital Expenditure used to construct latrines and toilets represent about 5% of people's expenditure while Operational Expenditure and toilet fees represent 1 and 2 percent respectively of household overall expenditure per year. Hypothetically, there could have been 17 households that spend more than 5% and up to 44$ of their reported expenditure (median of 9%.) to build their sanitation facilities. Only two of these have received a subsidy.

Table 57 Statistics on sanitation affordability Ghana

		CapEx as proportion of per person extrapolated expenditure	OpEx as proportion of extrapolated per person expenditure	Toilet fee as proportion of extrapolated per person expenditure
N	Valid	36	41	59
	Missing	1303	1298	1280
Mean		.09	.02	.02
Median		.05	.01	.02
Std. Deviation		.107	.030	.014
Minimum		0	0	0
Maximum		0	0	0

For sanitation, a traditional pit latrine with an impermeable slab cost US$ 54 (Mozambique median) and US$ 76 (Ghana median) per family surely prevents many to access sanitation facilities independently of the promotion and demand creation done. The food/extreme poverty line per capita per day in Mozambique was US$ 0.6 and in Ghana US$ 0.8. A traditional pit latrine with impermeable slab is therefore equivalent to about 3 months of salary for a very poor family in Mozambique and in Ghana.

The main conclusion is that affordability overall of sanitation services is within the proposed indicators, but sanitation facilities for the very poor might not be affordable. Additionally, with the lack of expenditure on maintenance, latrines might be overall affordable but might not meet a basic level of cleanliness or requirements for pit emptying.

5.7.10 Conclusions on service levels

There are a few gaps in the data available in the surveys to provide an in depth assessment of all the criteria proposed in the human rights framework. However, it was possible to test some of the indicators proposed and provide evidence on their suitability and reliability. Additionally, the analysis on service levels and affordability reinforces the findings towards hypothesis 2 and provides more nuances on what is it that households are prepared to pay for.

Table 58 Summary of findings for service level indicators

Criteria in the Human Rights Framework	Indicators proposed in the Framework	Summary of findings
Physically accessible (water and sanitation)	Water source within 1.000 meters from the home	The indicator fails to take into account several sources formal and informal and different water uses
	Round trip to water source should not exceed 30 minutes	Distance and time are appropriate and good indicators that can be collected and provide reliable results (even with recall bias) Queuing time is a very relevant component of access and reflected in the time indicator
	Accessible within immediate vicinity of household, workplace and educational or health institution	The survey was only conducted with households, no conclusions can be made on access in other locations, but this should not be problematic to collect using surveys
	Accessible by the disabled, elderly, women and children	This indicator needs to be collected through purposive sampling and observation. Women and children are the ones accessing water supply sources. No information was collected specifically on the disabled or the elderly. For sanitation it is not possible/ not reliable to ask

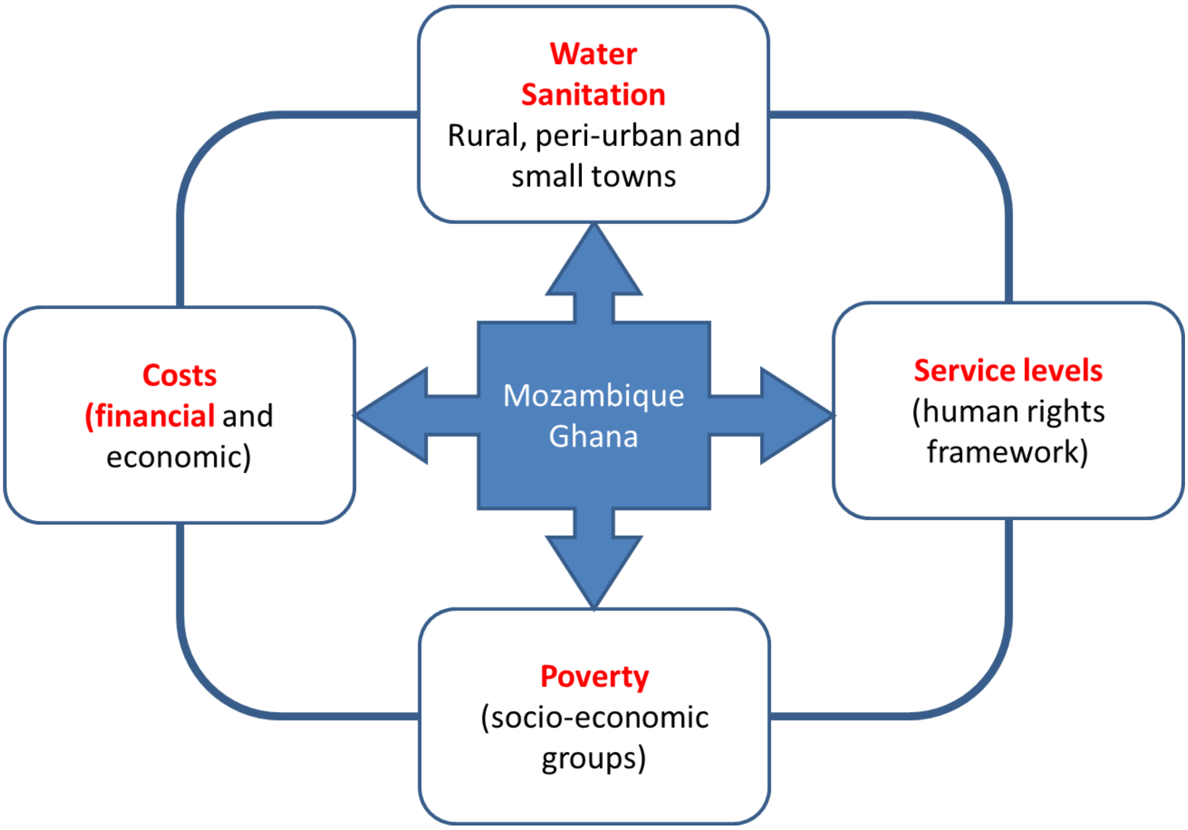
		who is using the facilities and the way to collect reliably this indicator (long observation methods) might not be cost-effective for large scale monitoring efforts.
Sufficiency	Between 50 and 100 litres of water per person per day for basic needs	Given that households access different sources, formal and informal for multiple purposes and not only basic needs, the indicator is difficult to collect. Further, households indicate they are satisfied with the quantity available through their many sources.
Continuity	Time that water is available either as hours per day or/and days per year	No data was collected on continuity but reliability (measured in terms of days that facilities are working in the year) can be used as a proxy indicator as it is already a norm in many countries and data collection is relatively simple. A reliability indicator can also be used for sanitation facilities to indicate the cleanliness of the facilities and the quality of the construction.
Water quality	Water quality testing As second best use “improved source” for “safer and “non-improved” for “less safe”	Most of the boreholes with hand pumps have been tested only once when they have been installed, usually the records are not accessible. Affordable and reliable water quality testing methods to be used in remote rural areas or/and provide quick results is an urgent need in the sector.
Affordability	The costs for water and sanitation should not exceed 5% of the household’s income.	Indicator requires expenditure or income data from households. It is more relevant for population below national poverty line This measure will not allow comparability across countries or regions, but will be useful to target interventions, especially related with sanitation facilities which pose an affordability risk.
Acceptability	Water should be of acceptable colour, odour and taste and water and sanitation facilities must be culturally appropriate, respecting gender, lifecycle, dignity and privacy requirements.	Most indicators are related with acceptability. A service might be bad, but given the lack of options still considered acceptable. Lack of measurable and comparable indicators. Might be useful at country level to test existing norms on other indicators.

Given that not much has changed since the 1970s in terms of reported progress in the indicators above, maybe the human rights framework will need to be adapted to a more modern world, with higher ambitions and willingness to pay from the poorest households.

In addition to the indicators above, which are mostly geared towards those that have some type of access, setting targets specifically for reducing inequalities in access to water and sanitation services will enable countries to strike a balance between investing in sustainable and better services while at the same time investing in reaching the people that have so far been left out.

5.8 Poverty levels and the services demanded

This chapter summarises the findings discussed in the previous chapters but from a poverty perspective. It answers the sub-question: to what extent costs and service levels vary with household socio-economic status?



The most striking conclusion is that the results reflect the ability to pay for improved water and sanitation services from a sample which is mainly constituted by the very poor according to the national food poverty line (in Mozambique) and the poor (in Ghana).

The poor access more sources than the non-poor and therefore access less reliable services. There are more poor households in rural areas (compared to peri-urban) and boreholes with handpumps remain an important source for the poorest in both countries. In Mozambique the poorest and the poor access water through boreholes with hand pumps while the least poor receive water primarily through piped schemes.

For Ghana there is less of a distinction between the sources accessed by the poor and the non-poor (the sample is better off overall). However, it is clear that only the non-poor access households tap connections and yard standpipes.

In Mozambique, the higher the wealth status, the lower the distance to the primary formal source but in Ghana the wealth status does not influence the distance, maybe because the majority of the households, being better off, are selecting sources closer to their homes already.

For both countries those in peri-urban areas access more water than those in rural areas. The poor consume less litres per day compared with non-poor.

In Mozambique, capital expenditure is lower for the poorest households who also spend less on recurrent expenditure when compared with the poor and the least poor. In Ghana, the median of water payments is higher for the sources less than 250 meters compared with the sources between 251-1000 meters.

In Mozambique small increments in income or wealth can have a large impact in the quality of the services demanded. In Ghana, the differences are there but are less sharp.

In Mozambique the poorest households in the sample use more unsafe sanitation latrines rather than improved latrines. The access to toilets by different socio-economic categories is not so marked in Ghana. Nevertheless, it is the non-poor that access the most sophisticated Kumasi Ventilated Pit and the toilet with septic tanks.

In Ghana, no correlation was found between capital expenditure to build latrines and the socio-economic status of the households. However, the non-poor spend more on operational maintenance (free of subsidies) than the poor. In Mozambique the poor spend less on capital expenditure compared with the least poor and operational expenditure is lower for the poorest which use the less sophisticated facilities.

6 CONCLUSIONS

6.1 Overall conclusions

Boreholes with handpumps became the preferred model for external agencies to provide rural water services in developing countries since the 1960s. Maybe because it's the cheapest option for an external donor and from a health or Human Rights perspective it provides a basic service. However, this clashes with the real demand from households. If given a choice, households do not want to walk more than 100 meters to access communal boreholes and hand pumps.

In the past thirty years there have been numerous efforts to make the borehole with handpump model/approach work: training communities, developing monitoring processes, promoting spare parts availability, making sure there are funds for maintenance, etc. Despite a few success cases across the world, the main reason why it has not been easy for this model to develop into a full service provision is because it is the wrong model for countries with high growth levels and populations aspiring to better service provision which does not require carrying 20 litre jerry cans (20 kilogrammes) for hours a day.

In most other sectors (roads, energy, education, health, agriculture) there have been developments in approaches and innovations that fit the aspirations of a world-wide wealthier population. In the water and sanitation sector the stagnation in approaches has been so severe that we are now monitoring 19th century technologies with 21st century state of the art technology Figure 45 (Thompson, Hope and Foster, 2012).

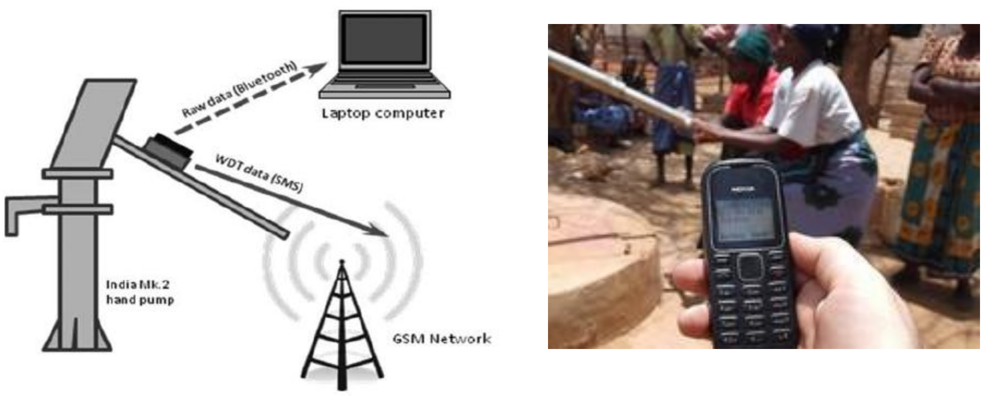


Figure 45 Experimental set up of mobile data collection from handpump

Sources: Thompson, Hope and Foster, 2012 and University of Oxford, 2012

Surveys collected from 3049 households in Ghana and Mozambique rural and peri-urban areas, which wealth is well below the international and national poverty lines have shown the variety of sources both formal and informal that are accessed on a daily basis for households to cope with their water needs. Most households in the survey take more than 30 minutes per round trip to get water. There have been little changes compared with the literature in the 1970s.

Small increases in wealth have a large impact in the level of services demanded, and the impact is higher the poorer the population. The less poor access less sources, access less boreholes with hand pumps and the distance and time from the household to main water source reduces significantly. The main reasons to access a specific formal source for the majority of the households in the sample is perceived water quality and proximity. From the perspective of most of the households in both countries, the tariffs charged were considered acceptable.

It was found that capital expenditure, operational expenditure and payments to access water increase as household wealth increases. The very poor will pay more for non-communal sources such as yard taps, household connections and even unprotected sources if these are closer to the households. They prefer to spend on water treatment and payment to access the neighbour’s taps rather than investing on the (cheaper) maintenance of the boreholes with hand pumps. Expenditure on maintenance of communal sources remains constant independently of the household wealth. A smaller minority in the sample is spending considerable amounts to build their own wells or rainwater harvesting systems.

The findings from the data, point to a mismatch between the traditional approach for development in the sector in the last 50 years and the effective demand from households.

With the communal hand pump approach, external donors pay (relatively) low capital expenditure for a service that doesn't meet basic requirements - and for which there is very low willingness to pay. To make this approach to development work has required a lot of public finance to cover recurrent costs (or let the infrastructure fail).

With an approach that delivers water closer to households, through mostly piped schemes, capital expenditure is relatively higher for a service that is demanded and for which the willingness to pay is higher resulting in lower recurrent costs required from public finance – where there is a political preparedness to charge.

In both approaches, capital expenditure and capital maintenance expenditure require funds from public finance (taxes and transfers) but higher levels of service can be achieved and payment for such services promises a reduction of public finance over time.

The other main problem with the traditional approach is that unlike other infrastructure intensive sectors, the household or the community is left the responsibility to maintain the water and sanitation assets build. As a result, assets fall into disrepair or service levels are sub-optimal. Rural water supply providers need to approach asset management like urban utilities. Some set of technologies and systems require low maintenance costs but as complexity increases from shallow wells to multi-village gravity schemes, the institutional gap for asset management increases.

The more 'appropriate', "low costs", "local" and non-networked a water supply technology is, the sooner that it requires major capital maintenance for providing the same level of service as originally designed for (serviceability). "Pipes" are much closer to 'fit and forget' approaches with the likelihood that economic growth will have caught up by the time capital maintenance expenditure is needed whereas hand pumps, with their short life spans can never last long enough for economic growth to bridge the financing gap.

> "*Infrastructure aid causes a disservice to developing economies. Perhaps the correct policy implication would be to re-allocate portions of this aid to maintenance." (Rioja, 2003)*

Sanitation in rural areas of lower-middle income countries is much behind water in terms of people that still need to be reached. Sanitation interventions in the last 10 years are focused on promoting demand for latrine construction. Progress has been painstakingly slow with 37% of the world population without improved sanitation facilities. Reports of slippage up to 90% to previous unhygienic behaviours are not uncommon (Plan, 2013). Without follow up support, behaviour change and health impact will not be sustained and similar to the water sector, we will be reporting failure for the next 30 years. The sample has also shown that there might be a percentage of the population that cannot afford improved latrines. This calls for specific approaches to target the poorest.

It is not possible to compare reports on access to improved sanitation because there is not a commonly agreed framework or indicators that define sanitation as a service. Most criteria are still related with the household as the sole responsible for safely disposing of excreta. The human rights framework recognises sanitation as a right but indicators for measurement are limited. This is particularly problematic in densely populated areas where pits are filling up and there are no arrangements for capital maintenance costs related with desludging and pit emptying.

Criteria to define a sanitation service will need to integrate household level measurements with service provider indicators which look at the wider environmental implications for human excreta disposal.

Ultimately, the world now is not the same as in the 1970s, water and sanitation models of development and the indicators being used to measure progress need to be revised to be more aligned with the real aspirations and demand from households living in rural areas in low and middle income countries.

6.2 Conclusions on costs and service levels for water supply

Extensive data collection into the expenditure and services received by households in Mozambique and Ghana concludes that the level of water and sanitation services delivered to rural populations is poor, below national or international norms concerning access, quality, reliability and use. Poorer households receive overall a lower level of service than non-poor households. However, from the perspective of the households, they are relatively happy with their sources of water, especially the non-communal and the informal sources. These sources are closer to the households (avoiding the heavy burden on women to carry water from the further away formal sources), provide the required quantity and do not suffer from long waiting times and queues. This water is said by consumers to be affordable.

From a cost perspective, in rural and peri-urban areas, household capital expenditure (calculated per person) contribution for communal sources that provide a low level of service is small (median US$ 3 for borehole with handpump) compared with more individual yard taps (median US$ 11 for yard taps). This information is only available for Mozambique. The contributions to operational expenditure are small at around US$ 1 per person per year for all types of facilities in Mozambique. Comparatively, in Ghana, where the sample is less poor, user charges to access better water services are half the costs at US$ 0.5 per person per year. These are within the literature review and the WASHCost benchmarks.

Households are contributing very small amounts to capital maintenance expenditure and very rarely have these costs being reflected in user charges and tariffs. Communities or/and district staff are left to figure by themselves how to collect sufficient amounts to replace their systems when key components break or come to the end of their lifespan. In poorer countries, or in regions of countries without a strong cash-based economy, identifying costs and developing systems to pay for services can be difficult. As a result, capital maintenance falls by the wayside, systems fall into disrepair, and users lose the health, time, education, and other benefits until someone pays for the provision of a new or rehabilitated facility (new capital expenditure). Savings could be achieved (or more people could be served) if capital maintenance would take place, avoiding the unnecessary high expenditure with re-building infrastructure over and over again in the same areas.

Under present practice, without capital maintenance and other recurrent expenditure being taken properly into account by donor organisations and governments, capital investments in water supply are not sustainable. Or, in other words, investing in improved water services will not deliver long term improvements in outcomes unless the service is at a level and of a type that matches the effective demand of households.

6.3 Conclusions on costs and service levels for sanitation

Seven years ago when the surveys were developed, there were limited discussions on what constitutes a “sanitation service” in rural areas in developing countries. This is still the case today and is reflected in the limited criteria and indicators proposed for sanitation in the human rights framework. The present criteria and indicators proposed such as access by all members of the household, acceptability and dignity are too vague to be implemented in practice and provide little indication of progress and development. Environmental aspects related with the safe disposal of faeces are missing all together. In practice, without an agreed and shared definition in the sector of what is a sanitation service, it is not possible to define which indicators should be used to measure progress.

In terms of sanitation access, in both countries, a high percentage of respondents' practices open defecation. From those that invest in their own facilities, household capital expenditure for building latrines is generally higher in Ghana (median US$ GDP 17 / US$ PPP 20) when compared with Mozambique (median US$ GDP 6 / US$ PPP 9). The majority of the families in Mozambique that build traditional pit latrines used their own labour and materials which are not captured through financial transactions. The food/extreme poverty line per capita per day in Mozambique was US$ 0.6 and in Ghana US$ 0.8. A traditional pit latrine with impermeable slab is therefore equivalent to about 3 months of salary for a very poor family in Mozambique and in Ghana. Therefore, even if there is increased demand there is an issue of affordability/demand that needs to be looked into for increasing sanitation access.

For traditional pit latrines with impermeable slabs, the household expenditure in both countries is higher than the literature review and the WASHCost benchmarks. The household expenditure for pit latrines with impermeable slab, VIP types and septic-tank latrines are within the WASHCost benchmarks and the literature review. The present dataset is helpful in narrowing the wide ranges available at the moment in the sector.

Limited expenditure has been reported in Ghana on operation and maintenance and the resulting ranges are much lower than the benchmarks or the literature. On the other hand, in small towns, households are accessing public toilets and paying considerable more than the maintenance of their own latrines. In Mozambique, even with labour and materials volunteered by the households, the maintenance costs of the more sophisticated facilities are higher than the benchmarks which might indicate affordability constrains.

In the experience of the author across several countries, powerful demand creation over the last years is leading households to build latrines at a rate not seen before, but maintenance expenditure is not really taking place. Similarly to water services, this lack of maintenance threatens long term functioning and the health improvements that such facilities aim to provide.

6.4 Conclusions from the (grey) literature

During the 90s, the main motivation for reporting aggregated financial costs for the water and sanitation sector in lower-income countries has been the calculations needed to estimate how much it would cost to achieve the Millennium Development Goals. From 2000, another motivation for collecting unit costs has been the need to show to Finance Ministers and others the benefits of investing in improving drinking water and sanitation. With this focus, economic costs have been collected for cost/benefit analysis and demand studies. Most of the financial and economic research in this area has been undertaken for populations accessing piped supplies.

However, in the last years, unit costs estimates have become more country and region specific and reviews have demonstrated an additional motivation to collect and analyse unit costs in the sector: *value for money*. As expressed by the Government of Uganda (2008): “There have been questions raised about the water supply and sanitation cost effectiveness and efficiency for several years. These concerns have been used by Ministry of Finance, Planning and Economic Development as one of the reasons for not increasing the WSS’ share of the national budget”. More recently, concerns emerged among sector experts that if cost reviews are not associated with the services being delivered, they are not very useful to inform policy, tariff setting or pro-poor approaches.

Nevertheless, most external support agencies (bilateral and multilateral agencies, NGOs and foundations) in the sector who promote accountability and transparency have not been able to produce the real unit costs per capita of their own supported interventions. The main methodological problem with the unit costs estimations reviewed for this thesis is that the picture presented is incomplete. As decades of experience in the WASH sector have proven, it requires more than a hand-pump to ensure access, and more than a latrine to ensure proper hygiene behaviour. It is not enough to cost pieces of technology. The sector needs to measure how much it costs to provide a service.

Robinson (2009) and Trémolet (2010) comparing sanitation costs recognise that the “substantial cost variations largely reflect the different levels of service provided by different projects.” Basic sanitation might comprise a single pit latrine in the Philippines or a toilet connected to a septic tank, a sink and a shower in Ecuador.

Even in similar contexts, it's not uncommon to find similar size schemes where costs vary with a factor of 10 or more. However, the available information is not sufficient to determine the basis of the costs data (PEM, 2005; Burr and Fonseca, 2013).

6.5 Reflections on the objectives and hypothesis of the thesis

The main research question was: "Can low-income rural households pay for water supply and sanitation services?" with the two possible answers/hypothesis:

- Hypothesis 1: Low income rural households cannot pay for the construction and maintenance costs or/and tariffs are too high.
- Hypothesis 2: Low income rural households can pay for improved water and sanitation but are not prioritising to do so.

To answer the main research question and test the two hypotheses, this research proposed to:

1. Identify what are the financial costs to households to reach their present level of rural water supply and sanitation services in Mozambique and Ghana;
2. Analyse if costs and service levels vary with household socio-economic status and to what extent; and,
3. Identify what are the non-financial contributions (time and in-kind contributions) of households to reach their present level of services.

The answer to the main research question was achieved: low income rural households can pay for improved water and sanitation but are not prioritising to do so. This is hypothesis 2 which has been supported with evidence from the household surveys and by literature in the field. However, more interesting are the nuances and the explanations which have emerged from the in-depth analysis of the sub questions.

The first sub-question was achieved. Financial costs related with the capital expenditure and the recurrent expenditure incurred by households have been collected, analysed and compared for both water and sanitation. There are more details for the Mozambique sample compared with the Ghana sample, but the Ghana sample, which respondents are less poor, has far more valid responses on the amounts that households are paying to access water and sanitation services.

The second sub-question was also achieved. All the indicators and analysis was done for the poor and non-poor in both country samples providing an additional level of analysis and insights critical to the overall conclusion.

The final sub-question was partly achieved. The most relevant economic cost – time spent collecting water - was thoroughly analysed in Mozambique, but limited information was available in the Ghana sample. Time spent constructing water or sanitation facilities were not collected, broad equivalences could be calculated for sanitation infrastructure in Mozambique alone. Overall in kind contributions for water or for sanitation have not been captured in the questionnaires limiting the analysis.

Existing questionnaires and data from a project were used for the analysis in the thesis. The main strengths of the approach lay in the size of the datasets which makes the results unique in the sector and valid from a statistical perspective. Using the terminology, costs categories and methodologies for cost analysis based on the urban water sector and using it consistently in the rural water and sanitation sectors in developing countries provides a robust and consistent cost analysis.

The main weaknesses relate to the non-comparability of some of the results, given the slightly different way that questions were asked in each of the countries or simply because in Ghana less information was collected. The economic cost analysis was more limited in scope than anticipated given some critical missing information in both surveys (which were not designed for economic cost analysis).

The main contribution to the knowledge in the sector relates with providing an in depth analysis and robust evidence on costs and service levels which are unique and challenge the traditional approach to development in the water and sanitation sector.

Finally, this research has initiated financial household benchmarking for rural water services through an understanding of household expenditure against the indicators being proposed to measure the progressive realisation towards the Human Rights to Water and Sanitation.

7 Recommendations

7.1.1 Beyond the "borehole with handpump" communal approach

Investment in rural water supply, when viewed in terms of sustainability and impact, has consistently failed at least over the least 40 years because of a focus on the construction of communal 19th century infrastructure which is important from a health perspective but has not evolved to provide sustainable services that people are actually demanding.

With the fast growth of many low-middle income countries and the wealth of households in general moving to above US$1 a day (Zanden et al. 2011), the traditional approach to rural and peri-urban water supply needs to be reconsidered to include:

i) water uses for multiple purposes, from different sources providing a different level of service;
ii) providing the much needed reduced distance by, where possible, promoting the use of own wells and pumps (called self-supply in the sector); and
iii) assessing the possibility of increasing access by providing small piped networks.

7.1.2 Household affordability to access basic sanitation services

Subsidies for accessing sanitation facilities directed to households have been "banned" across most of the programmatic approaches from government and implementing agencies, since they ended up being captured by the non-so poor, but it is clear that demand promotion is a necessary - but not sufficient - condition to expand coverage to the very poor.

As a result, governments and external agencies will have to:

- Accept that simpler low-cost impermeable slab with a traditional structure is the service delivered to the poorest, since through their labour and materials and in the absence of subsidies seem to be the most affordable, but these simpler facilities do not meet the standards being set by the Human Rights to Water and Sanitation.
- Within pro-poor strategies be prepared to finance capital expenditure for the very poor by improving subsidy design and targeting.

- With existing funds available for sanitation, it is unrealistic that governments and external agencies want the population to access more sophisticated facilities with higher service norms, especially the poorest.

7.1.3 Towards asset management

The rural water sector is capital intensive and is in an urgent need of asset management planning and allocation of financial responsibilities for support after construction has taken place (hardware and software).

Many of the investments needed in new services are a consequence of existing low levels of maintenance and the additional problem facing lower income countries concerns the existing backlog of capital maintenance. If financial resources are limited, maintaining existing infrastructure before building new is the right decision because in the future rehabilitation will cost more.

> *The problem facing public officials considering the adoption of asset management is that the damage of deferred maintenance has already occurred and needs to be addressed by a significant infusion of funding for rehabilitation or replacement that does not currently exist..." (Garvin in Amekudzi et al. 2008).*

An effective asset management strategy must provide clear answers to three key questions:

- How can capacity of local government for managing water services be economically mobilized at the local level?
- Who will provide an adequate and steady source of funding, especially for maintenance?
- And who is responsible for developing asset management plans and funding them?

7.1.4 Improving the quality of financial and economic costs reported

As shown in the literature review on unit costs, each study in the sector uses different methodologies to describe and compare costs. There are accounting standards which have been adapted from the urban to the rural sector that can be used to ensure consistency. Additionally, it is critical to link analysis of expenditure with outcomes (the services provided) and ideally with the impact (the socio-economic and health impacts) to provide useful measures of cost-effectiveness for water and sanitation services in low-middle income countries.

7.1.5 Making sense of costs

Prioritising and creating space for analysis and learning from the data is as important as reporting. Most staff in implementing organisations and government departments is not questioning, discussing and making service decisions based on expenditure surveys and data because the value added of using this sort of information is either not fully understood or does not match the incentives in place for improving accountability.

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APPENDICES

Appendix A Comparing financial data in the grey literature

The main questions when revising the literature concerned how to categorise financial costs and which methodologies have been used to compare such costs.

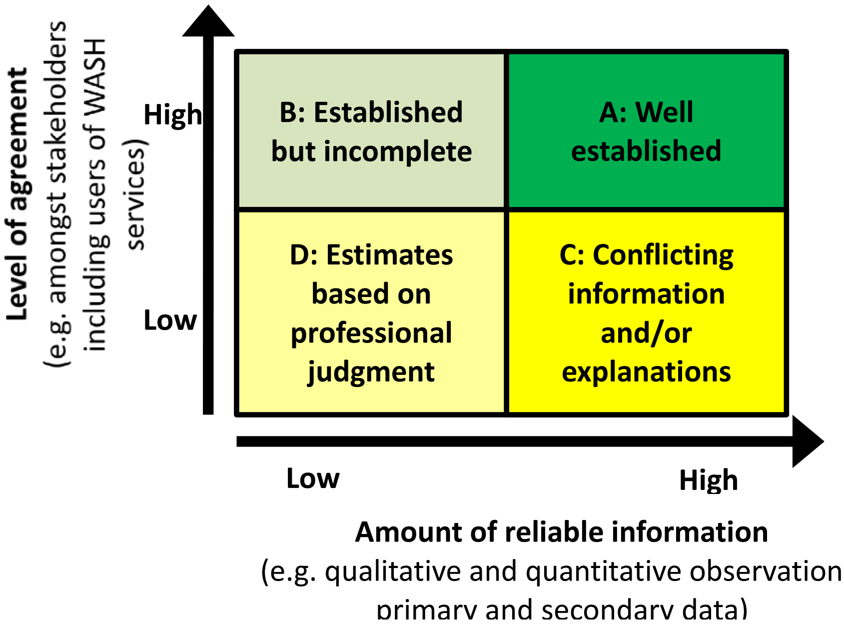
Service providers need to know their costs in order to determine how much to charge for services directly from consumers through tariffs and how much needs to be recovered through taxation (and possibly transfers). However, tracking all the financial expenditure, both from consumers and service providers is a complicated affair as demonstrated in this literature review.

Financial costs in a community in an African country can be reported as zero for a community if a scheme has been fully constructed by NGOs or government subsidies when in fact there have been “community contributions” and “international tax transfers” that took place and have a cost. Matt Damon, a famous movie star and spokesperson for the charity organisation “water.org”, mentions in a high profile campaign that it takes US$ 25 for life to provide a toilet (water.org, 2013) but these costs refer to installation only and ignore maintenance costs. A handpump which costs a community US$ 20 per person might deliver much less water and of poorer quality than a similar handpump in the same area that costs half the price.

There is not an equivalent chapter on economic costs since the literature available is very limited and data even less disaggregated for a meaningful analysis and comparison.

A.1.1 Classification system for accuracy and reliability

Cost data in the literature has been collected in different manners and accuracy and reliability differs considerably. Some publications and information are based on professional judgement, others rely on a very small number of observations. There is also cost data which comes from larger samples which were collected using systematic surveys at different governmental levels. Some authors have been personally contacted to clarify some of the data reported. In order to ensure that readers are aware of the reliability and limitations of the cost data reported, a classification system has been chosen for the analysis of the unit costs data collected (Figure A-1). Information is labelled from A to D, with A being well established information and therefore the most reliable and D consisting of broad estimates based on professional judgement. As more information is collected, discussed and validated it is possible for information to move from D to A.



Coding	Description
A	This rating is achieved if: 1) A body of accurate and precise information has been built up on for, example, the OpEx of single-village supply schemes; 2) This information is not contested amongst stakeholders (including users); 3) The sample size is large enough to support statistical analysis of variability and analysis of the main causes of this variability; and 4) An understanding has built up on levels and root causes of uncertainty in this information.
B	This rating is achieved if: 1) A limited body of accurate and precise information has been collected on for, example, the OpEx of single-village supply schemes and 2) This information is not contested amongst stakeholders (including users).
C	This rating is achieved if: 1) A body of accurate and precise information has been built up on for, example, the OpEx of single-village supply schemes; 2) The sample size is large enough to support statistical analysis of variability and analysis of the main causes of this variability; and 3) An understanding has built up on levels and root causes of uncertainty in this information. However, the information or interpretations of this information is contested.
D	Most information collected and quality controlled is likely to have this rating. However, this is expected to change as more evidence is accumulated.

Source: adapted from IWMI, 2007 and Ofwat, 2004

Figure A-1 Classification system for measuring accuracy and reliability of cost data in the literature

This system has been adapted from models used by IWMI (2007) and by Ofwat (2004). The Ofwat system provides a reliability system of A to D and provides scores 1-5 for confidence grades which have substituted the previous 1-4 accuracy bands which were based on the percentage of cost information thought reliable. The strength of the IWMI model is that it brings together accuracy and reliability in a two dimensional scale (4 possibilities instead of 20). Together with the source of information this classification system provides readers with a (visual) understanding of the reliability and limitations of the information being collected and also shows the level of agreement that exists regarding the information amongst stakeholders. In the Ofwat model, percentages or bands for accuracy are expected to be provided by the data collectors and analyst (i.e. 10% percent accurate) which are too vague and open for interpretation. The adaptation of the IWMI classification system uses the OFWAT approach, but it made it more practical for the purpose of the data being collected which is expected to become more accurate and reliable the more it is requested and collected.

A.1.2 Data analysis framework for the grey literature

Cost data from the literature was collected when the literature review was done, harmonised and analysed. An Excel spread sheet has been developed for this purpose. The fields of the spreadsheet for data analysis include:

- Reference (author, date)
- Technology options for which there are costs available (Table 10)
- Regional location (Africa, Asia, Latin America or globally for lower income countries)
- Location (country or area name)
- Main data source (official government publication, other official publication, report or interview/professional judgement). No data was used from the media or directly from household surveys or focus group discussions which are later used in the analysis chapters.
- Information reliability code (**Error! Reference source not found.**)
- Currency as reported in the documents
- The date of the costs reported
- Cost components
- Currency comparability process described below

A.1.3 Caveats and assumptions

Most unit costs in the literature have been calculated per capita and per year for easier comparison with the data resulting from the household surveys. In networked water supply services, it is most common to use the cost per cubic meter, as it measures to some extend the efficiency of the utility but it doesn't reflect the existing and potential coverage. In non-networked (mostly rural) water supply services, the cost per cubic meter is rarely available given the non-existence of metered connections. The calculations in this exercise did not take into account the (limited) literature with costs per cubic meter.

Most of the sanitation unit costs in the literature have been provided per household. For reaching a figure per capita, all data has been divided by 5. The water unit costs are already reported per capita, however there were many instances when only the cost per infrastructure has been provided without a measure of the population covered. This data has not been used.

Assumptions about length of life, and volume of water/wastewater involved per head, are crucial for cost comparability, and unclear from the cost data found in the literature. The implication for the validity of the analysis is that a technological option which has an (unrealistic) assumption of a long working life will seem cheaper than other options or the other way around. Finally, the literature presents the actual costs, not the ideal costs and there is no link with the real level of services provided (or not provided). Therefore data needs to be treated carefully if quoted elsewhere.

A.1.4 Literature cost analysis framework (illustrative only)

Costs per capita rural and peri-urban water (US$ 2011)

Reference	Technology options	Location	Region	Main data source	Data reliability	Currency as reported	Date costs reported	GDP deflator index (2011 current prices)	USD PPP 2011	USD 2011	CapEx Local currency	CapEx USD PPP 2011	CapEx USD 2011	OpEx Local currency	OpEx USD PPP 2011	OpEx USD 2011	CapManEx Local currency	CapManEx USD PPP 2011	CapManEx USD 2011
								See "Currency indicators" sheet											
Carefoot and Gibson, 1984	Peri-urban water	Low income countries	Africa	Report	D	USD	1984	1.93	1	1	100	193.00	193.00						
Carefoot and Gibson, 1984	Rural water	Low income countries	Africa	Report	D	USD	1984	1.93	1	1	30	57.90	57.90						
Christmas and Rosy, 1990	Peri-urban water	Low income countries	Low income countries	Interview	D	USD	1990	1.6	1	1	100	160.00	160.00						
Christmas and Rosy, 1990	Rural water	Low income countries	Low income countries	Interview	D	USD	1990	1.6	1	1	30	48.00	48.00						
Smits and Fonseca, 2007	Borehole distribution system with public standposts	Low income countries	Low income countries	Interview	D	USD	2004	1.18	1	1	70	82.60	82.60						
Smits and Fonseca, 2007	Hand dug well	Low income countries	Low income countries	Interview	D	USD	2004	1.18	1	1	25	29.50	29.50						
Smits and Fonseca, 2007	Household rain water harvesting	Low income countries	Low income countries	Interview	D	USD	2004	1.18	1	1	40	47.20	47.20						
Smits and Fonseca, 2007	Manually drilled borehole with handpump	Low income countries	Low income countries	Interview	D	USD	2004	1.18	1	1	20	23.60	23.60						
WaterAid Nepal, 2004	Manually drilled borehole with handpump	Nepal	Asia	Report	B	USD	2004	1.18	1	1	45	53.10	53.10						
Smits and Fonseca, 2007	Multi village scheme (gravity fed mostly with standpipes)	Low income countries	Low income countries	Interview	D	USD	2004	1.18	1	1	50	59.00	59.00						
WaterAid Nepal, 2004	Multi village scheme (gravity fed mostly with standpipes)	Nepal	Asia	Report	B	USD	2004	1.18	1	1	45	53.10	53.10						
Smits and Fonseca, 2007	Self supply (protected HH shallow well)	Low income countries	Low income countries	Interview	D	USD	2004	1.18	1	1	3	3.54	3.54						
WaterAid Nepal, 2004	Shallow well with handpump	Nepal	Asia	Report	B	USD	2004	1.18	1	1	10	11.80	11.80						
Smits and Fonseca, 2007	Small piped system	Low income countries	Low income countries	Interview	D	USD	2004	1.18	1	1	110	129.80	129.80						
WaterAid Nepal, 2004	Small piped system	Nepal	Asia	Report	B	USD	2004	1.18	1	1	40	47.20	47.20						
Hutton, 2008	Hand dug well	Africa	Africa	Report	D	USD	2005	1.15	1	1	34	39.10	39.10	0.2	0.23	0.23			
Hutton, 2008	Hand dug well	Asia	Africa	Report	D	USD	2005	1.15	1	1	35	40.25	40.25	0.2	0.23	0.23			
Hutton, 2008	Hand dug well	Latin America	Latin America	Report	D	USD	2005	1.15	1	1	77	88.55	88.55	0.5	0.58	0.58			
SNNPR, 2008	Hand dug well	Ethiopia	Africa	Official gov	C	ETB	2005	2.41	5.60000	16.9	40	17.23	5.70						
Hutton, 2008	Household rain water harvesting	Africa	Africa	Report	D	USD	2005	1.15	1	1	79	90.85	90.85	0.5	0.58	0.58			
Hutton, 2008	Household rain water harvesting	Asia	Asia	Report	D	USD	2005	1.15	1	1	55	63.25	63.25	0.4	0.46	0.46			
Hutton, 2008	Household rain water harvesting	Latin America	Latin America	Report	D	USD	2005	1.15	1	1	58	66.70	66.70	0.4	0.46	0.46			
PRM/WSP, 2005	Household rain water harvesting	Kenya	Africa	Report	A	KES	2005	1.51	41.76	88.81	9818	355.01	167.36	160	5.26	2.88			
SNNPR, 2008	Large spring development	Ethiopia	Africa	Official gov	C	ETB	2005	2.41	5.60000	16.9	75	33.67	10.70						
PRM/WSP, 2005	Manually drilled borehole with handpump	Kenya	Africa	Report	A	KES	2005	1.51	41.76	88.81	329	11.90	5.59	16	0.58	0.27			
SNNPR, 2008	Manually drilled borehole with handpump	Ethiopia	Africa	Official gov	C	ETB	2005	2.41	5.60000	16.9	122	54.65	17.40				18	8.03	2.57
Hutton, 2008	Mechanically drilled borehole with handpump	Africa	Africa	Report	D	USD	2005	1.15	1	1	37	42.55	42.55	0.2	0.23	0.23			
Hutton, 2008	Mechanically drilled borehole with handpump	Asia	Asia	Report	D	USD	2005	1.15	1	1	27	31.05	31.05	0.2	0.23	0.23			
Hutton, 2008	Mechanically drilled borehole with handpump	Latin America	Latin America	Report	D	USD	2005	1.15	1	1	89	102.35	102.35	0.6	0.69	0.69			
PRM/WSP, 2005	Mechanically drilled borehole with handpump	Kenya	Africa	Report	A	KES	2005	1.51	41.76	88.81	1788	63.66	29.47	27	0.98	0.46			
SNNPR, 2008	Mechanically drilled borehole with handpump	Ethiopia	Africa	Official gov	C	ETB	2005	2.41	5.60000	16.9	255	113.81	36.36				23	10.26	3.28
Hutton, 2008	Medium piped system	Africa	Africa	Report	D	USD	2005	1.15	1	1	164	188.60	188.60	13.4	15.41	15.41			
Hutton, 2008	Medium piped system	Asia	Asia	Report	D	USD	2005	1.15	1	1	148	170.20	170.20	9.6	11.04	11.04			
Hutton, 2008	Medium piped system	Latin America	Latin America	Report	D	USD	2005	1.15	1	1	232	266.80	266.80	14.6	16.79	16.79			
PRM/WSP, 2005	Medium piped system	Kenya	Africa	Report	A	KES	2005	1.51	41.76	88.81	1779	64.33	30.25	168.6	5.87	2.83			
SNNPR, 2008	Medium piped system	Ethiopia	Africa	Official gov	C	ETB	2005	2.41	5.60000	16.9	486	216.90	69.31						
PRM/WSP, 2005	Sand dam	Kenya	Africa	Report	A	KES	2005	1.51	41.76	88.81	2941	106.34	50.00	4.8	0.17	0.08			
SNNPR, 2008	Shallow well with handpump	Ethiopia	Africa	Official gov	C	ETB	2005	2.41	5.60000	16.9	93	41.51	13.26				14	6.25	2.00
Hutton, 2008	Small piped system	Africa	Africa	Report	D	USD	2005	1.15	1	1	50	57.50	57.50	0.5	0.58	0.58			
Hutton, 2008	Small piped system	Asia	Asia	Report	D	USD	2005	1.15	1	1	103	118.45	118.45	1	1.15	1.15			
Hutton, 2008	Small piped system	Latin America	Latin America	Report	D	USD	2005	1.15	1	1	66	75.90	75.90	0.7	0.81	0.81			

A.1.5 Further details on analysis of grey literature costs

Comparing the average capital expenditure US$ PPP 2011 (Figure A-2) with the CapEx US$ GDP 2011 using the official exchange rate, the differences are minimal (**Error! Reference source not found.**). This is explained by the fact that most of the unit costs reported for non-African countries have been already converted to US$ using an official exchange rate. Therefore most of the calculations made in US$ PPP 2011 are not accurate.

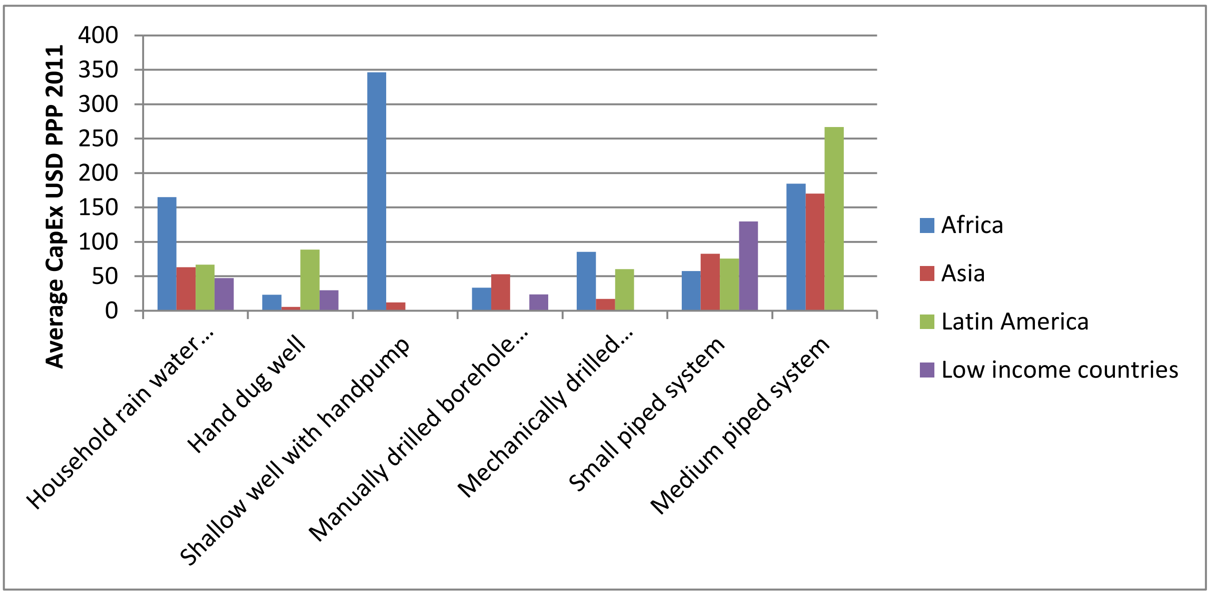


Figure A-2 Average per capita capital expenditure drinking water rural and peri-urban areas US$ PPP 2011

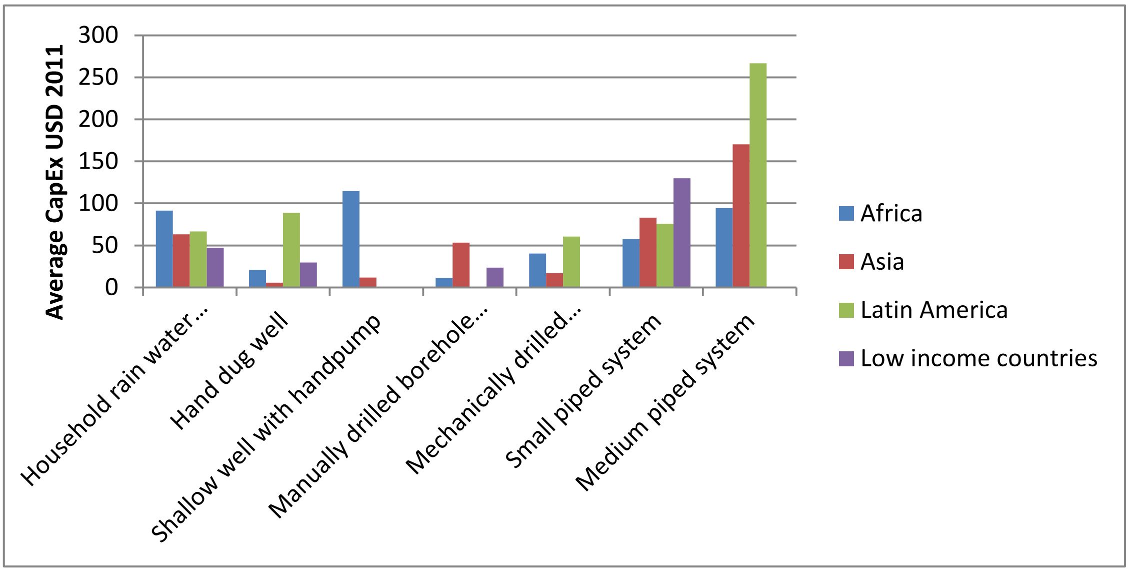


Figure A-3 Average per capita capital expenditure drinking water rural and peri-urban areas US$ GDP 2011

The reliability of the unit cost information has increased with far more data available for Africa but also falling under categories A (Well Established) and B (Established but incomplete) (Table A-1). The professional estimates for lower income countries, including some of the first references from 1990 and 2000 fall well under the ranges of the overall unit costs mentioned.

Table A-1 Technology options reliability/accuracy code per region (water and sanitation)

Reliability coding for unit costs sources	Count of options reviewed: drinking water	Count of options reviewed: sanitation
Africa	37	60
A	12	11
B	6	20
C	11	2
D	8	27
Asia	12	57
A	0	1
B	6	32
D	6	24
Latin America	6	10
B	1	1
D	5	9
Lower income countries	9	4
B	0	1
D	9	3
Grand total	64	131

An analysis per region (Figure A-4 and Figure A-5) shows clear regional disparities in the sanitation capital expenditure per person per technology type. Most of the currencies are being reported in US$ and the effects of undervalued currency cannot be fully taken into account. However, it is clear that either using market exchange rates or PPP current prices 2011, the costs of the same technologies is considerably more expensive in Africa and Latin America and cheaper in Asia.

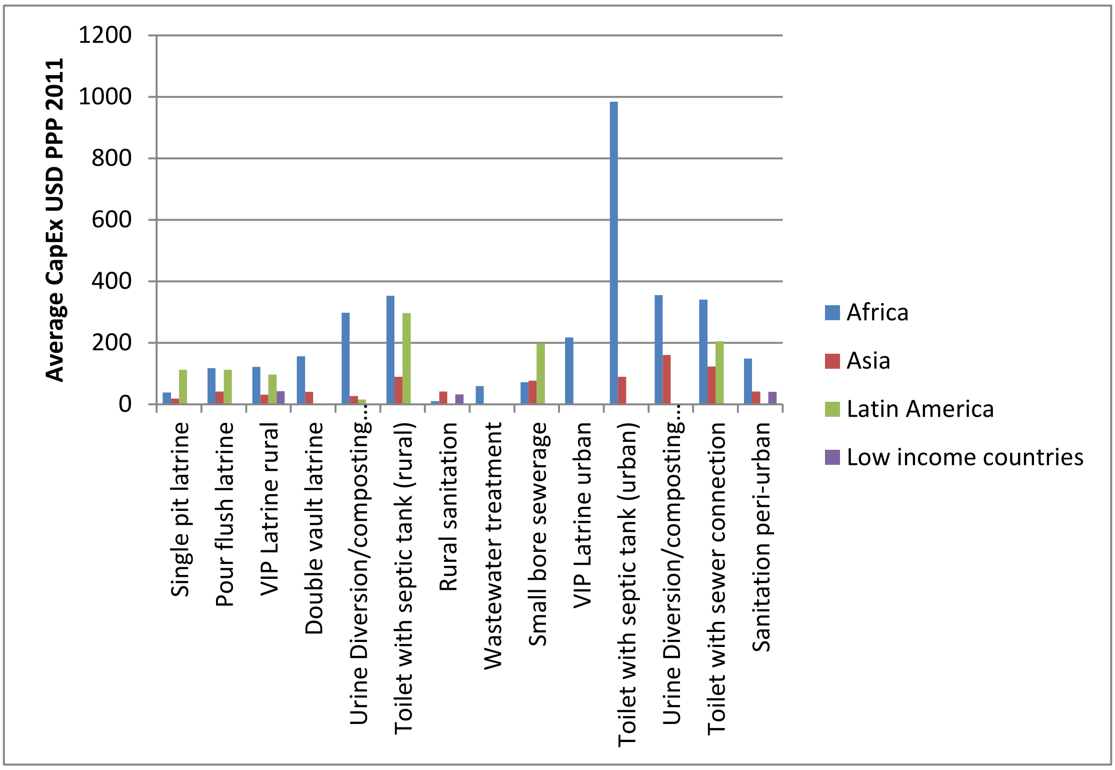


Figure A-4 Average per capita capital expenditure sanitation rural and peri-urban areas US$ PPP 2011

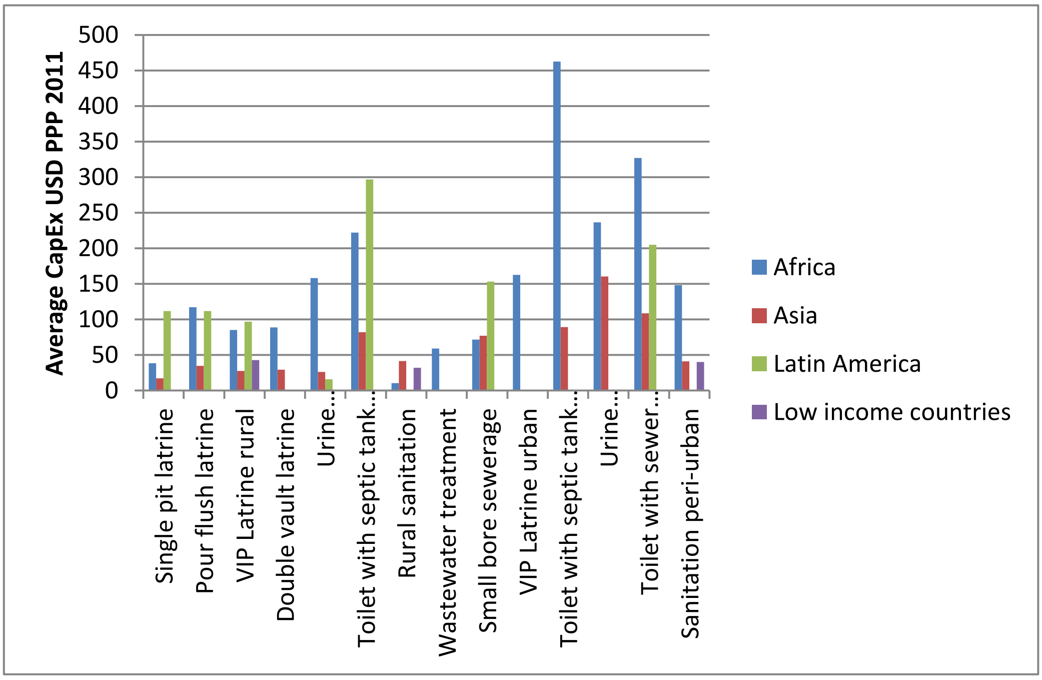


Figure A-5 Average per capita capital expenditure sanitation rural and peri-urban areas US$ 2011

Appendix B Socio-economic categories

This chapter describes the findings from dividing the sample into poverty categories based on reported expenditure for Mozambique and on the main economic activity of head of household for the Ghana sample.

Given the results from applying different methods for measuring poverty in the sample, the best indicator to categorise household socio-economic categories is expenditure per person per day (2010 prices). However, this information is not available for Ghana (except for the smaller pilot trial). In Mozambique, the national and the international poverty lines show that the large majority of the sample – from a global perspective – is made of households who are very poor or poor.

B.1.1 Mozambique sample: households general characterisation

The initial sample based on households reported expenditure shows that the standard deviation is not close to the mean (Table B-1), there is high variance and the distribution is highly skewed to the left (Figure B-1). This initial statistical analysis is done in meticais and to show-case what has been done with all the other variables before presenting the findings, but not shown in this document.

Table B-1 Frequencies Mozambique sample before outliers removed

N	Valid	1693
	Missing	17
Mean		12.18
Median		7.54
Std. Deviation		14.765
Variance		217.995
Skewness		4.087
Std. Error of Skewness		.059
Kurtosis		29.900
Std. Error of Kurtosis		.119

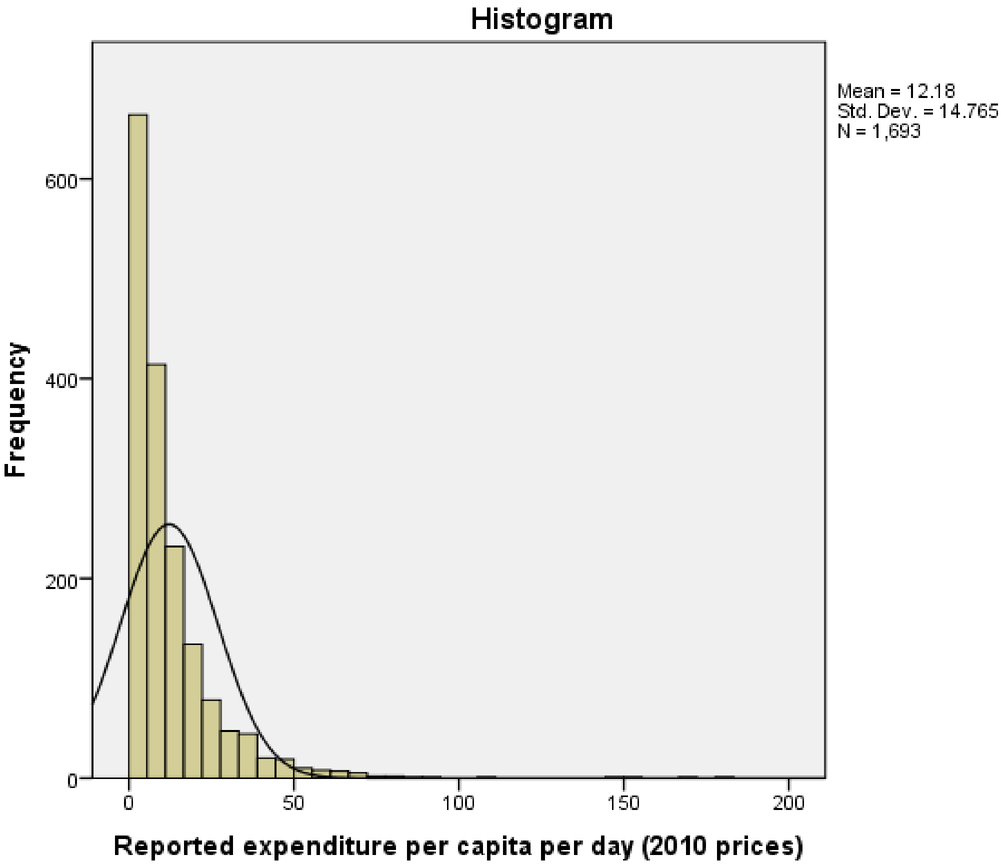


Figure B-1 Histogram for reported expenditure (meticais) before outliers removed

The P-P plot shows the cumulative probability of each variable against the cumulative probability of a normal distribution. The data are ranked and sorted and the z-scores calculated. If values fall on the diagonal of the plot then the variable is normally distributed, however, when 1) the data sag consistently above or below the diagonal then the kurtosis differs from a normal distribution 2) when the data points are S-shaped the problem is skewedness. Both are present in the expenditure distribution for rural (Figure B-2) and peri-urban populations (Figure B-3).

This means that the distribution is not normal but in practical terms, as long as the sample is fairly large (which is the case), outliers are a more pressing concern than normality because normality really matters when we want to construct confidence intervals around the parameters and given the size of the dataset, the measures of central tendency still apply.

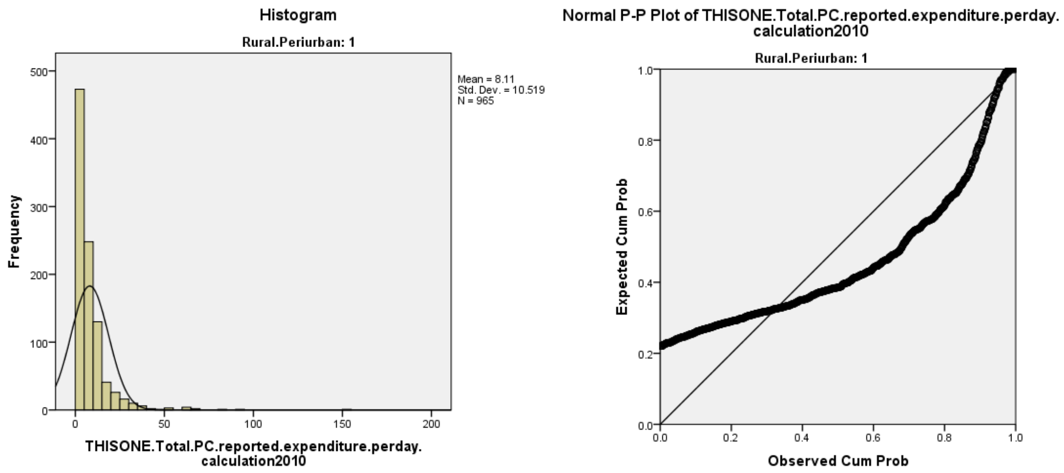


Figure B-2 Histogram and normal P-P plot of <u>rural</u> expenditure sample

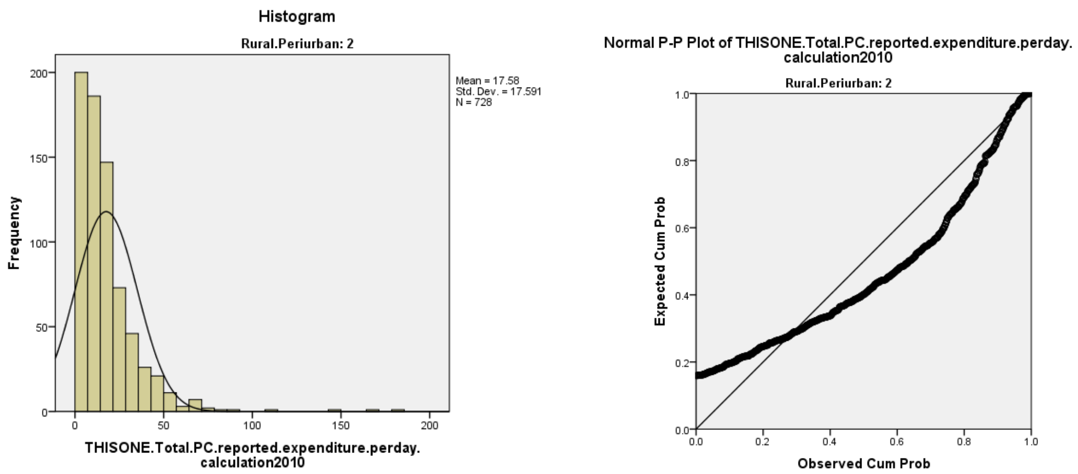


Figure B-3 Histogram and normal P-P plot of <u>peri-urban</u> expenditure sample

In the histogram on the left a lot of what look like outliers have been detected. A more detailed analysis using a plot box shows many extreme values illustrated by the small stars (Figure B-4). These extreme values can induce a lot of bias in the results.

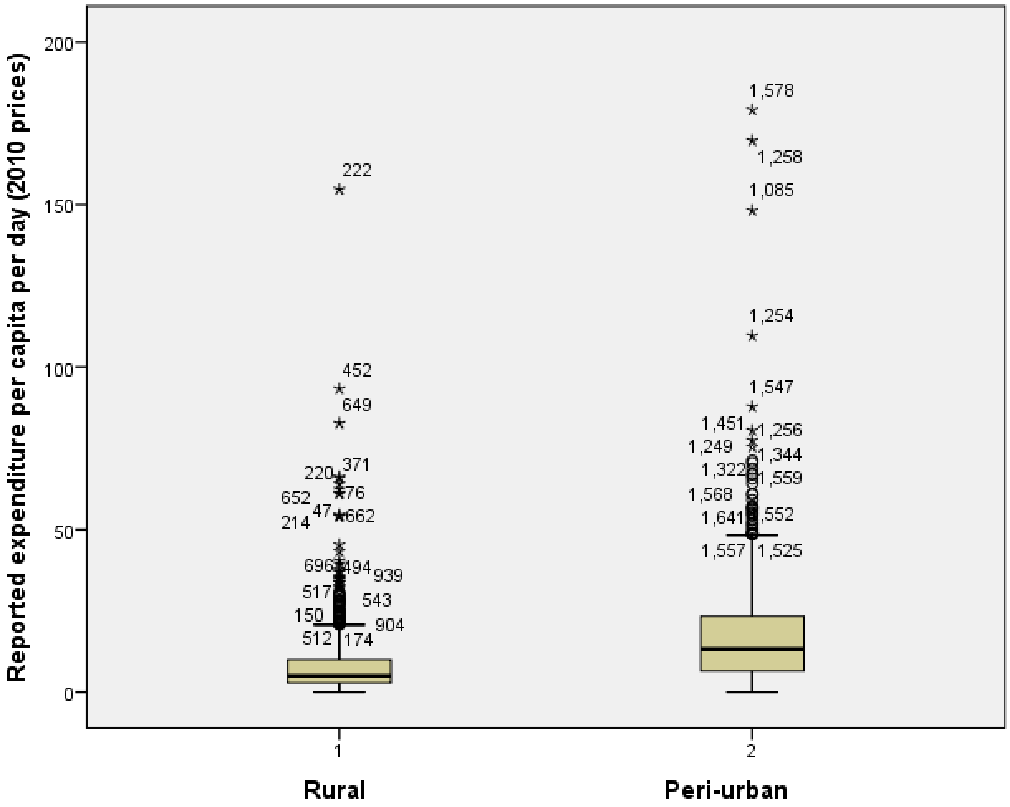


Figure B-4 Plot graph of reported expenditure per capita per day (meticais 2010 prices) for rural and peri-urban population before removal of outliers

To reduce the bias, trimming the data was done by deleting a certain amount of scores from the extremes using robust methods. The data was converted into z scores to look for the outliers. It was expected that about 5% of z scores to be greater than 1.96; 1% to be greater than 2.58 and none to be greater than 3.29. The count of z scores identified the following outliers (Table B-2).

Table B-2 Count of z scores for identifying outliers

Z scores	Count	Column N %
Extreme z scores>3.29	26	1.5%
Probable outliers z>2.58	15	0.9%
Potential outliers z>1.96	29	1.7%
Normal range	1622	95.9%

Based on the identification of outliers, the extreme scores and the probable outliers have been eliminated (41 values). The histogram post outlier cleaning shows a standard deviation closer to the mean and a lower skew (Table B-3, Figure B-5).

Table B-3 Frequencies Mozambique sample after outliers removed

N	Valid	1652
	Missing	58
Mean		10.63
Std. Error of Mean		.245
Median		7.33
Std. Deviation		9.975
Skewness		1.539
Std. Error of Skewness		.060
Kurtosis		2.162
Std. Error of Kurtosis		.120
Percentiles	25	3.37
	50	7.33
	75	14.67

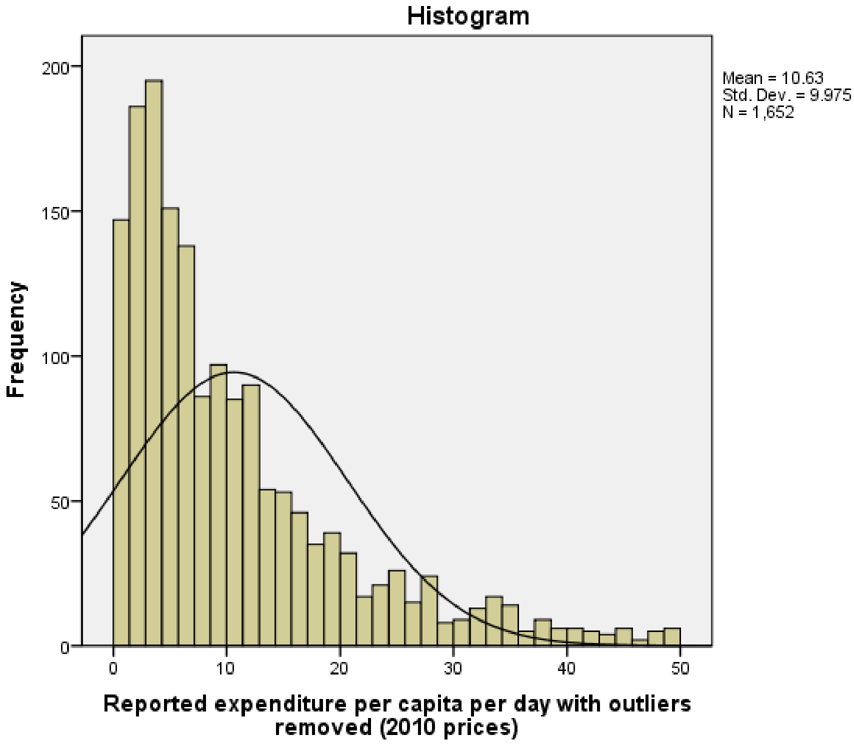


Figure B-5 Histogram for reported expenditure (meticais) after outliers removed

Looking at the distribution and avoiding a totally arbitrary choice, it was decided to classify the sample population using the percentiles ranges (at the bottom of Table B-3) within the following categories (Table B-4 in meticais and in USD in Figure B-5).

Table B-4 Socio-economic categories for the sample population using expenditure percentiles after outliers removed, Mozambique

Percentiles ranges	Socio-economic category	Count (%)	Rural (%)	Peri-urban (%)
First and second percentile	Poorest (Exp2010 < 7.33)	827 (50.1)	623 (65.4)	204 (29.2)
Third percentile	Poor (Exp2010 7.34 - 14.67)	411 (24.9)	223 (23.4)	188 (26.9)
Fourth percentile	Least poor (Exp2010 > 14.68)	412 (25.0)	106 (11.1)	306 (43.8)

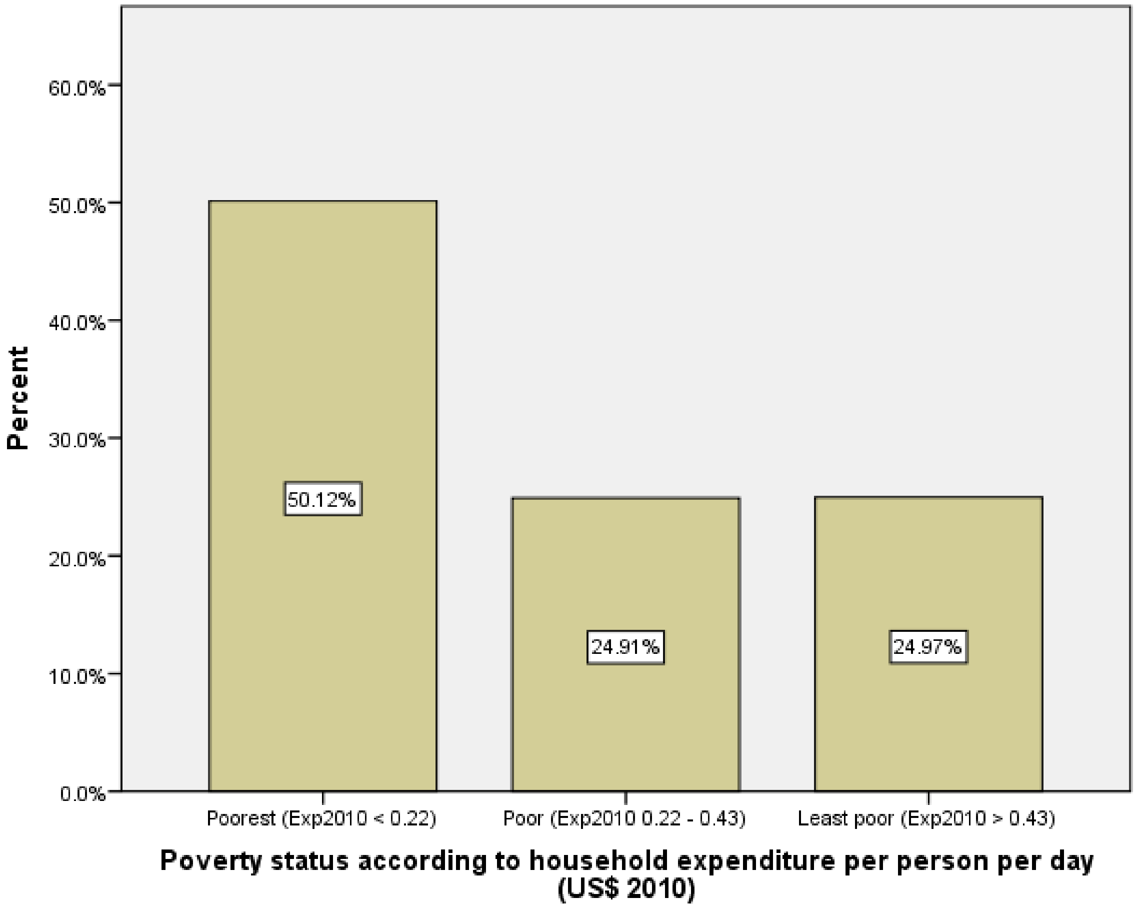


Figure B-6 Poverty status for Mozambique sample

B.1.2 Ghana sample: households general characterisation

For Ghana, the only way to categorise the households into sub-sets was to divide them according to the activity of the head of the household as a broad equivalence to the socio-economic status. An attempt was made to further divide the poorest into poor and very poor but the results were not different enough (Figure B-7). Some other tests were done to analyse this possibility which was discarded. The Ghana sample was therefore divided only into two categories: poor and non-poor (Figure B-8)

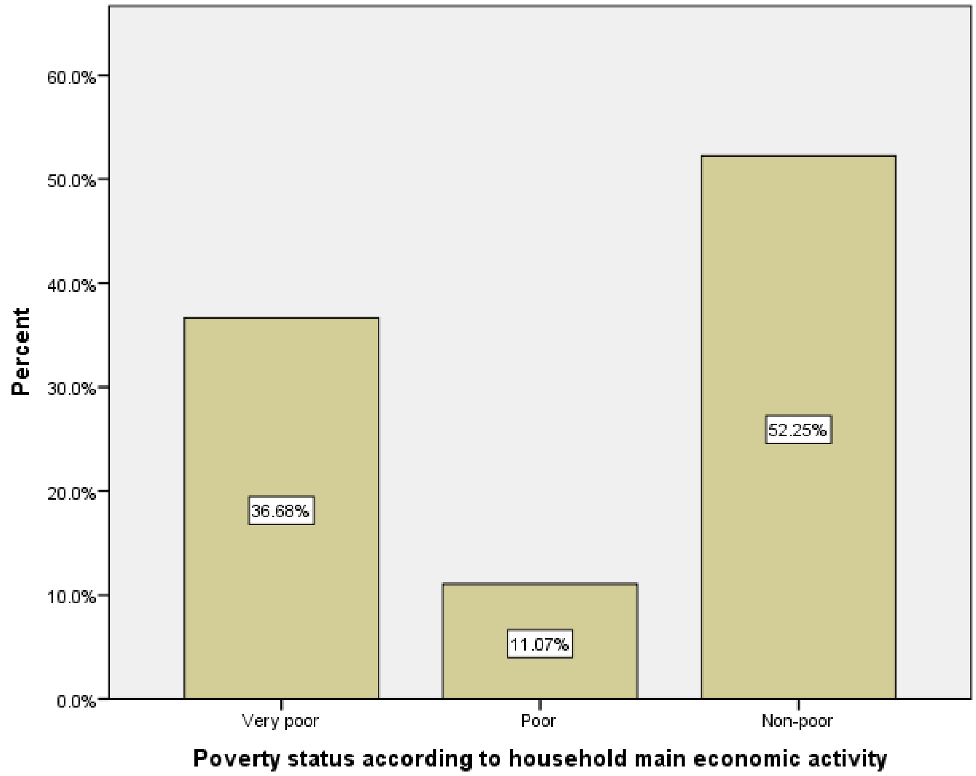


Figure B-7 Poverty status for Ghana sample with three categories

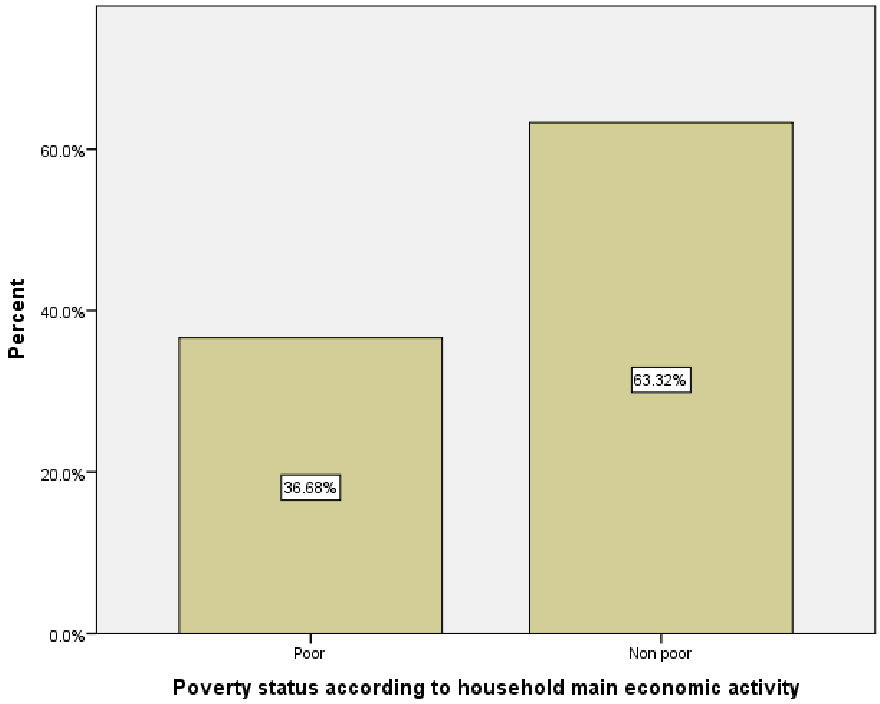


Figure B-8 Poverty status for Ghana sample with two categories

Appendix C Water sources and uses

C.1.1 Mozambique

In Mozambique, both in rural and peri-urban areas about a quarter of the households in the sample access an alternative source during the dry season which tends to be predominantly unprotected wells and other informal sources, independently of the poverty status. In the wet season, 9.2% of rural households access another source other than the one in the dry season, while in peri-urban areas the percentage is slightly lower (6.6%). The additional source in the dry season is in the majority of cases an informal source. A smaller minority in the sample (2.7% of rural and 1.3% of peri-urban households respectively) accesses a secondary source during the wet season.

The primary sources in the dry and wet season are mainly used for drinking, for cooking, dishwashing, hand washing and body washing (Figure C-1). The alternative sources in both seasons are used for drinking when the main source fails and, in addition to the uses above, are used for washing clothes. There are a limited number of households that use any of the drinking sources for productive activities such as irrigation or construction but when this happens they mainly use the primary and alternative sources in the dry season.

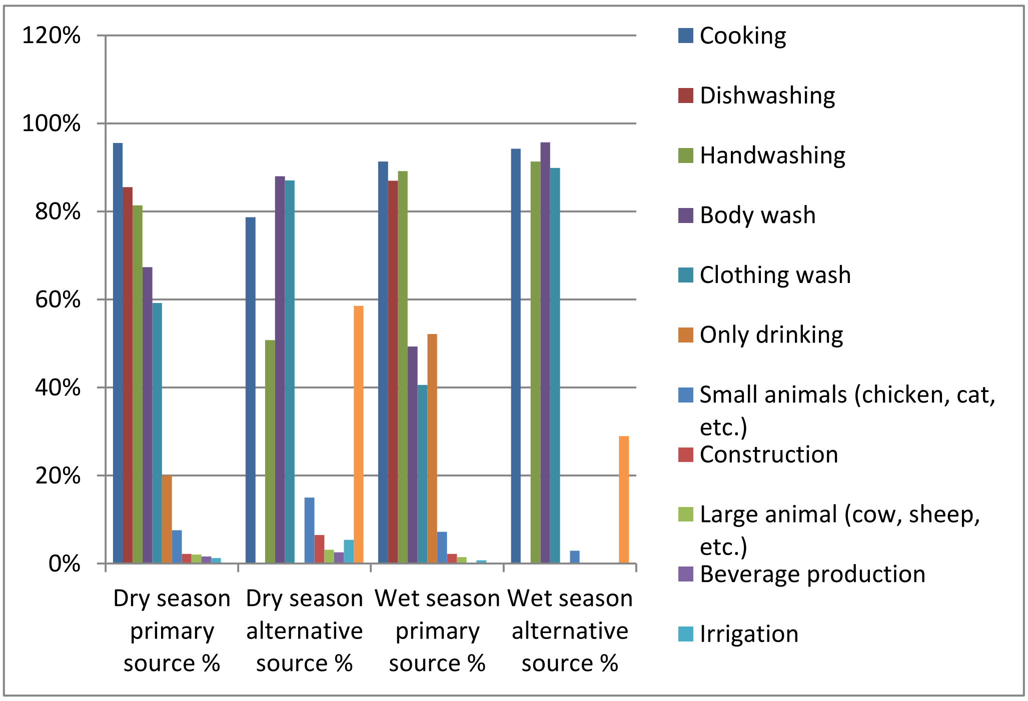


Figure C-1 Uses of water sources dry and wet seasons different sources (%)

Table C-1 Uses of water sources dry and wet seasons, Mozambique

Uses of water	Water source dry season (%)		Water sources wet season when different from dry season (%)	
	Primary (N=1710)	Alternative (N=540)	Primary (N=138)	Alternative (N=69)
Cooking	1634 (96%)	425 (79%)	126 (91%)	65 (94%)
Dishwashing	1462 (85%)	na	120 (87%)	Na
Handwashing	1391(81%)	274 (51%)	123 (89%)	63 (91%)
Body wash	1152 (67%)	475 (88%)	68 (49%)	66 (96%)
Clothing wash	1012 (59%)	470 (87%)	56 (41%)	62 (90%)
Only drinking	342 (20%)	na	72 (52%)	Na
Small animals (chicken, cat, etc.)	130 (8%)	81(15%)	10 (7%)	2 (3%)
Construction	38 (2%)	35 (6%)	3 (2%)	0 (0%)
Large animal (cow, sheep, etc.)	35 (2%)	17 (3%)	2 (1%)	0 (0%)
Beverage production	28 (2%)	14 (3%)	0 (0%)	0 (0%)
Irrigation	22(1%)	29 (5%)	1 (1%)	0 (0%)
Drinking when primary source fails	na	316 (59%)	na	20

Table C-2 Uses of water sources dry and wet seasons, Mozambique

Reasons for using water sources	Water source dry season (%)		Water sources wet season (%)	
	Primary (N=1710)	Alternative (N=540)	Primary (N=138)	Alternative (N=69)
The water is of good quality	607 (35%)	150 (28%)	30 (22%)	26 (38%)
It's the closest source	535 (31%)	164 (30%)	28 (20%)	23 (33%)
It is the only source (or available when the other breaks down)	476 (28%)	18 (3%)	10 (7%)	7 (10%)
There is always water	380 (22%)	203 (38%)	11 (8%)	2 (3%)
The cost of water is reasonable	330 (19%)	9 (2%)	15 (11%)	0
Water is free	246 (14%)	239 (44%)	24 (17%)	42 (61%)
The queuing time is low	143 (8%)	201(37%)	46 (33%)	14 (20%)
To reuse rainwater	0	0	17 (12%)	5 (7%)

C.1.2 Ghana

In Ghana, the majority of households (62% N=836) use formal sources for all domestic purposes (Figure C-2). Formal sources are also being used by 25% (N=333) of the households for commercial uses. Water is mostly used for cooking and selling food (Figure C-3). Informal sources are mostly used for domestic purposes but also for productive uses (Figure C-4). When the analysis is done per socio-economic group, the non-poor use the water from formal sources primarily also to cook and sell food and then for livestock.

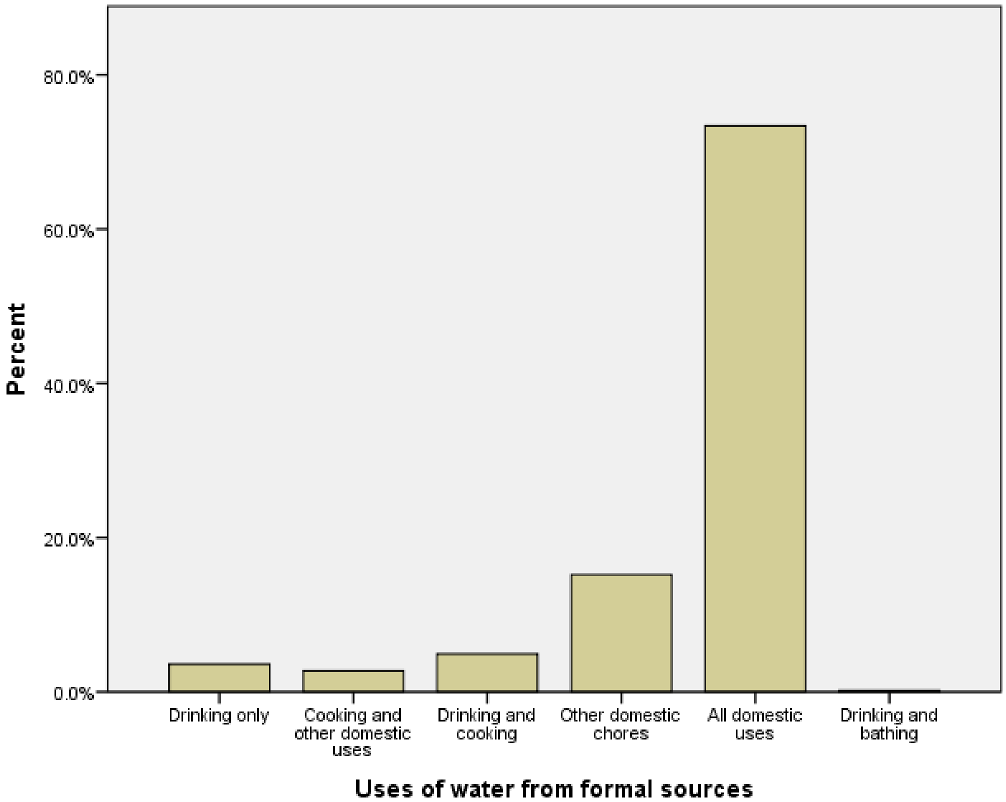


Figure C-2 Domestic uses of water from formal sources, Ghana

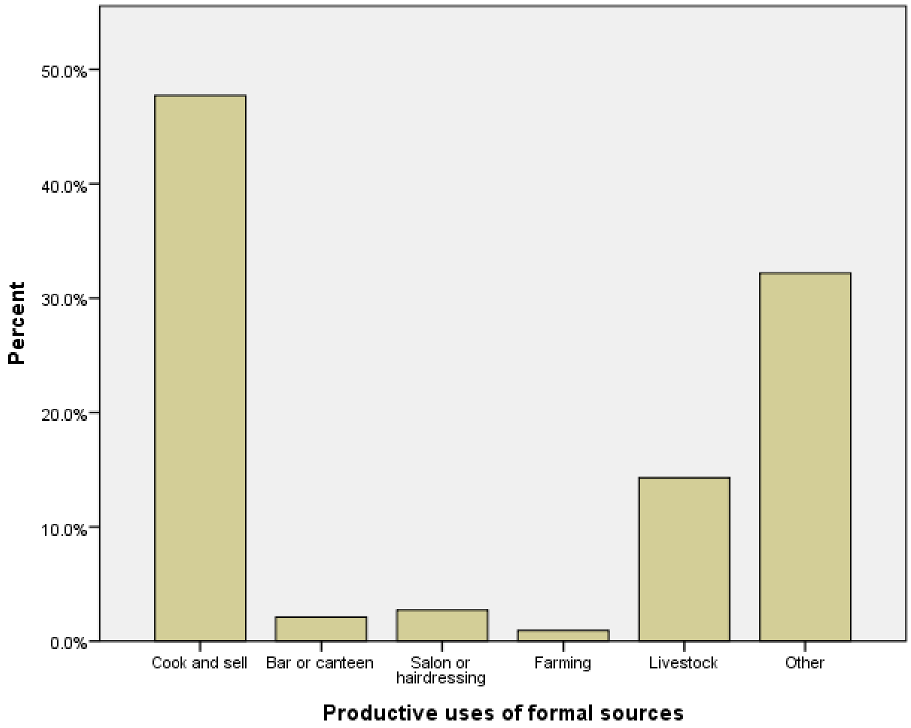


Figure C-3 Productive uses of water from formal sources, Ghana

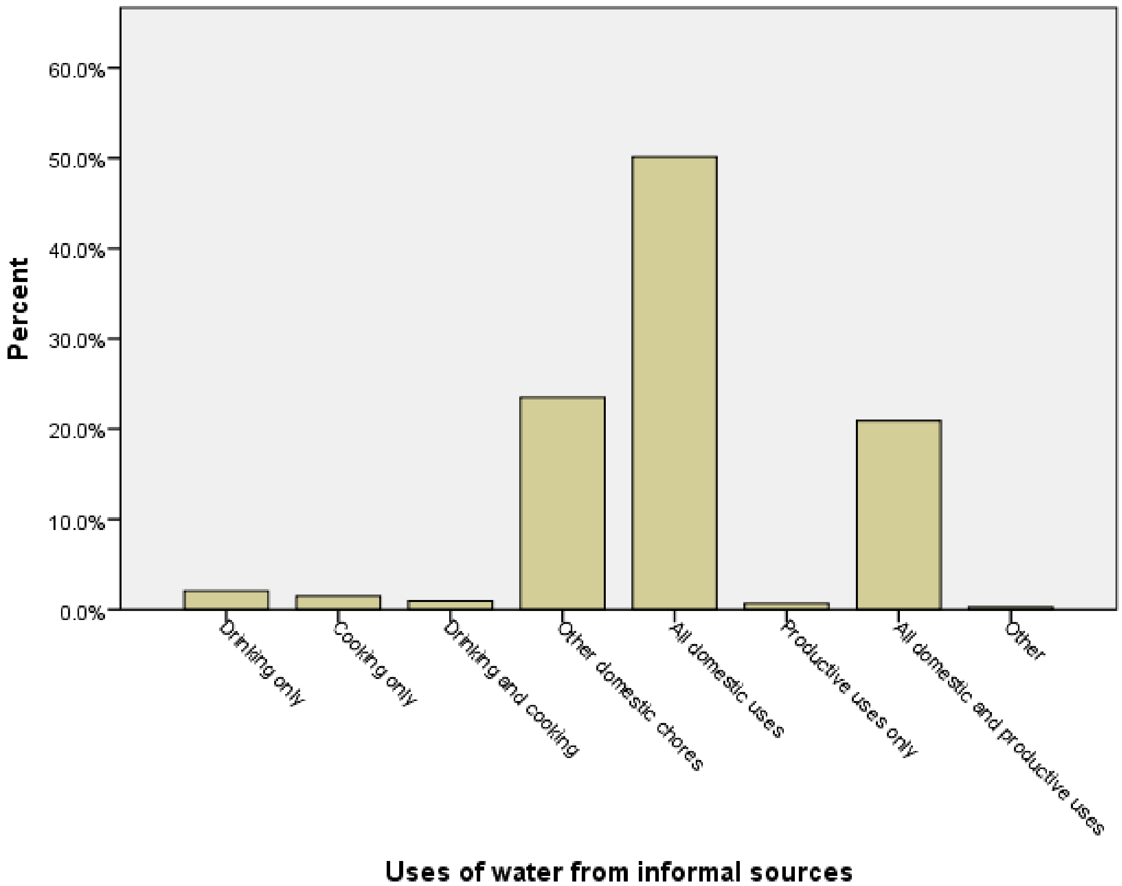


Figure C-4 Uses of water from informal sources

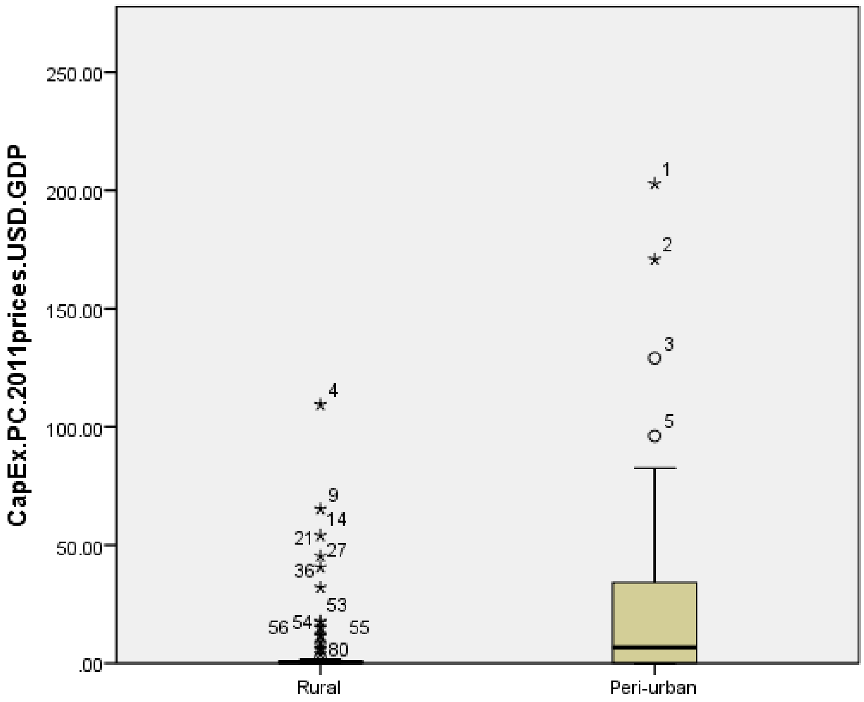
Appendix D Household financial expenditure for accessing water

D.1.1 Mozambique

There are three ways to analyse household capital expenditure: rural vs peri-urban areas, per socio-economic status and per main source of water supply. These are shown in the plot graphs (Figure D-1). The most extreme outliers have been removed but other extreme values have not been deleted as there are reasons to believe they are valid – however this makes the distributions and ranges large (see summary interquartile ranges and sample sizes in (Table D-1).

In general per capita capital expenditure contribution is:

- Lower in rural areas with a median of $0.43 USD 2011 prices per capita against $6.70 in peri-urban areas;
- Lower for the poorest (median $0.33) and higher for the least poor (median $24.74);
- Higher for household own sources such as yard taps and lower for communal system such as boreholes and wells. The sample is too small to draw conclusions for the other sources. No capital expenditure was registered on neighbours' taps or with water collected from rivers, streams or lakes.



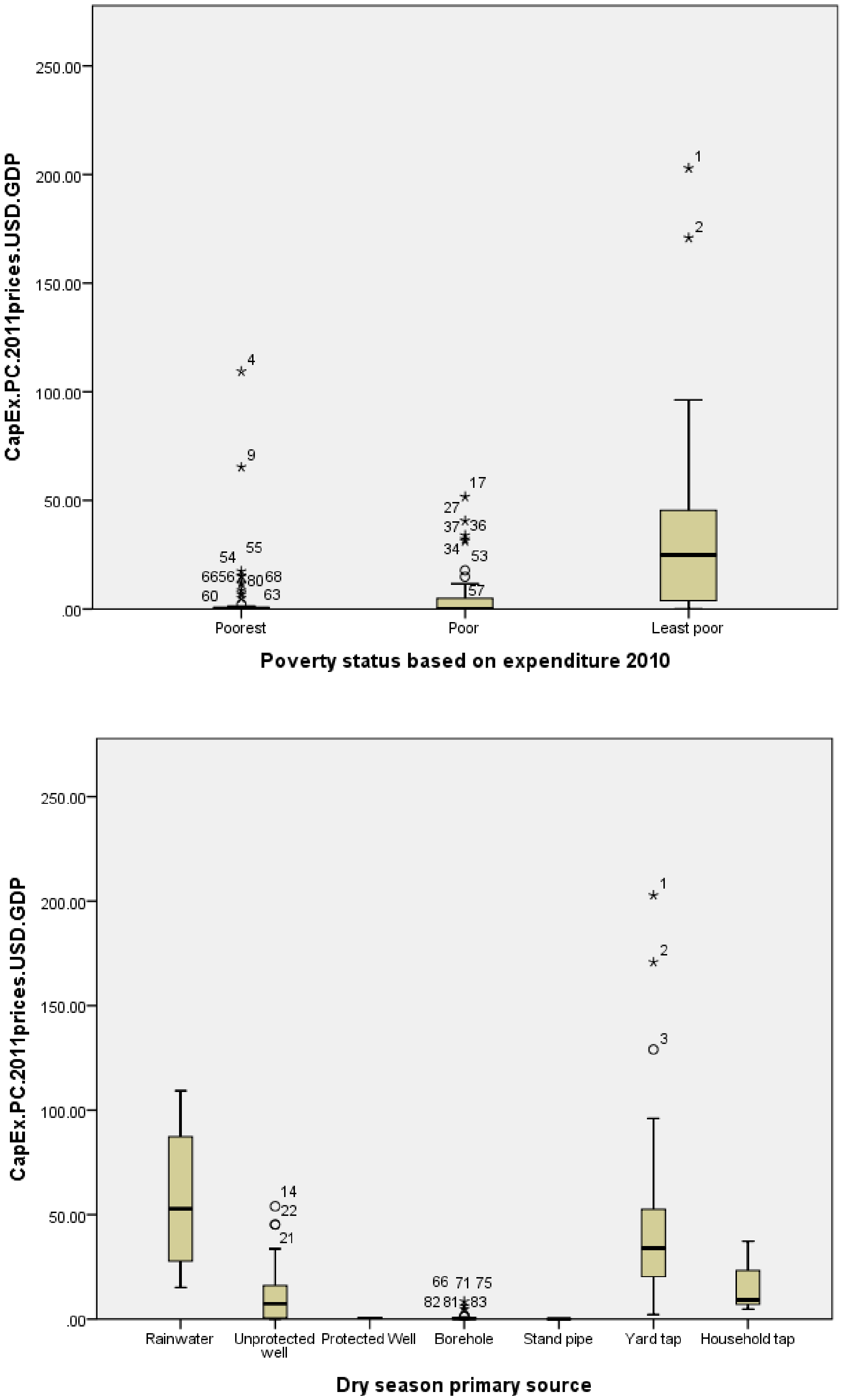


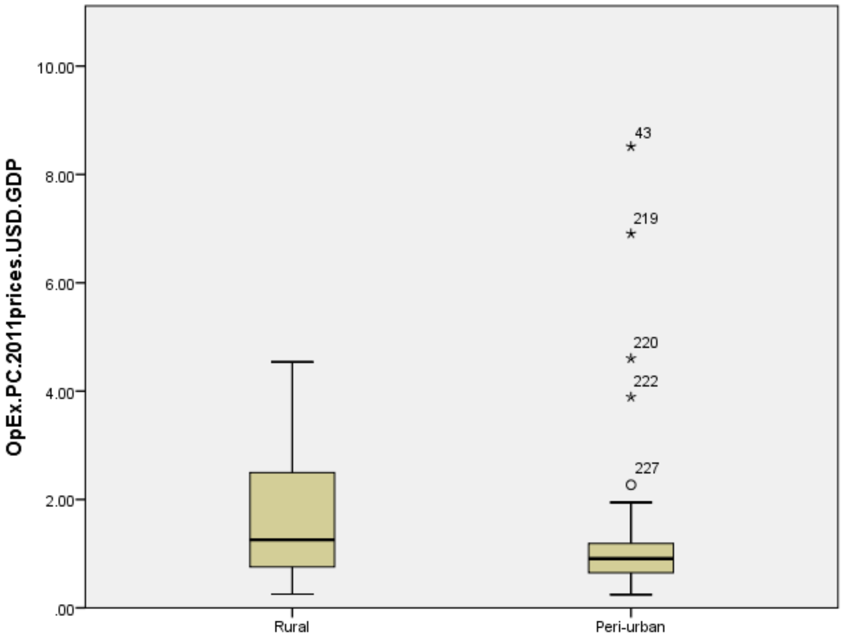
Figure D-1 Plot graphs for capital expenditure analysis

Table D-1 Summary statistics: per capita capital expenditure for water facilities

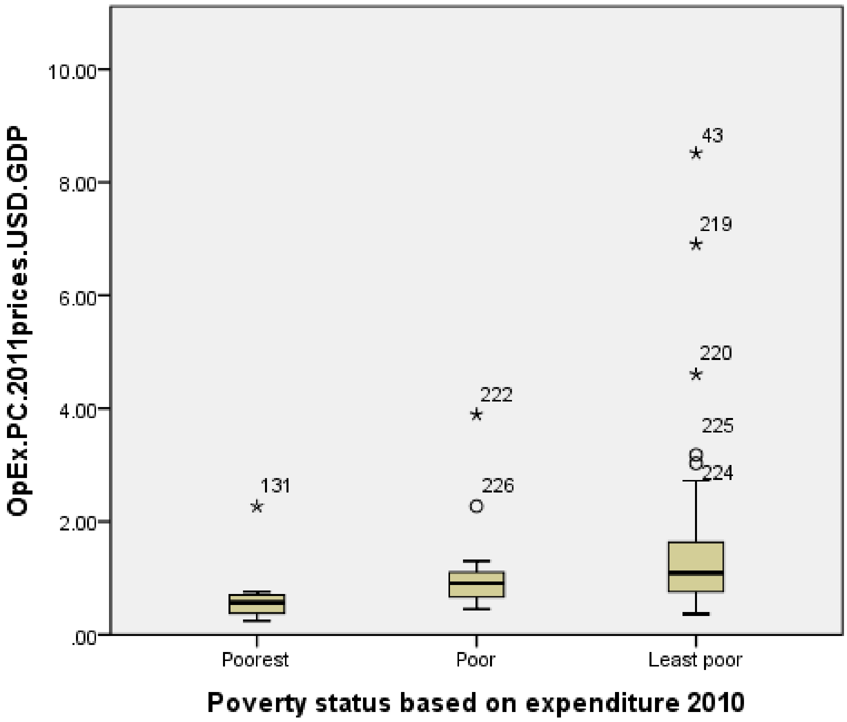
Capital Expenditure		Interquartile ranges		
(USD 2011 per capita)	Sample size	25 percentile	50 percentile = median	75 percentile
Rural	110	.20	.43	.77
Peri-urban	108	.09	6.7	34.19
Poorest	104	.08	.33	.64
Poor	42	.08	.24	5.06
Least poor	65	3.02	24.7	45.3
Rainwater	4	21.61	52.90	98.33
Unprotected well	31	.26	7.47	17.39
Protected well	4	.34	.51	.65
Borehole	124	.08	.22	.49
Standpipe	2	.09	.13	.
Yard tap	50	20.25	34.08	52.87
Household tap	3	4.83	9.30	.

The same analysis was done for annual household recurrent expenditure. The plot graphs show different results when compared with capital expenditure (Figure D-2 and Table D-2)

- Annual recurrent expenditure is higher in rural areas (median $1.25 USD 2011 prices per capita per year) than peri-urban areas (median $0.90).
- Although the sample size is small, the poorest spent less on operational expenditure ($0.56) when compared with the poor ($0.9) and the least poor ($1.08).
- And surprisingly, annual recurrent expenditure with informal and unsafe sources for water treatment and paid transport tends to be higher than recurrent expenditure with formal systems (households own or neighbours). No recurrent expenditure was captured for protected wells, household taps or rainwater.



OpEx.PC.2011prices.USD.GDP
10.00
8.00
6.00
4.00
2.00
.00
43
219
220
222
227
Rural
Peri-urban



OpEx.PC.2011prices.USD.GDP
10.00
8.00
6.00
4.00
2.00
.00
43
219
220
222
225
224
131
226
Poorest
Poor
Least poor
Poverty status based on expenditure 2010

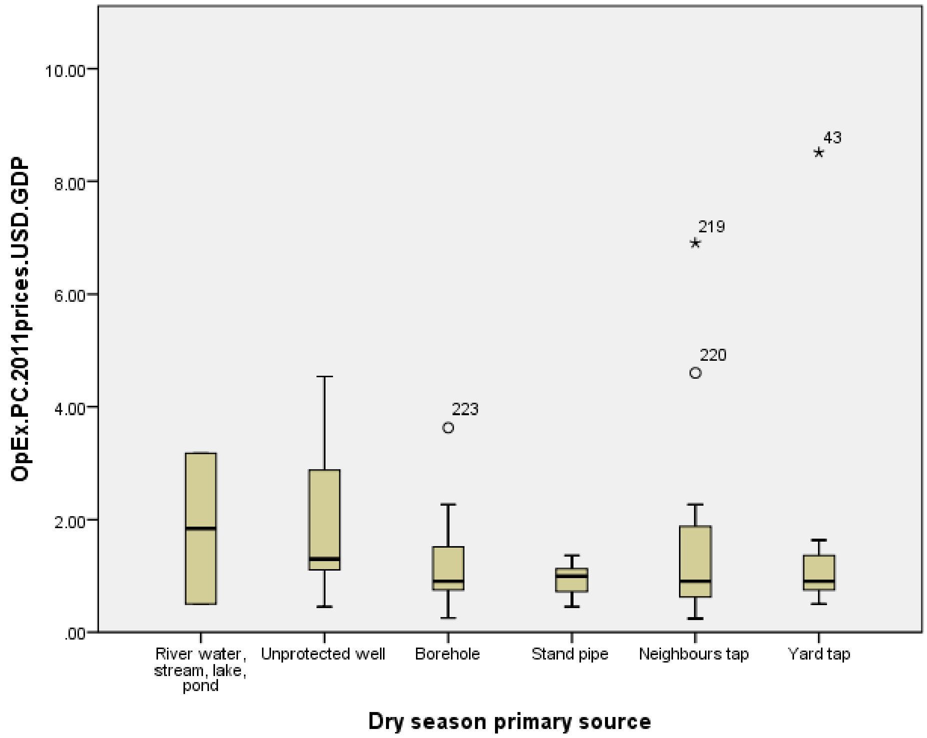


Figure D-2 Box plot graphs for operational expenditure analysis

Table D-2 Summary: Household recurrent expenditure interquartile ranges

Operational Expenditure	Interquartile ranges			
(USD 2011 per capita per year)	Sample size	25 percentile	50 percentile = median	75 percentile
Rural	20	.75	1.25	2.61
Peri-urban	40	.64	.90	1.20
Poorest	7	.25	.56	.75
Poor	11	.60	.90	1.29
Least poor	37	.75	1.08	1.72
River water, stream, lake, pond	2	.50	1.84	.
Unprotected well	11	1.08	1.29	3.02
Borehole	14	.70	.90	1.70
Standpipe	10	.68	.99	1.15
Neighbours tap	15	.60	.90	1.94
Yard tap	8	.75	.90	1.49

Trying to understand how some of the variables are related. It was found:

- No statistically significant correlation between OpEx and CapEx in peri-urban areas or in rural areas[10].
- Statistically significant correlation between CapEx and wealth status based on household expenditure (Pearson correlation coefficient = 48.6%, CI [.366,.606], p=.000). Wealth status accounts for 23.6% (R^2) of the variability in CapEx (Figure D-3).
- Statistically significant correlation between OpEx and wealth status based on household expenditure (Pearson correlation coefficient = 37.1%, CI [.051,.563], p=.005). Or that wealth status account for 13.8% (R^2) of the variability in OpEx (Figure D-4).

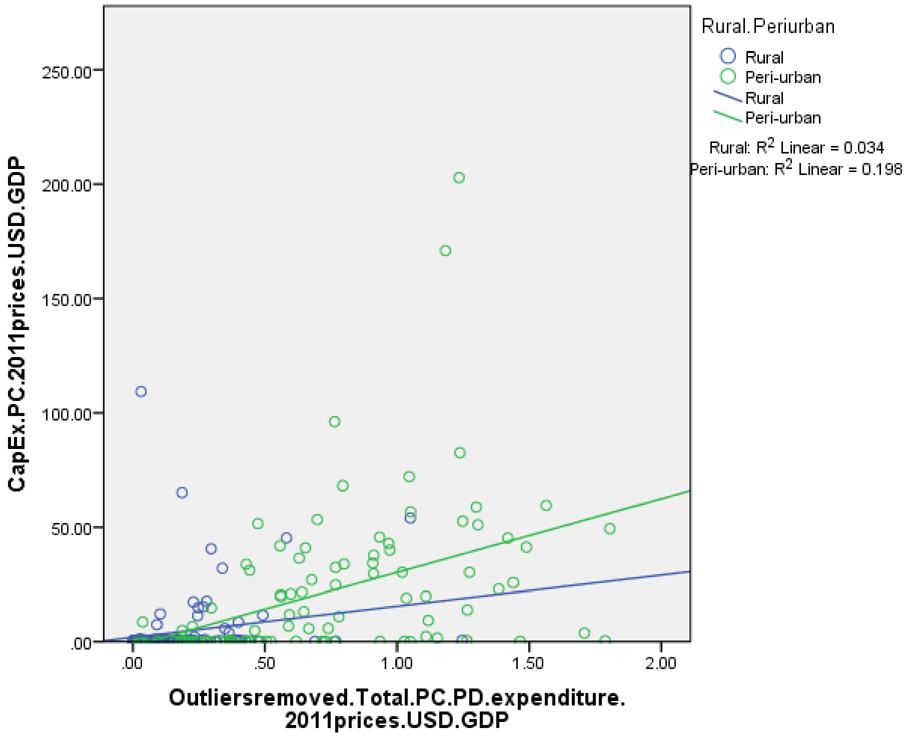


Figure D-3 CapEx on primary water source and household wealth status for rural and peri-urban areas

[10] Using the biserial correlation coefficient for comparing continuous variables (expenditure) with one variable with a continuous dichotomy (a rural or a peri-urban area).

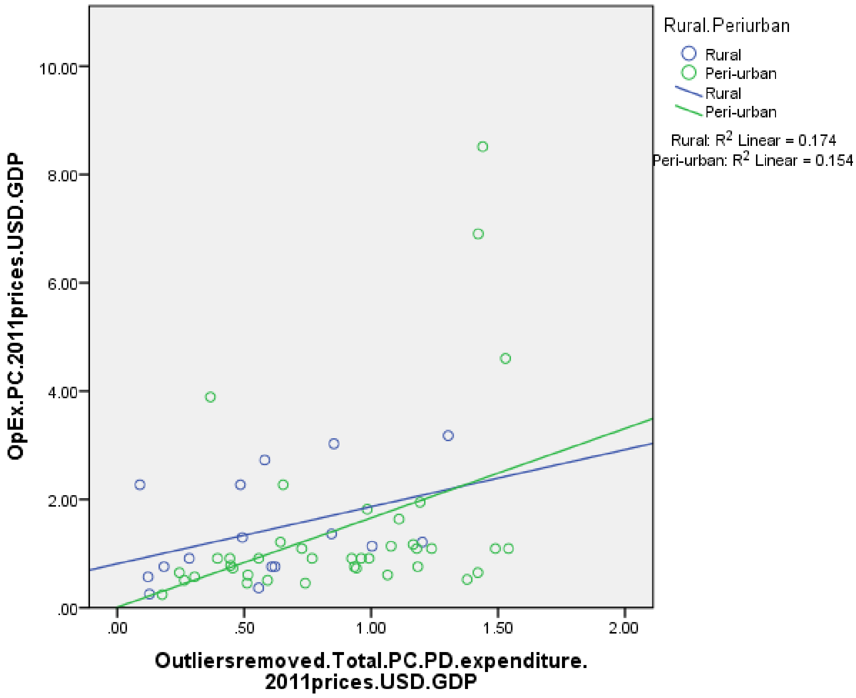


Figure D-4 OpEx on primary water source and household wealth status for rural and peri-urban areas

Although statistically significant correlations are weak it is interesting to see how CapEx and OpEx relate with wealth status per water source (dry season primary) (Figure D-5 Figure D-3and Figure D-6). Household initial investments in rainwater appear to diminish drastically as the households have more income, while investments in yard taps, unprotected wells and household taps increase.

The recurrent expenditure is mostly on water treatment (only in 5 cases it relates to transport) and clearly recurrent expenditure increases for neighbours tap, yard tap and water collected from rivers or streams. Recurrent expenditure for communal systems, such as boreholes and standpipes, seems to be independent from the wealth of the households.

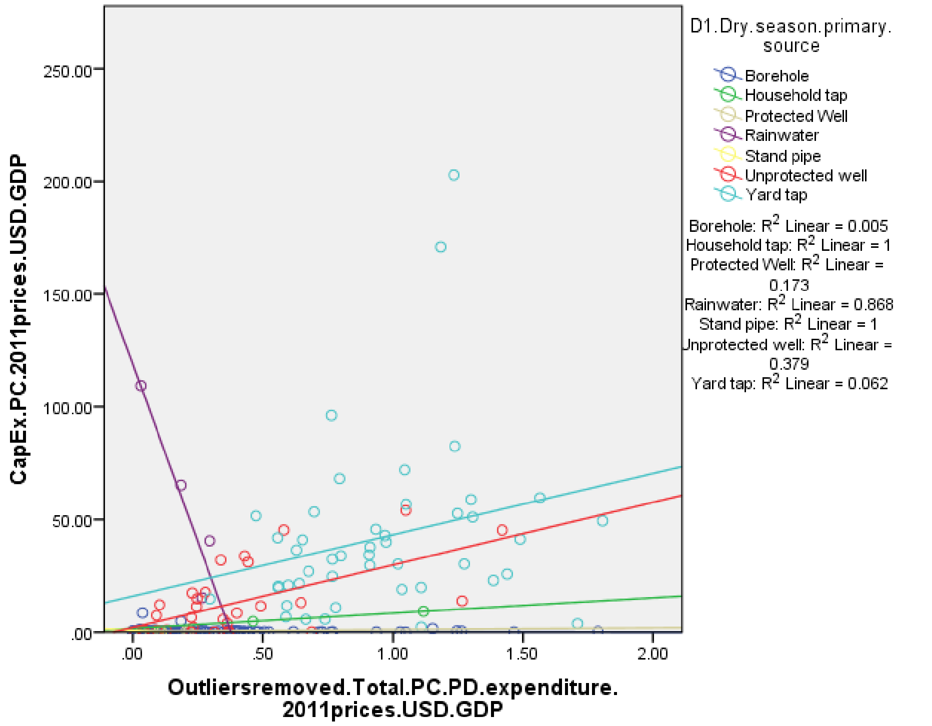


Figure D-5 CapEx per primary water sources and household wealth status

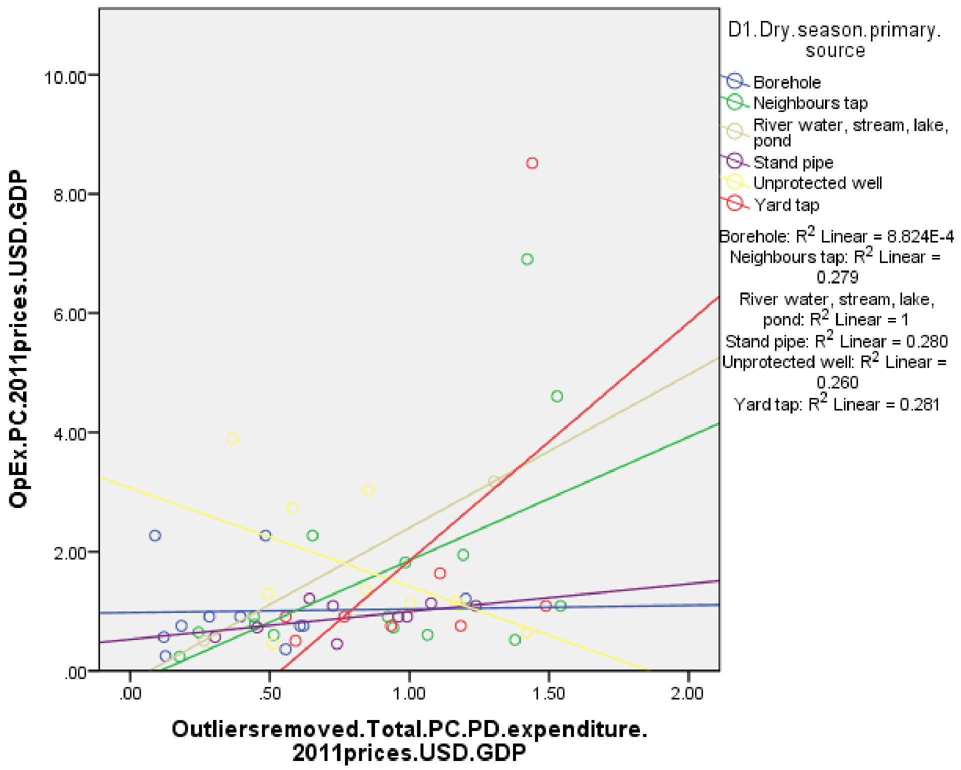


Figure D-6 OpEx per primary water sources and household wealth status

Other financial contributions include water payments with a fixed monthly fee, with a water meter (only used by the private operator and the water utility), a fee per bucket or jerry can and a payment when sources break. The contributions do not change much in the wet season and therefore results are shown for the dry season only (Table D-3). The large majority of consumers consider the user charges acceptable. No relationship was found between who manages the sources and the type or size of the water payments.

Table D-3 Water payments in the dry season

Water payment	Dry Season	
	Count (%)	Interquartile range (in meticais)
Fixed monthly fee	510 (50.1%)	(5-20)
Fee per bucket and jerry can	332 (32.6%)	(1-2)
Payment when it breaks	110 (10.8%)	See below
Water meter	65 (6.4%)	(184-434)
Total	1018 (60% of sample)	

The payments made when the system breaks can be considered capital maintenance. This expenditure was made for boreholes, protected and unprotected wells only and for 101 out of the 110 respondents to this question, the entity responsible for the water system maintenance is the community water committee. The interquartile range found was between US$ 0.05 and US$ 0.15 per capita per payment (2011 prices US$). It is not possible to proceed to make calculations per year per household because the questionnaire did not ask how many times this payment had been done.

There is no statistically relevant correlation between CapManEx and the source, but a statistically relevant correlation was found with the wealth status (Pearson correlation coefficient = 39.4%, CI [.105,.645], p=.000) Meaning that the wealth status accounts for 15.5% (R^2) of the variability in CapManEx (Figure D-7).

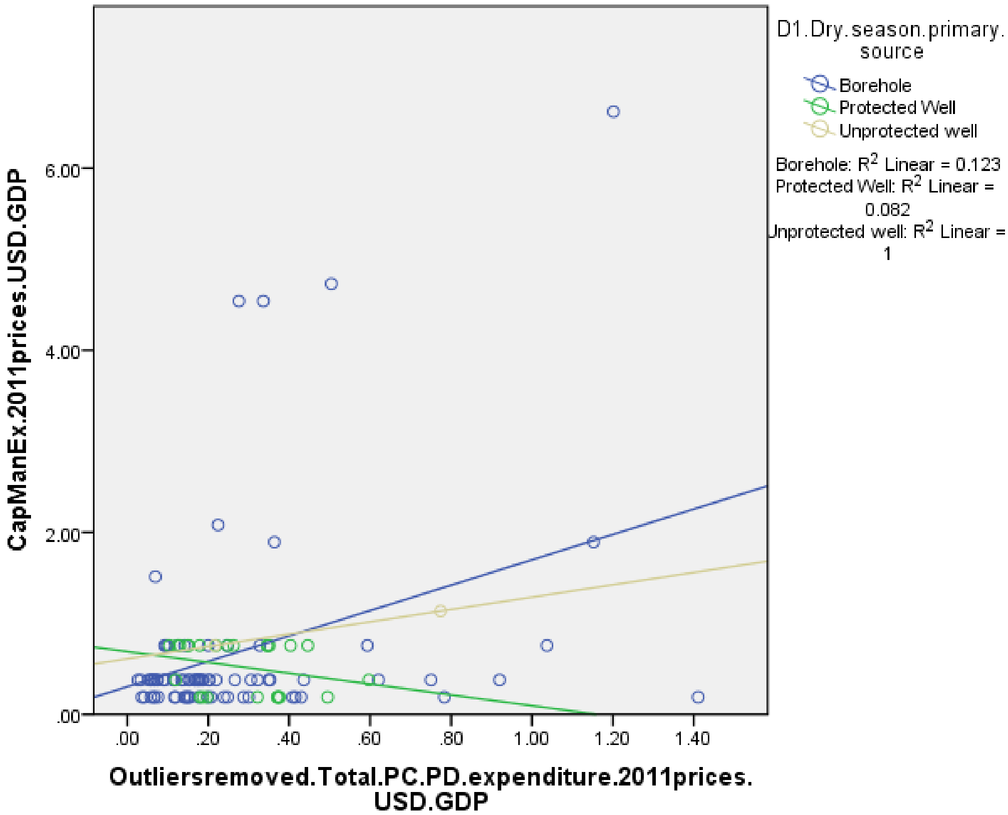


Figure D-7 Capital maintenance expenditure per source per wealth status

D.1.2 Ghana

In Ghana, households have to contribute a standard amount per person to the construction of formal point sources through the Water and Sanitation Committees (WATSAN). The analysis of the survey done to the WATSAN Committees shows that contributions are between 50 and 250 Ghana cedis (US$ 33 - 165) per community. The contributions are usually per household (per head above 18 years old). However, this information has not been collected in the household survey and an analysis cannot be made on the contributions of each of the households to either capital expenditure or capital maintenance expenditure. The large bulk of these expenditures is made by external programmes financed by donors and implemented by CWSA.

The majority of households in the sample (65% N=870) pays for formal sources with a median of US$ .46 per capita per year. A smaller number pays for informal sources with median of US$ 0 per capita per year and 26% (N=345) pays to vendors also with a median of US$ 0 per capita per year (Table D-4**).**

Table D-4 Statistics for water payments for formal and informal sources, Ghana

		Water payment, per capita per year USD 2011			
		Formal sources	Informal sources	Vendors	Total – all sources
N	Valid	870	66	345	938
	Missing	469	1273	994	401
Mean		.6964	1.6466	.5523	.9560
Median		.4601	.0000	.0000	.5105
Minimum		.00	.00	.00	.00
Maximum		6.90	10.21	17.25	17.25
Percentiles	25	.2398	.0000	.0000	.2346
	50	.4601	.0000	.0000	.5105
	75	.8799	2.9132	.2760	.9162

The analysis of the household recurrent expenditure has been done for the geographic areas, for the socio-economic categories and per source:

- Annual recurrent expenditure is higher in peri-urban areas (media $1.53 USD 2011 prices per capita per year) when compared with rural ($0.54) or small towns ($0.41) Figure D-8.
- The non-poor pay slightly more (US$ 0.57) than the poor (US$ 0.51)
- The payments per formal source vary. Households with piped connection pay the most (US$ 4.63 per year per person). Households are also paying more for boreholes with hand-dug wells and handpumps (US$0.54) when compared with yard standpipes or public standpipes (US$0.45). Households which depend exclusively on vendors spend a higher amount (US$0.91)

The majority of households pay “as-you-fetch” (61% N=811) and the remainder pay monthly (7% N=98); 33% find user charges acceptable.

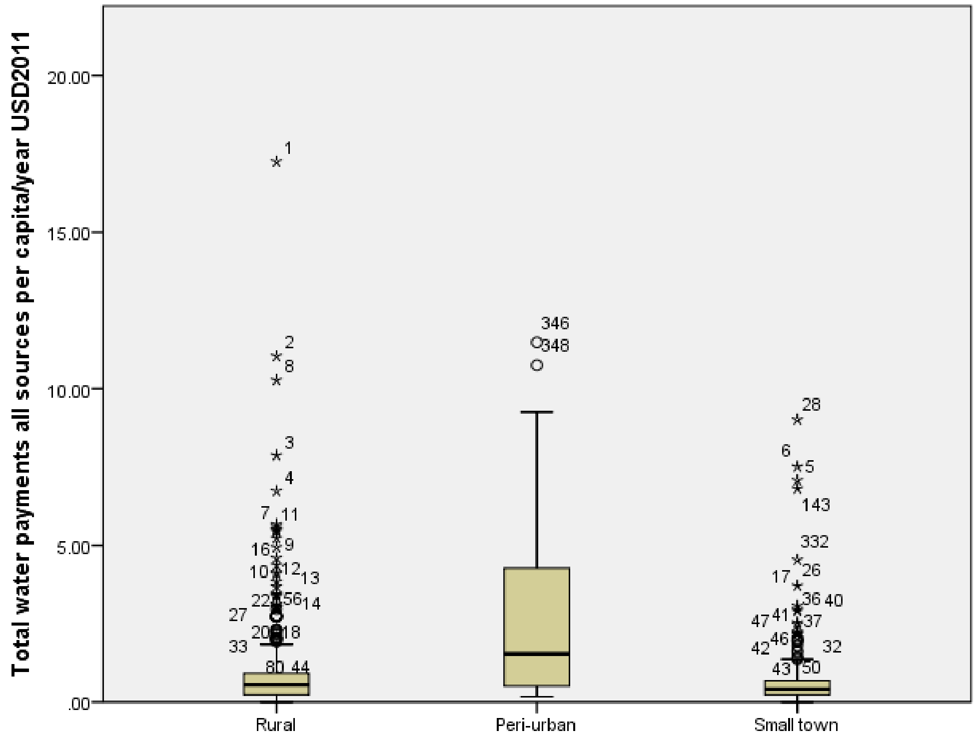


Figure D-8 Total water payments all sources per geographic location

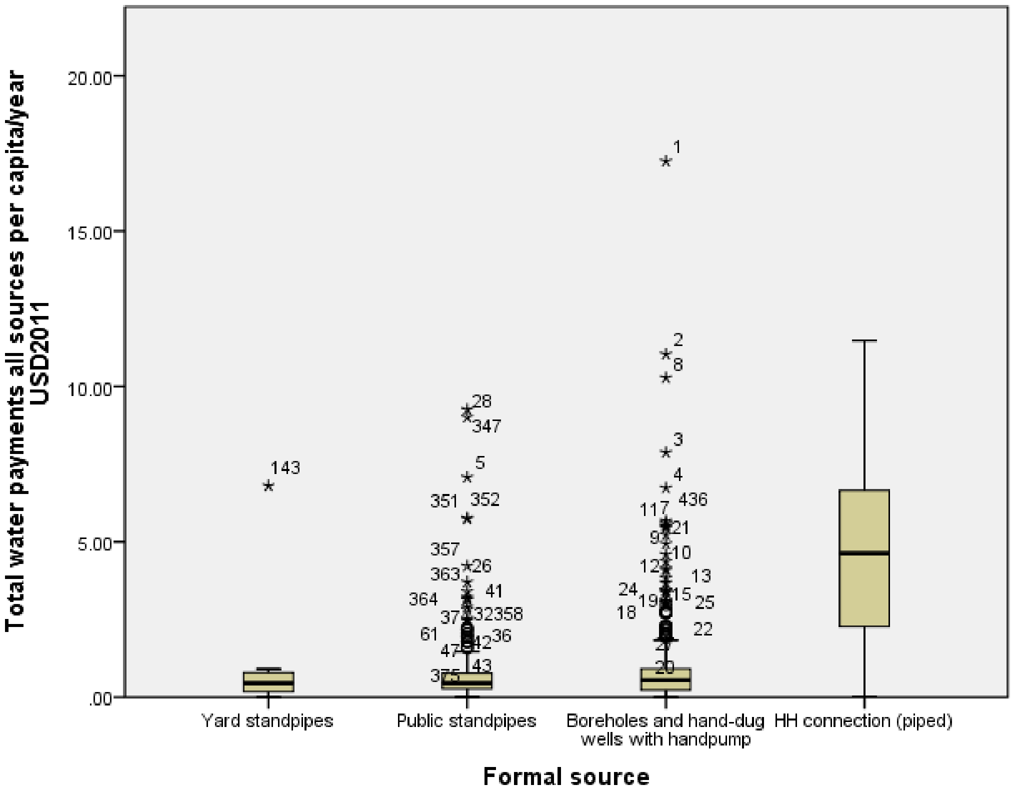


Figure D-9 Total water payments per formal source

Appendix E Household economic expenditure for accessing water

E.1.1 Mozambique

In Mozambique, reported time per round trip differs significantly depending on the sources used in the dry and wet season. A higher proportion of households take less time per round trip in the wet season compared with the dry season (Figure E-1). The high variance is mainly explained by the queuing time in the dry season as can be seen in the changes of mean and median (Table E-1).

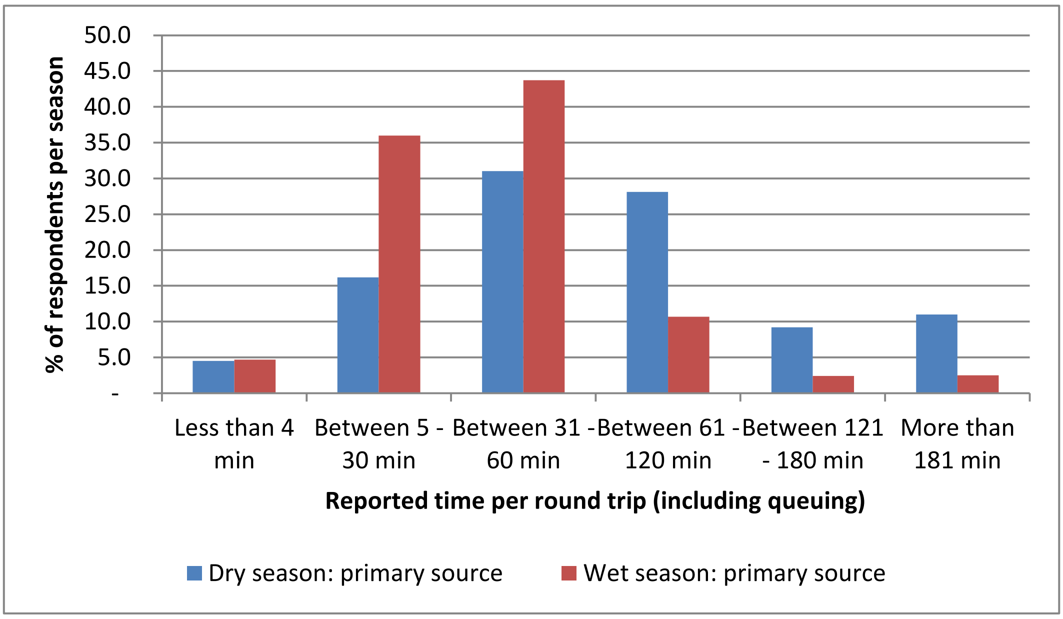


Figure E-1 Reported time per round trip, primary source Mozambique

Table E-1 Measures of central tendency

	Without queuing		With queuing	
	Dry season primary source	Wet season primary source	Dry season primary source	Wet season primary source
Mean	23.51	26.72	79.29	44.49
Median	19.00	20.00	59.00	35.00
Std. deviation	24.621	36.301	71.157	49.731
N	1123	1182	1123	1182

Queuing affects greatly the time spent per round trip – and therefore the economic costs for more than half the households (Table E-2). Queuing is particularly high for the communal sources: boreholes with handpumps, standpipes and protected wells (Table E-3).

Table E-2 Difference of reported time per round trip with and without queuing as % of households (primary source, dry season)

Households reported time per roundtrip (N=1123)	Without queuing (% of HHs)	With queuing (% of HHs)	Difference (% of HHs)
Less than 4 min	11.8%	4.5%	- 7.3%
Between 5-30min	68.0%	16.2%	**- 52.8%**
Between 31 - 60 min	16.8%	31.0%	+ 14.2%
Between 61 - 120 min	2.6%	28.1%	+25.5%
Between 121 - 180 min	.4%	9.2%	+8.8%
More than 181 min	.4%	11.0%	+10.6%

Table E-3 Minutes spent (mean and median) waiting per primary source in the dry season per trip, Mozambique

Primary source, dry season (N=1119)	Minutes spent waiting at source	
	Mean	Median
River water, stream, lake, pond	13	10
Rainwater	.	.
Unprotected well	46	12
Protected well	41	35
Borehole with handpump	78	60
Standpipe	73	45
Neighbours tap	14	5
Yard tap	20	20
Household tap	.	.

When the correlation analysis is done per source or per size of the household, there is no statistically significant correlation (using Spearman's and Pearson's correlation coefficients) but it is clear that the time spent in accessing informal sources (river water, streams, lakes or unprotected wells) is mostly between 31 and 60 minutes and doubles for accessing protected wells, boreholes with handpumps and standpipes for a significant number of the population. For rainwater and household tap there is no time reported for access and neighbour's taps are within a 30 minute range (Figure E-2).

Analysis between the minutes reported to access the different sources and the rural/peri-urban divide has a significant statistic correlation. Spearman correlation coefficient =27.9%, CI [-329, -223], p=.000.

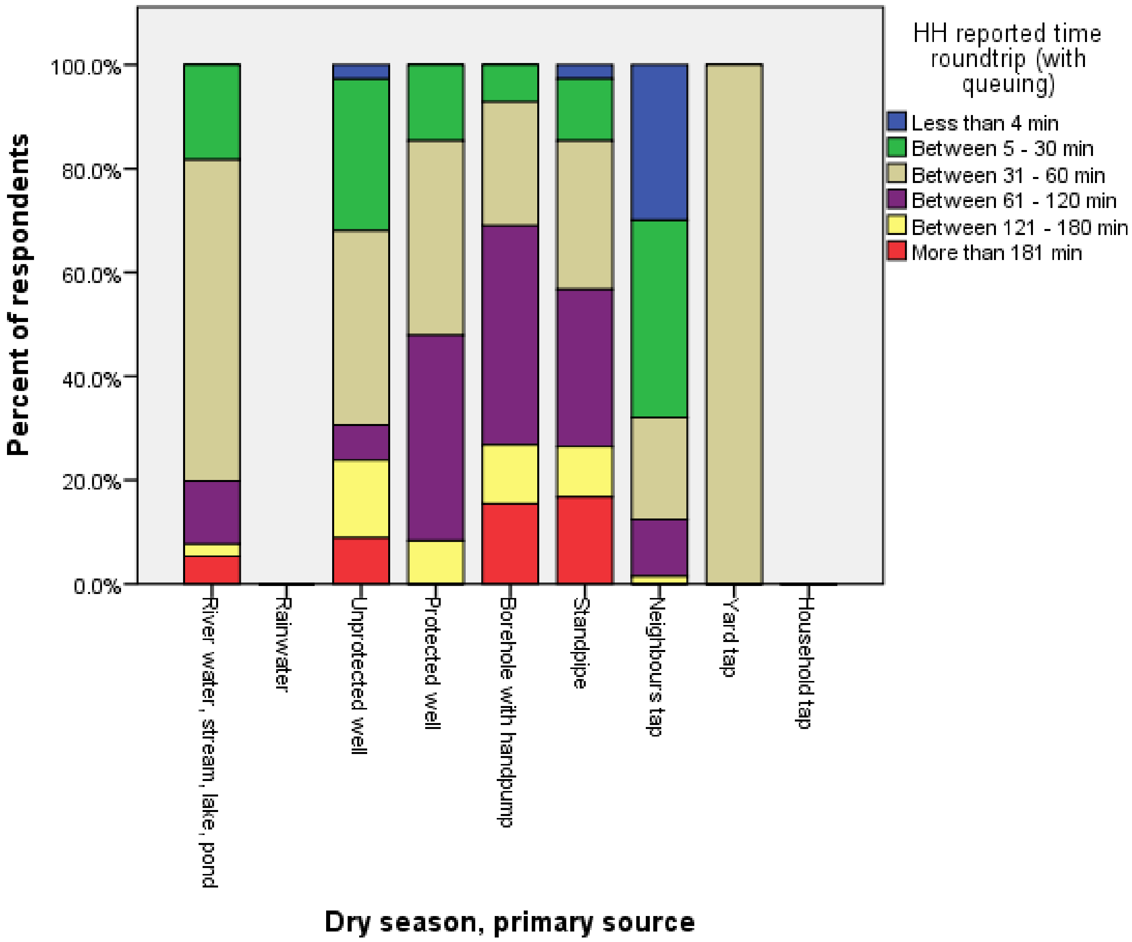


Figure E-2 HH reported time to primary source, dry season

The amount of roundtrips per day per person in the dry and wet seasons was calculated by multiplying by the number of reported trips to the primary source in each season. The closer is the primary source from the household, the higher are the number of roundtrips per source Table E-4).

After elimination of the outliers, which reported more than 500 minutes a day in total for collecting water, the median time per day per person spent overall collecting water is 30.86 minutes if using the reported household size in the questionnaire (Table E-5, Table E-6).

Table E-4 Median round trips per day and time reported by household to the primary source, dry and wet season

Household reported time round trip primary source	Roundtrips per day water collection (median)	
	Dry season	Wet season
Less than 4 min	5	5
Between 5 - 30 min	4	3
Between 31 - 60 min	3	2
Between 61 - 120 min	3	2
Between 121 - 180 min	3	2
More than 181 min	2	2

Using the Pearson coefficient for the wealth status and the time spent collecting water in each of the seasons, the only statistically relevant correlation found was with the time spent in the alternative source for the dry season. 3.16% (R2) of the wealth status accounts for the variability in the total amount of time spent by households collecting water in the alternative source during the dry season. (Coefficient = -17.8%, CI [-.254,-.092], p=.001)

Table E-5 Measures of central tendency time spent collecting water per day, per person per source

		Time per capita per day, per source			
		Dry season primary source	Dry season secondary source	Wet season primary source	Wet season secondary source
N	Valid	1119	504	1179	17
	Missing	591	1206	531	1693
Mean		62.27	30.56	27.41	59.39
Median		40.00	21.55	15.63	34.40
Std. Deviation		76.594	35.187	40.667	62.731
Minimum		0	1	0	3
Maximum		1185	400	651	228

Table E-6 Measures of central tendency time spent collecting water per day, per season and per year

		Time per capita per day, per season and per year		
		Dry season	Wet season	Average per year
N	Valid	1262	1182	1313
	Missing	448	528	397
Mean		67.42	28.19	45.09
Median		46.40	15.71	30.86
Std. Deviation		79.624	43.907	52.789
Minimum		0	0	0
Maximum		1185	651	668

E.1.2 Ghana

In Ghana the reported time per round trip including queuing is about 25 minutes (median). Without queuing is 5 minutes. The analysis cannot be done separately for the dry and the wet season, and it is also not known how many times per day the trip is done. Compared with Mozambique in the Ghana sample which is "urban" in nature, respondents spend in its majority between 5 and 30 minutes to access water (Figure E-4). In the Mozambique sample, the largest proportion of the sample was taking between 31 and 60 minutes per round trip.

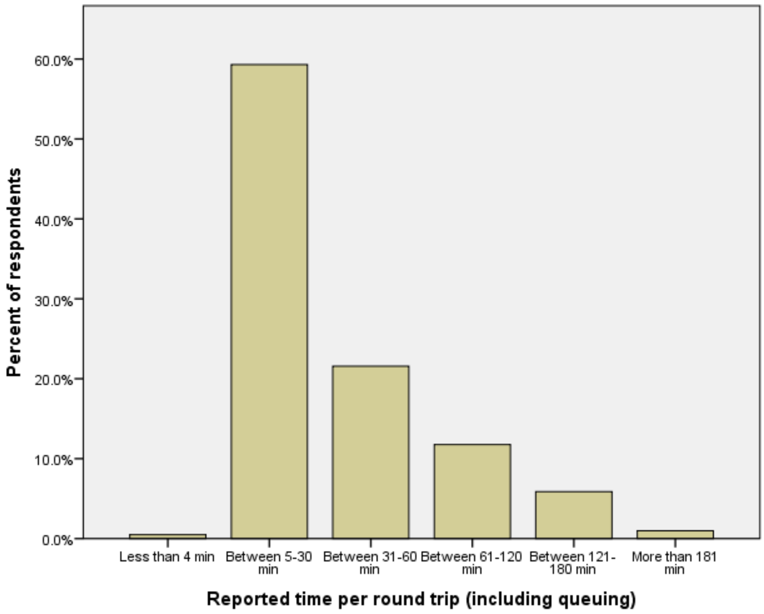


Figure E-3 Reported time per round trip, Ghana

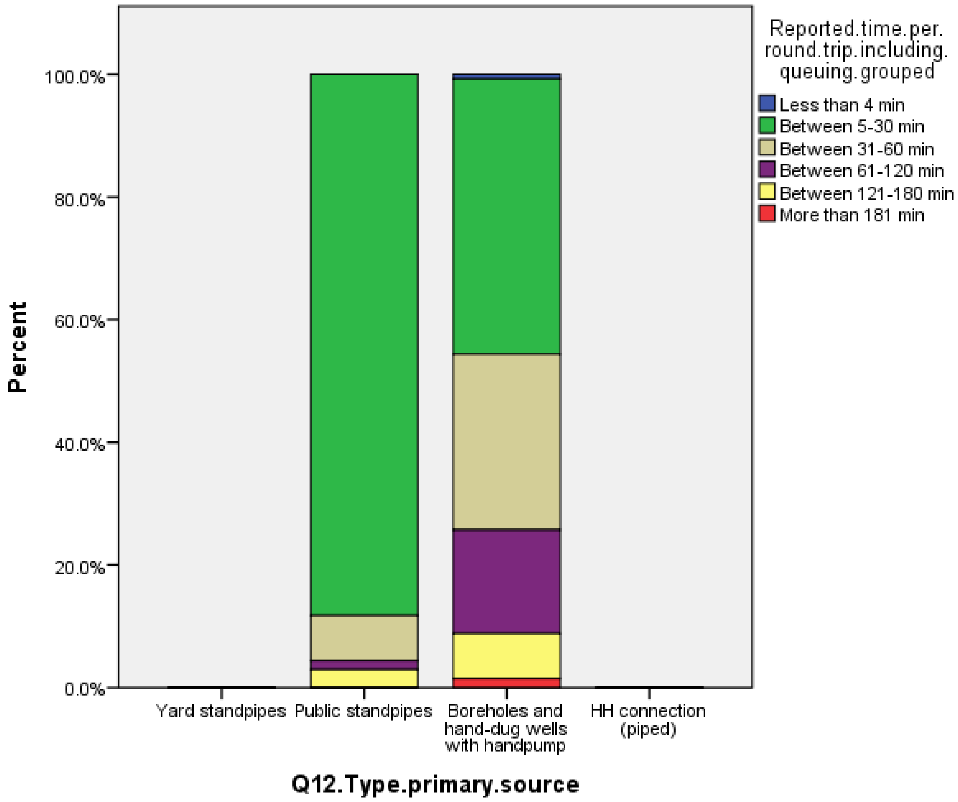


Figure E-4 Reported time per round trip, formal sources, Ghana

Queuing is mostly experienced in the communal sources: boreholes and hand-dug wells with handpump and public standpipes (Figure 33) and therefore correlated with rural and small-towns respectively (Figure I-7). The poor spend 10 minutes per round trip (median N=424) while the non-poor spend 5 minutes (median N=732).

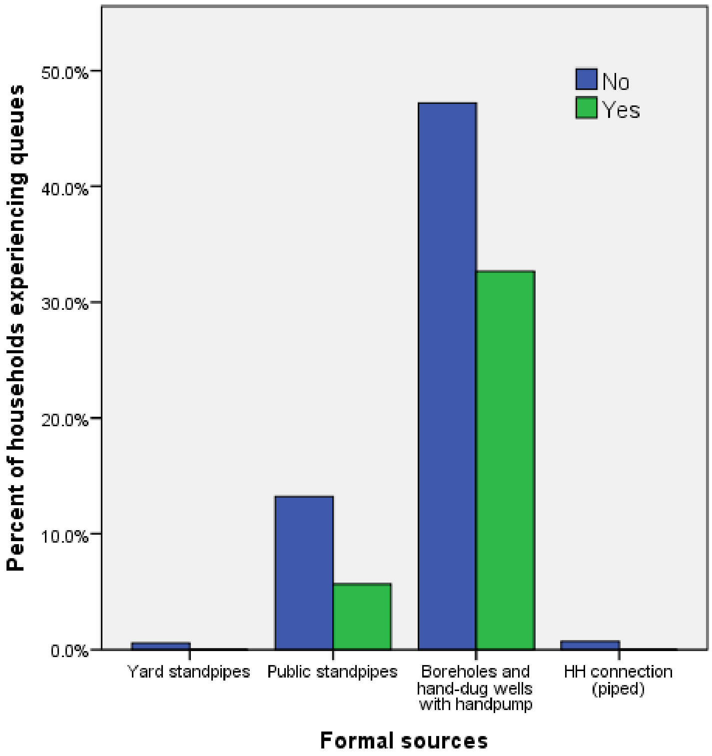


Figure E-5 Queuing for formal sources, Ghana

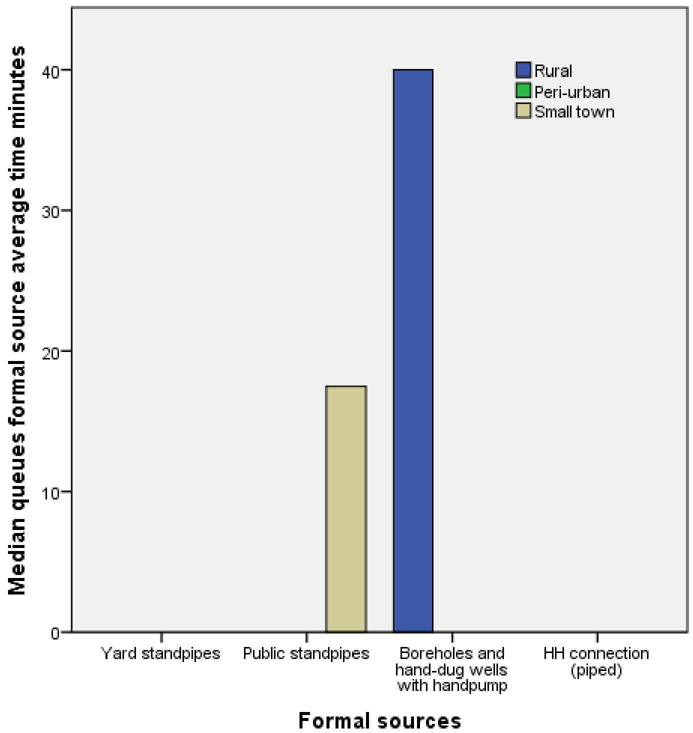


Figure E-6 Queuing for formal sources per geographic area, Ghana

Appendix F Access to sanitation facilities

F.1.1 Mozambique, access to sanitation facilities

Table F-1 Excreta disposal frequency table Mozambique

	Excreta disposal	Frequency	Percent	
Considered unsafe	Open defecation	402	23.5	89.3
	Dig and bury	206	12.0	
	Bucket	1	.1	
	Traditional latrine	757	44.3	
	Improved traditional latrine	160	9.4	
Considered safe	Latrine with slab	115	6.7	10.7
	VIP latrine	19	1.1	
	Toilet with septic tank (with piped water)	10	.6	
	Toilet with septic tank (using a bucket)	40	2.3	
	Total	1710	100	100

Through observation, only one latrine was clearly not being used. From the households using toilets or latrines, 12% shared their facilities mostly with 2 or 3 families (Figure F-1). The most shared facility is the latrine with slab followed by the improved traditional latrine.

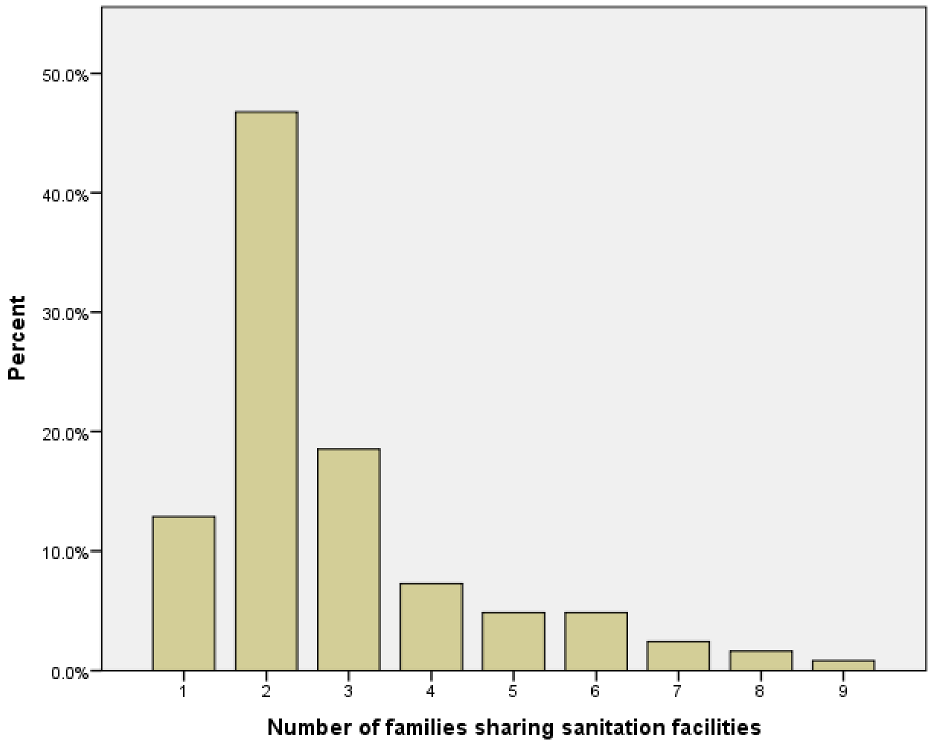


Figure F-1 Families sharing toilets and latrines (% of those with access to facilities)

Photograph 1 A dirty and non-used latrine in Mozambique. Photo credit: Peter McIntyre

The latrines are mostly located in the household's own backyard (Figure F-2) and the majority were constructed 4 years prior to the survey between 2007-2010 (Figure F-3).

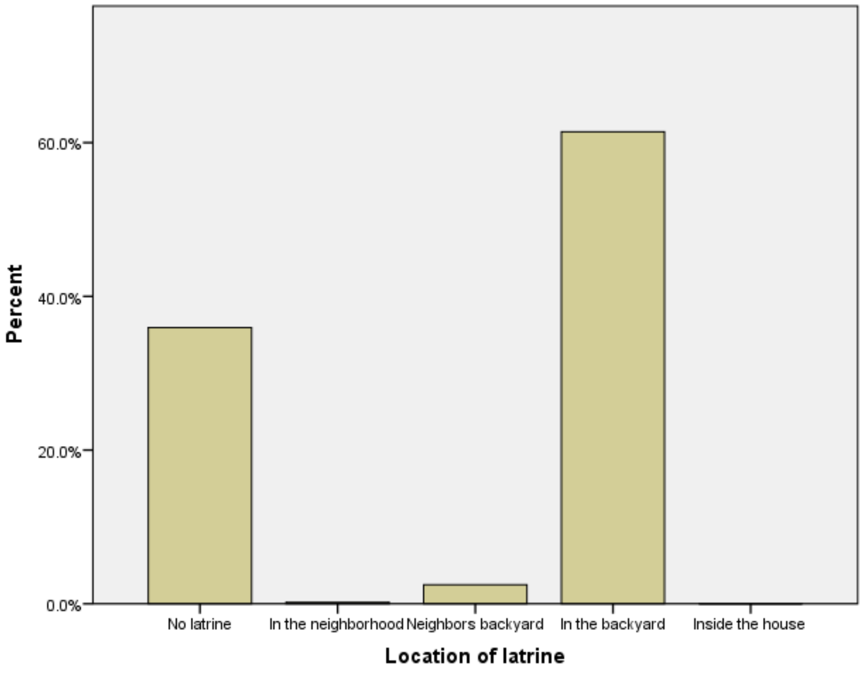


Figure F-2 Location of toilets and latrines

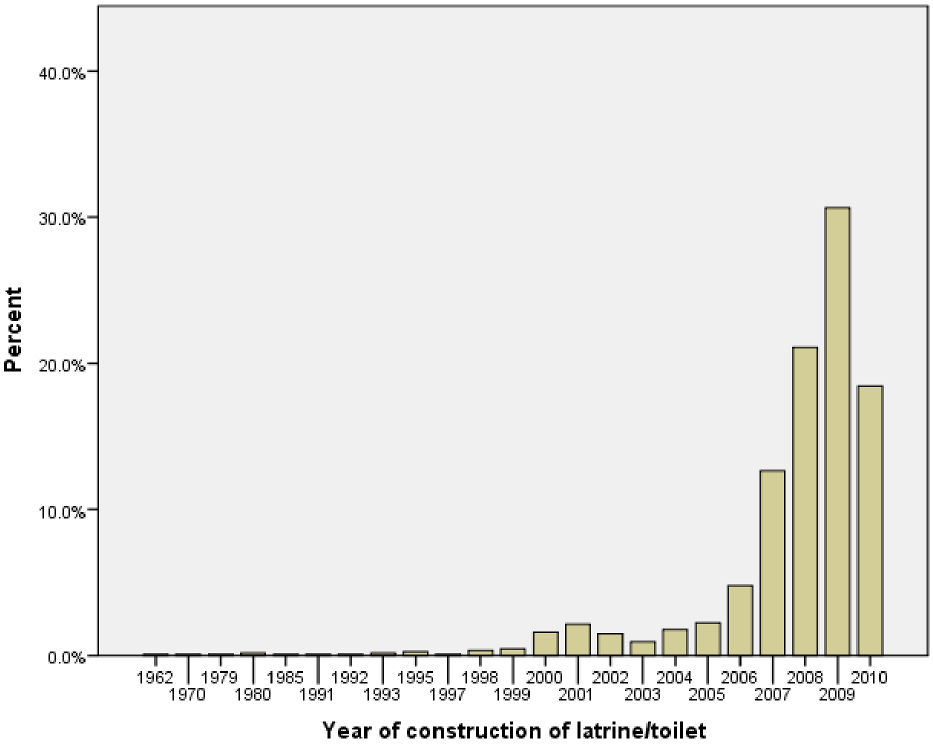


Figure F-3 Year of construction of toilets and latrines

F.1.2 Ghana, access to sanitation facilities

Table F-2 Excreta disposal frequency table Ghana

	Excreta disposal	Frequency	Percent	
Considered unsafe	Open defecation	321	24	79.9
	Dig and bury	156	11.7	
	Traditional latrine	107	8	
	Public toilet	417	31.2	
	Neighbour's toilet	68	5.1	
Considered safe	Latrine with slab	17	1.3	20.1
	VIP latrine	203	15.2	
	Kumasi Ventilated Improved Pit	19	1.4	
	Toilet with septic tank	30	2.2	
	Total	1337	100	100

The latrines and toilets were constructed mainly between 2006 and 2009 (Figure F-4).

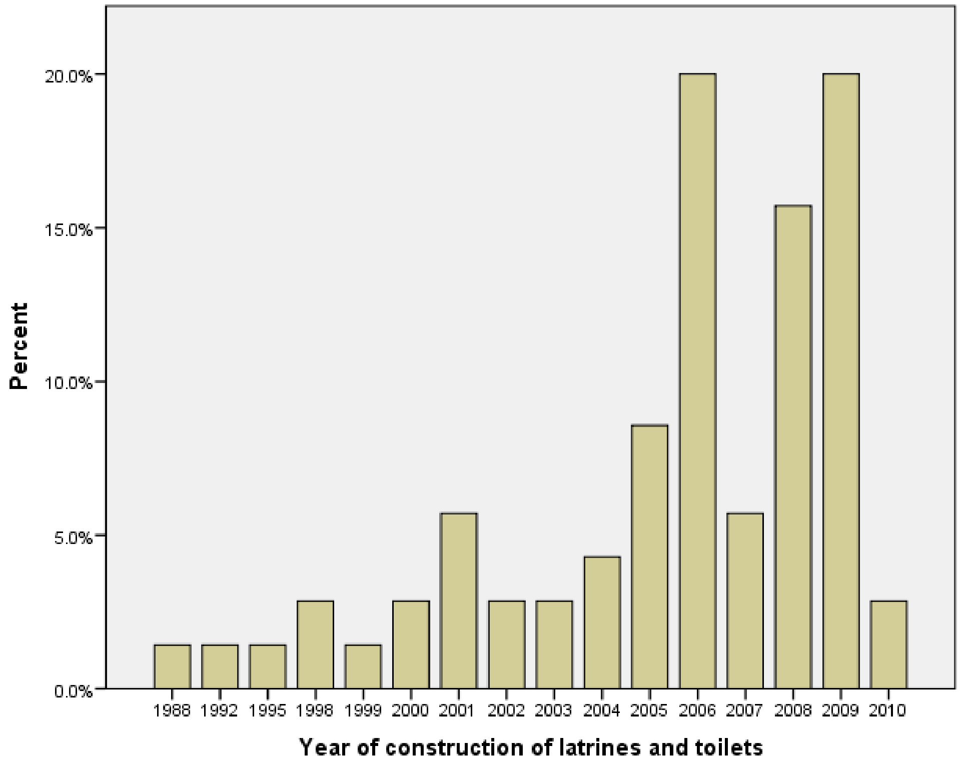


Figure F-4 Year of construction of toilets and latrines

Appendix G Financial costs with building and maintaining latrines

G.1.1 Mozambique

Similar to the analysis done for water expenditure, the household costs with sanitation facilities have been analysed.

Capital expenditure

The most striking finding is that 71.4% (742) of the households with a latrine or toilet report zero financial costs on labour, 73.6% (754) report zero financial costs on materials and 90.1% (950) report not to have received any form of financial subsidy (although donations have been delivered in kind as materials to build latrines). This is mainly because it's the households themselves that dig the pits, source the materials and build the latrines.

From those households that report overall expenditure higher than zero (345 or 32% of those reporting expenditures), the spread in the reported expenditures varies between $0.51 and $117.3 USD 2011 prices, with a median of $5.7.

Table G-1 Statistics on capital expenditure sanitation Mozambique

		Capital expenditure per capita ($US 2011)	
		All expenditure reported	Reported > 0
N	Valid	1065	345
	Missing	645	1365
Mean		4.41	13.6038
Median		.00	5.7190
Std. Deviation		12.560	19.04189
Minimum		0	.51
Maximum		117	117.30

The remaining of the analysis will focus on the responses from households with financial expenditure higher than zero. In general, per capita capital expenditure on sanitation facilities is:

- Lower in rural areas with a median of $2.01 USD 2011 prices per capita against $9.23 in peri-urban areas;

- Lower for the poorest (median $1.37) and higher for the least poor (median $10.06);
- Slightly higher if the latrine is in own backyard (median $5.68) compared with if its located in the neighbour's backyard (median $4.58) but the sample is too small to draw further conclusions on this aspect;

Higher for households with "more sophisticated" facilities such as septic tanks and VIP latrines compared with the more traditional latrines (Figure G-1).

These are patterns similar to those found with water supply financial capital expenditures.

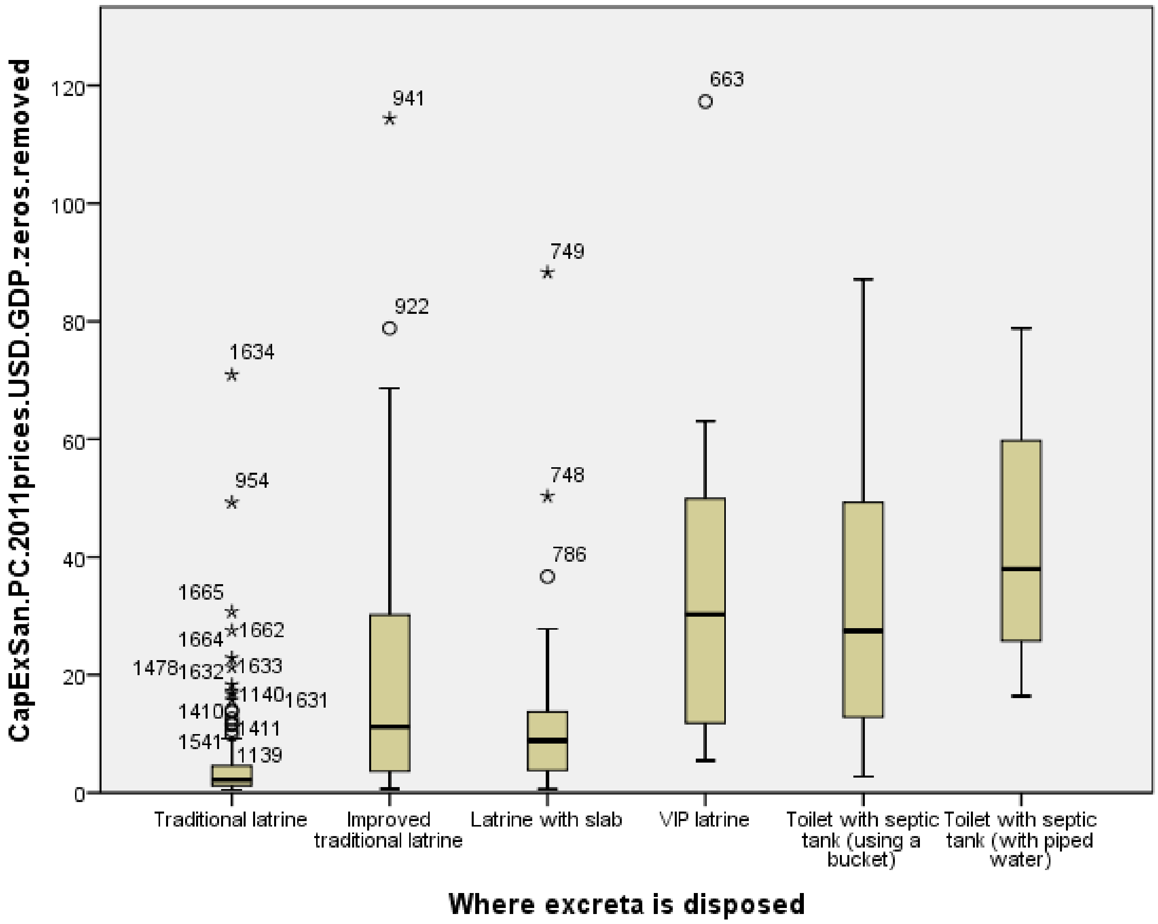


Figure G-1 Capital expenditure per capita vs sanitation facilities accessed

Table G-2 Summary statistics: per capita capital expenditure for sanitation facilities

		Capital Expenditure (USD 2011 per capita)		
	Sample size	Mean	Median	Std. Deviation
Rural	107	5.01	2.01	8.269
Peri-urban	238	17.47	9.23	21.153
Poorest	55	2.85	1.37	3.549
Poor	95	7.35	3.78	9.116
Least poor	170	17.90	10.06	20.707
In the backyard	333	13.40	5.68	18.829
In the neighbours backyard	7	8.91	4.58	7.560
Toilets with septic tank (using piped water)	9	42.53	37.99	21.691
Toilets with septic tank (using bucket)	19	34.65	27.52	27.095
VIP latrine	12	35.75	30.29	32.082
Latrine with slab	65	11.37	8.87	13.036
Improved traditional latrine	91	19.44	11.20	20.675
Traditional latrine	149	4.80	2.19	8.339

Operational expenditure

The same analysis was done for operational expenditure. The majority of households reported zero financial expenditure with maintenance the last year prior to the survey. Most of the operational expenditure is in kind or own labour. Only 36 households have reported yearly financial expenditures higher than zero (Table G-3).

Table G-3 Statistics on yearly operational expenditure sanitation

		Operational expenditure per capita ($US 2011)	
		All expenditure reported	Reported > 0
N	Valid	1077	36
	Missing	633	1674
Mean		.18	5.47
Median		.00	3.25
Std. Deviation		1.492	6.219
Minimum		0	1
Maximum		25	25

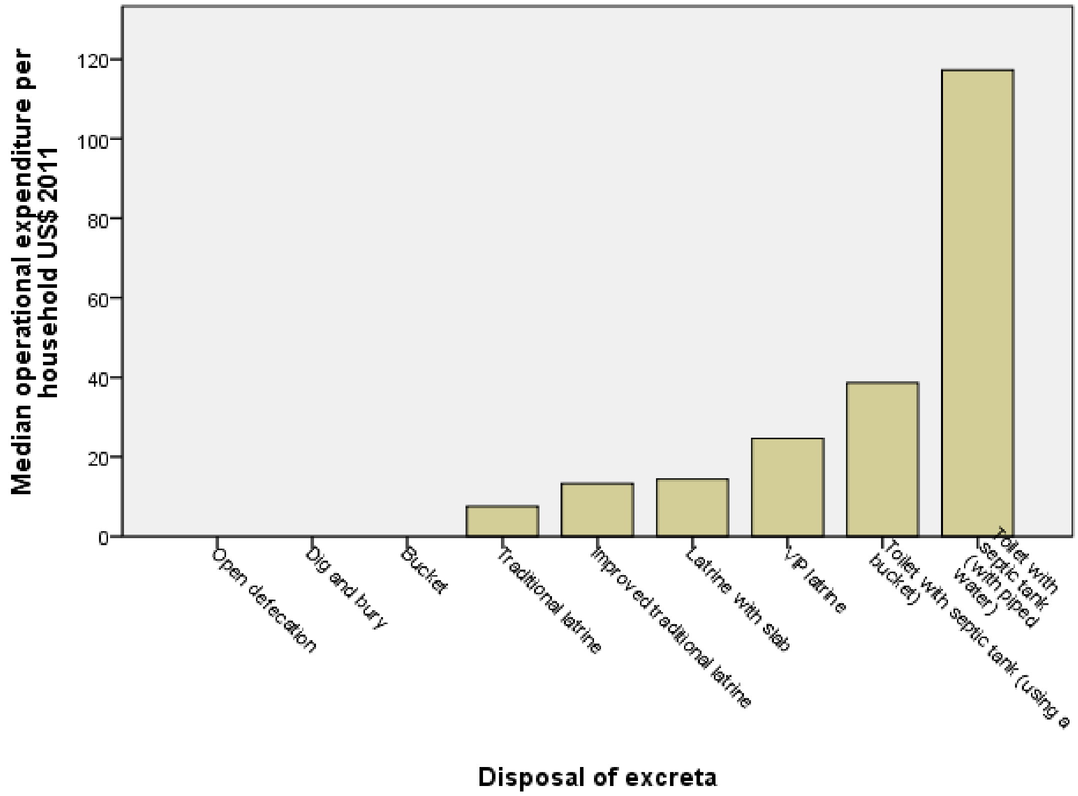


Figure G-2 Median yearly operational expenditure per household and sanitation facilities accessed

Table G-4 Statistics on yearly operational expenditure sanitation per household and per facility

	Operational Expenditure per facility per household US$ 2011		
	Count	Mean	Median
Toilet with septic tank (with piped water)	10	117	117
Toilet with septic tank (using a bucket)	40	39	39
VIP latrine	19	25	25
Latrine with slab	115	34	14
Improved traditional latrine	160	18	13
Traditional latrine	757	19	8
Bucket	1	.	.
Dig and bury	206	.	.
Open defecation	402	.	.

Capital maintenance

Capital maintenance with latrines tends to happen when the slab or the superstructure need to be replaced or moved, or when pits are full and need to be emptied. In total 303 households (28.6%) have reported replacing their latrines more than one time (Figure G-3). For pit emptying, only 114 households (10.6%) have reported pit emptying (Figure G-4) and there is a clear correlation between the age of the latrine and how many times it has been emptied.

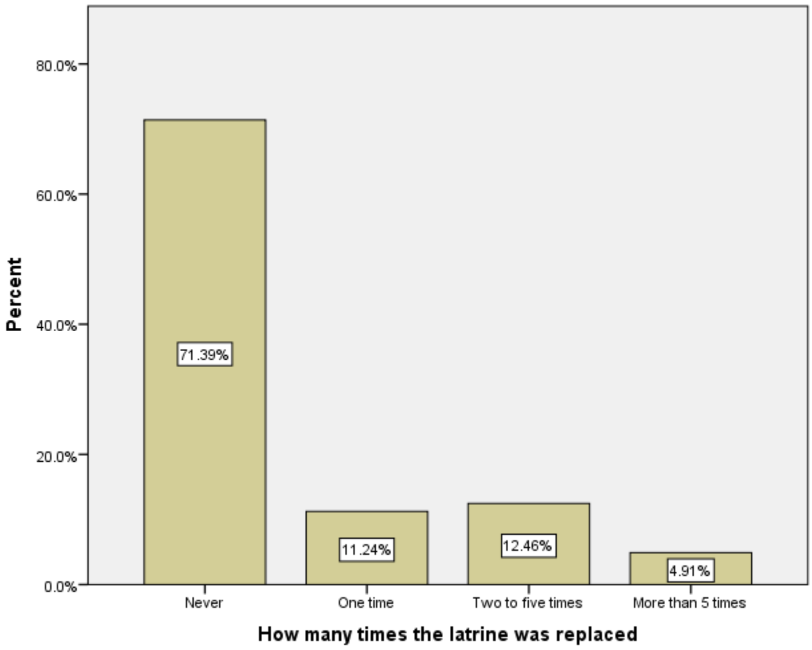


Figure G-3 Percentage of households that has reported replacing their latrines and frequency

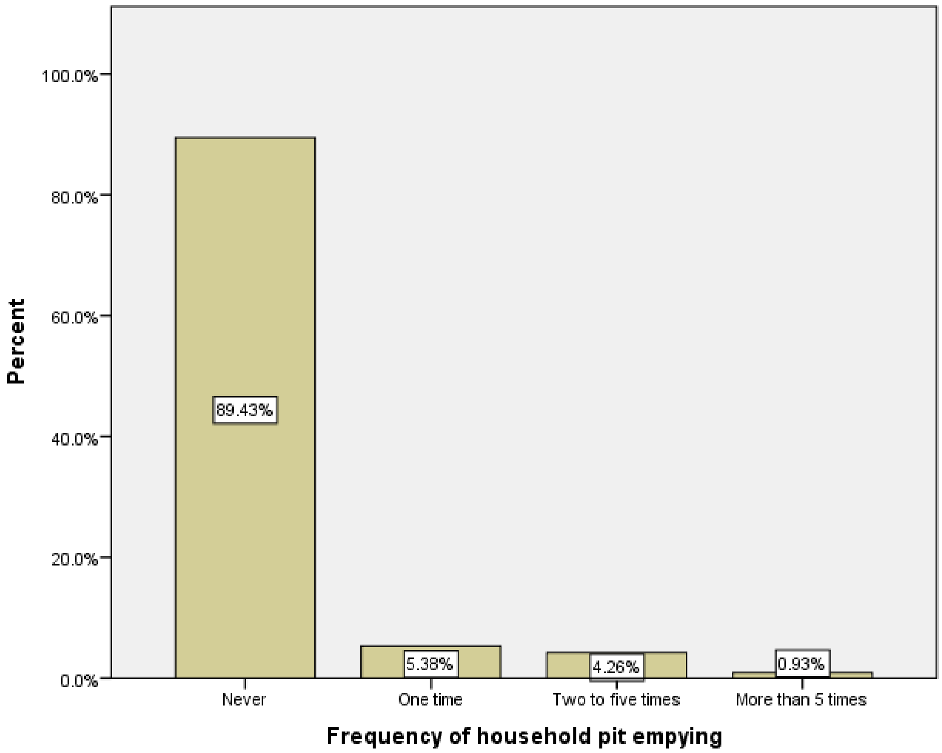


Figure G-4 Percentage of households that have reported pit emptying and frequency

For the calculations of the replacement and rebuilding costs, it was assumed that for each replacement, the households incurred a financial transaction (and not in kind) which was assumed to be similar to capital expenditure. The median of total replacement costs is US$ 45.35 (Table G-5).

Table G-5 Statistics on replacement and rebuilding latrines

		Replacement and rebuilding costs $US 2011		
		Total	Per year	Per capita per year
N	Valid	120	120	120
	Missing	1590	1590	1590
Mean		115.52	52.15	11.23
Median		45.35	13.24	2.16
Std. Deviation		177.377	132.183	28.163
Minimum		1	0	0
Maximum		950	950	193
Percentiles	25	12.91	4.15	.83
	50	45.35	13.24	2.16
	75	119.31	47.30	10.34

For the pit emptying, it was asked how much the households spent every time they had to empty the pit. The median for each time households had to empty the pits and had to incur financial costs was US$15.14 (N=52, Std. deviation = 26.3 Figure G-5) which is somewhat correlated with the different sanitation facilities used for disposing the excreta Figure G-6, although for the low cost options many households have reported zero financial costs since they empty the pits themselves.

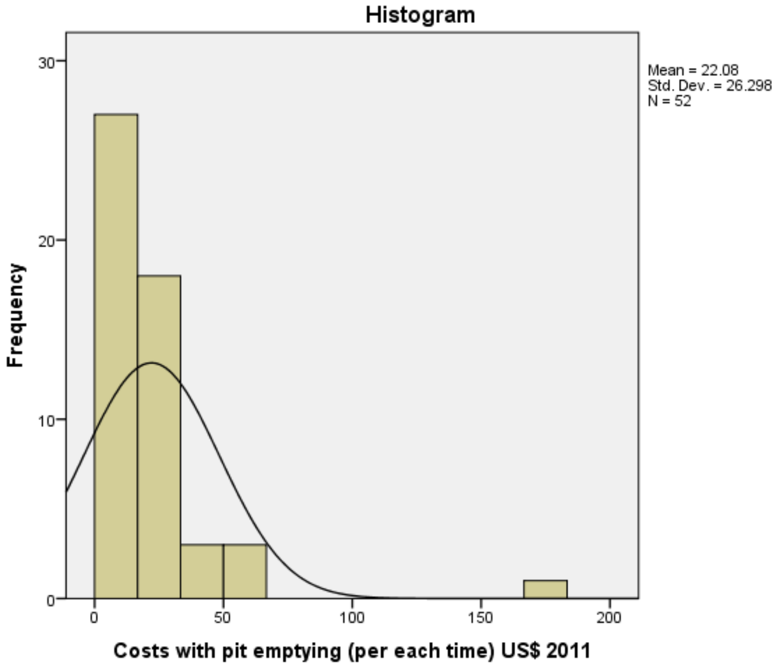


Figure G-5 Costs of pit emptying per unit when households incurred financial expenditures

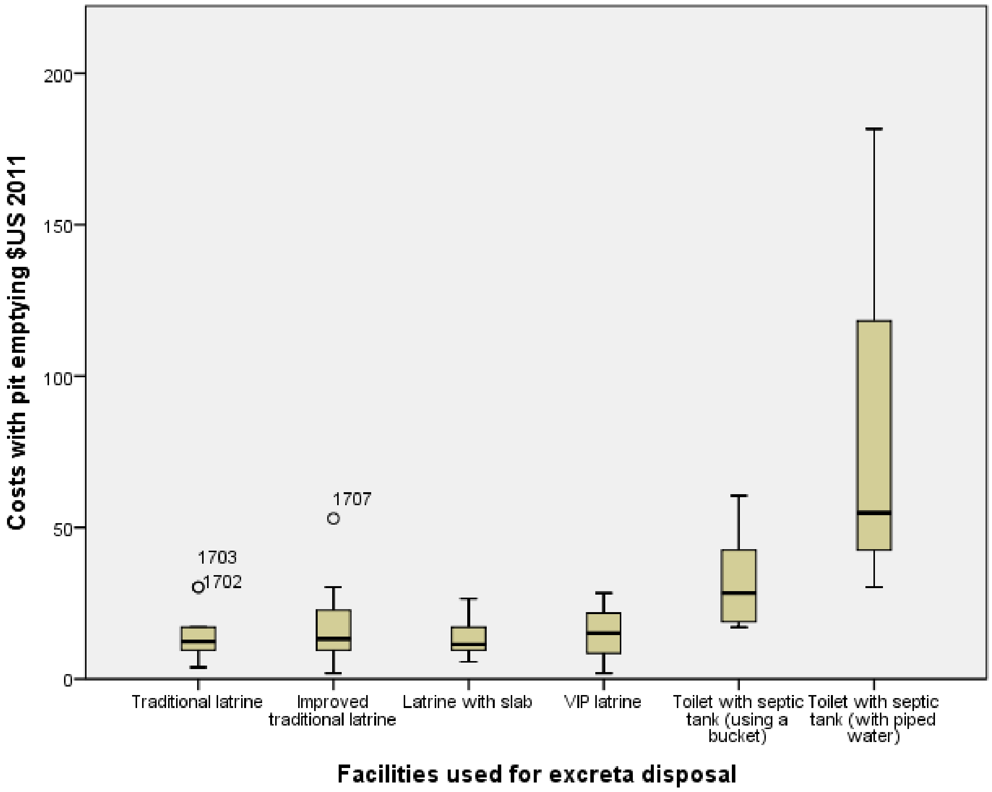


Figure G-6 Facilities used for excreta disposal and costs of pit emptying

When the overall costs of pit emptying are added through the years, the median rises to $US 60.95 (N=52, Std. deviation=87) and the increase is seen more markedly in the septic tanks (Figure G-7 and Table G-6).

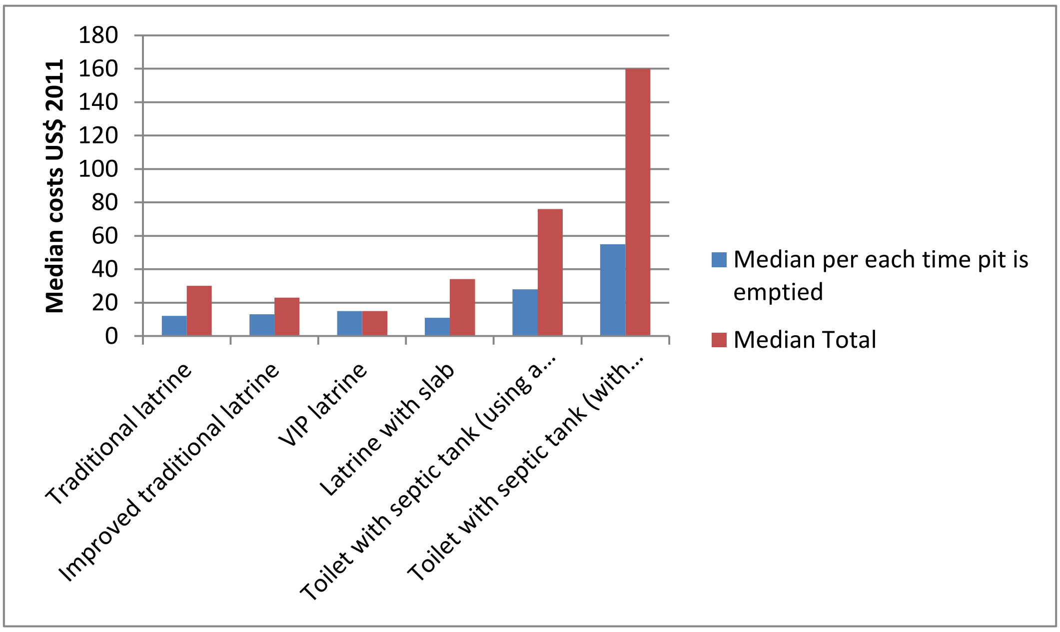


Figure G-7 Median costs pit emptying per excreta disposal facility

Table G-6 Statistics on pit latrine emptying

		Pit emptying costs $US 2011		
		Total	Per year	Per capita per year
N	Valid	52	50	50
	Missing	1658	1660	1660
Mean		60.95	7.08	2.27
Median		34.06	3.28	.81
Std. Deviation		86.991	8.980	5.895
Minimum		4	0	0
Maximum		529	41	41
Percentiles	25	15.61	1.82	.28
	50	34.06	3.28	.81
	75	84.50	8.22	2.31

With the assumptions described in the methodology, capital maintenance expenditure was derived from summing up the total costs of replacement and pit emptying for the latrines, per household in total (median US$ 39.16), per year (median US$ 8.97) and per person (US$ 1.83) (Table G-7).

Table G-7 Statistics on overall capital maintenance expenditure for sanitation

		Capital expenditure costs $US 2011		
		Total	Per year	Per capita per year
N	Valid	158	156	156
	Missing	1552	1554	1554
Mean		107.80	42.38	9.36
Median		39.16	8.97	1.83
Std. Deviation		167.819	118.049	25.561
Percentiles	25	13.93	2.98	.60
	50	39.16	8.97	1.83
	75	112.22	35.54	7.51

As a final financial expenditure analysis, the overall per year costs per person per sanitation facility has a median of US$2.23 (Figure G-8).

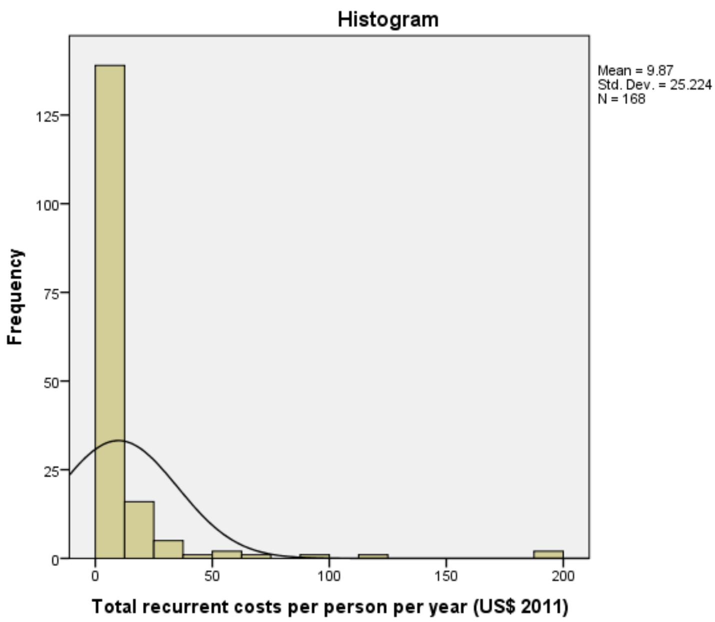


Figure G-8 Total recurrent financial expenditure sanitation

G.1.2 Ghana

Financial costs with building latrines

The Ghana sanitation questionnaire was less exhaustive than the Mozambique (the questionnaires were not designed to capture economic costs) and did not gather information when households were building or maintaining their own latrines.

In Ghana, only 40 households have reported financial expenditure (Table G-8) which ranges between zero and $189 USD 2011 prices per capita with a median of $17.

Contrary to Mozambique, the median capital expenditure is higher in rural areas (median $20, N=32) compared with small towns (median $15, N=8) but the number of variables is too small to draw further conclusions. Maybe this is the result of some small towns having in fact characteristics of rural areas.

The capital expenditure per type of technology does not vary much but the median is higher for latrines with slabs and VIP latrines when compared with traditional pit latrines (Figure G-9). Contrary to what is expected, the median capital expenditure from households with a toilet with septic tank are higher than the other facilities Figure G-10 (also if calculations are done per person).

Thirteen households have reported receiving a subsidy of about US$49 per household (median) which were provided to traditional latrines and VIP latrines this might be the reason why costs for these two specific type of facilities are “artificially” more expensive.

Table G-8 Statistics on household capital expenditure sanitation Ghana

		Capital expenditure per capita ($US 2011)
N	Valid	40
	Missing	1299
Mean		34.85
Median		17.06
Std. Deviation		46.420
Minimum		0
Maximum		189

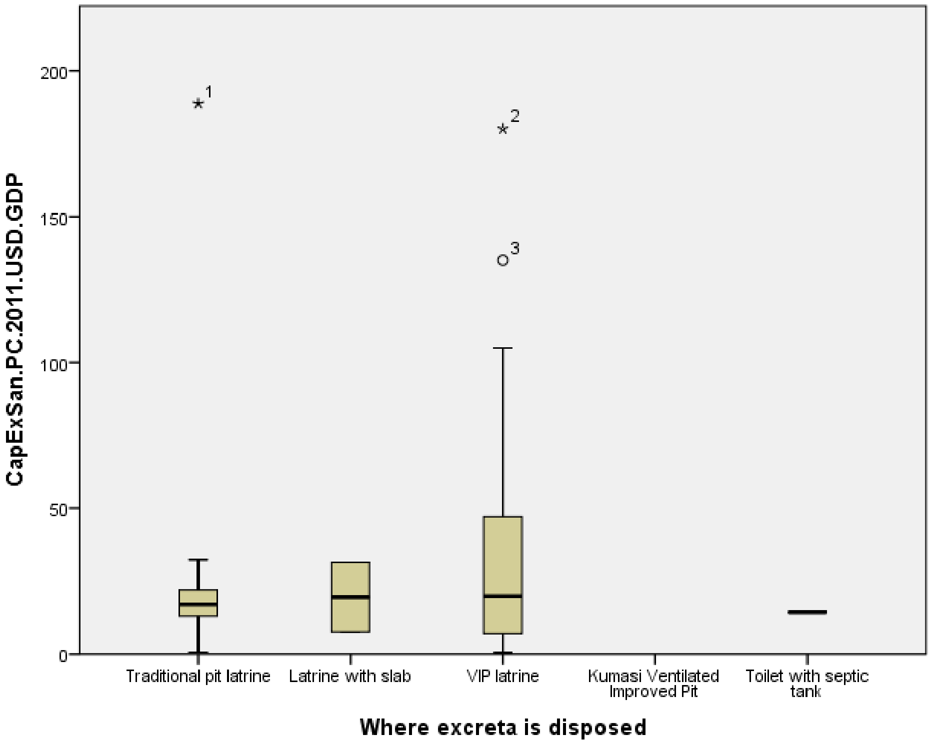


Figure G-9 Capital expenditure per capita vs sanitation facilities accessed

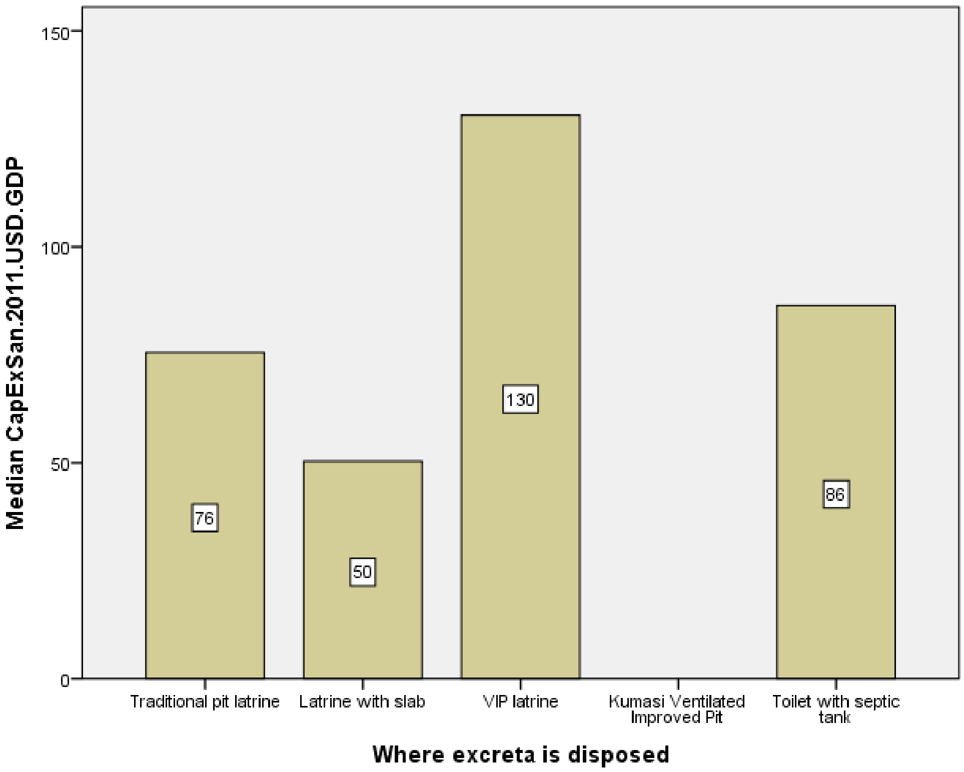


Figure G-10 Mean capital expenditure and sanitation facilities accessed

Financial costs with maintaining latrines

For operational expenditure 53 households have reported spending money on cleaning or disinfecting the latrines and toilets with a median of US$ 4.5 per person per year. Households spend more on the maintenance of VIP latrines (median) as shown in Figure G-11 and financial expenditure on maintenance in small towns is also higher than in rural areas.

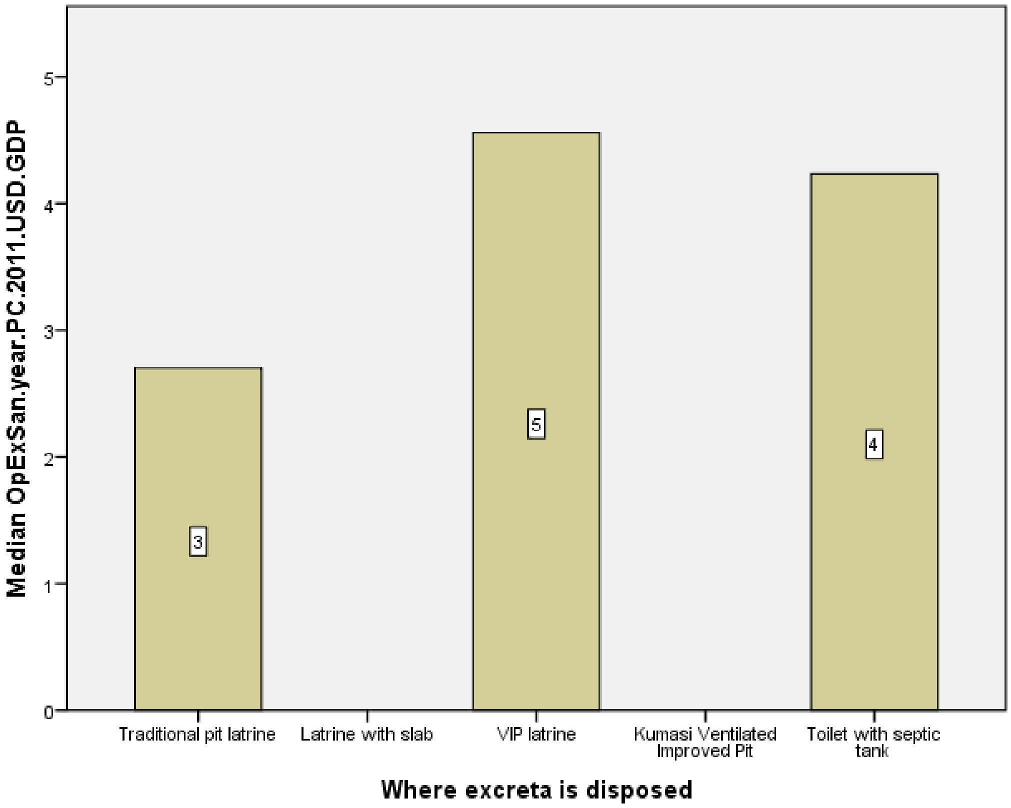


Figure G-11 Mean operational expenditure per person per year and sanitation facilities accessed

In Ghana, costs for accessing public toilets were collected, but an assumption was done on the number of an average visits per day per person (4). The estimated amount per person per year expenditure of 93 respondents and their families is US$ 6.57 (median) which is higher than the maintenance costs of own latrines (Table G-9).

Table G-9 Statistics on operational capital expenditure and public toilet tariff sanitation Ghana

		Public toilet tariff per capita per year ($US 2011)	Operational expenditure per capita per year ($US 2011)
N	Valid	93	53
	Missing	1246	1286
Mean		8.40	7.58
Median		6.57	4.50
Std. Deviation		6.849	9.893
Minimum		0	1
Maximum		33	54

While capital expenditure was not related with the socio-economic status of the households, operational maintenance (free of subsidies), clearly is (Figure G-12).

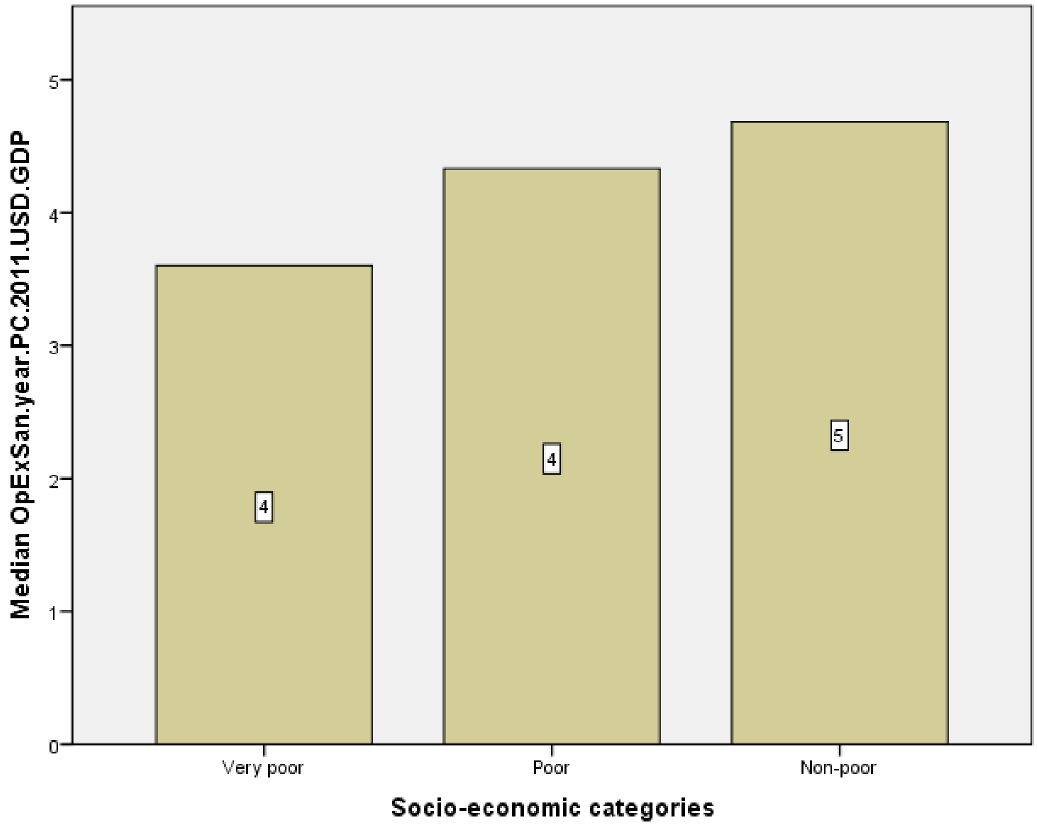


Figure G-12 Mean operational expenditure per person per year and socio-economic categories

No expenditure has been reported on capital maintenance expenditure to desludge, replace or repair the latrines.

Appendix H Economic costs building & maintaining latrines, Mozambique

The reported amounts on market costs for labour and materials to build latrines were generally lower than the amounts households had de facto spent on labour and materials. Although the standard deviation is high, the resulting median and mean are very close, reflecting some convergence in the answers provided (Table H-1).

Based on the median of reported market costs for labour, an amount of 300 meticais (US$ 11.35) and 200 meticais (US$ 7.57) is the amount required for materials if households would have to pay for them. The overall shadow price (economic costs) to build traditional pit latrines in rural low-income areas in Mozambique can therefore be assumed to be 500 meticais (US$ 18.92) or US$ 3.8 per capita. The costs for building latrines with slabs and superstructures with more solid materials will be higher.

Table H-1 Statistics table for cost equivalences (market rates reported) compared with households financial costs

		HH Financial costs labour (Meticais 2010)	Reported market cost labour (Meticais 2010)	HH Financial costs materials (Meticais 2010)	Reported market cost materials (Meticais 2010)
N	Valid	1039	243	1025	249
	Missing	671	1467	685	1461
Mean		154.14	299.86	332.30	258.59
Median		.00	300.00	.00	200.00
Std. Deviation		460.589	162.437	1013.664	415.365
Minimum		0	20	0	50
Maximum		6000	1500	9000	6000

Since there has been no time collected on the maintenance of the latrine no further shadow costs can be derived.

Appendix I Service levels and the human rights framework

I.1.1 Accessibility to water facilities

Adding to the chapter on economic costs (5.4), where time to access water was discussed, this chapter elaborates further on how water is being collected, the frequency and how distance is related with financial expenditure.

Mozambique

Water is collected primarily in 65% of cases (N=1103) by women above 15 years (Figure I-1). A small percentage of men (2%), and girls and boys (2%) also collect water. The receptacles most used to collect water are jerry cans (96%) followed by buckets and basins (22%) and water bottles (.9%). Water is mostly carried on heads and shoulders (94%) (Figure I-2). The car, the tchova (Figure I-3) and paying someone have only been reported in peri-urban areas.

The workload is significant, the average number of roundtrips per day in the sample is 3 (if only using one source) or 6 (using two sources) in wet or dry season and carrying at least 20 litres per time (Figure I-4). Only for the primary source in the wet season the median drops to 2 roundtrips per household per day.

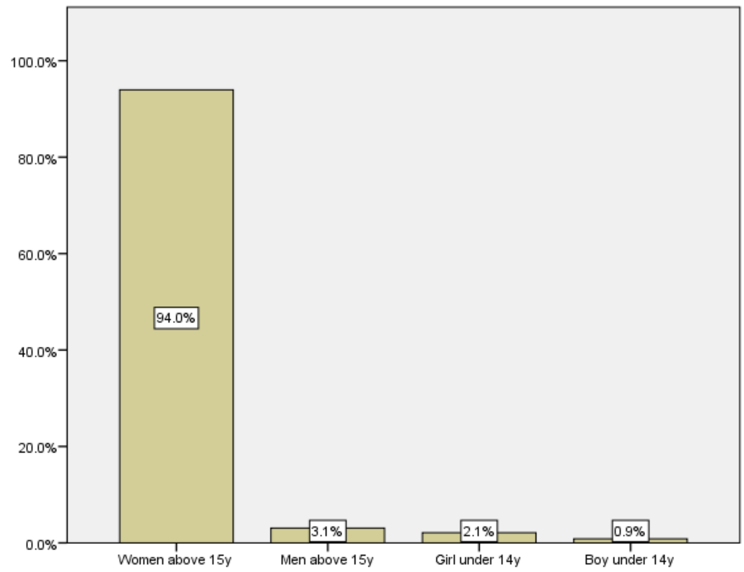


Figure I-1 Who collects water in the primary source in the dry season (% of valid answers)

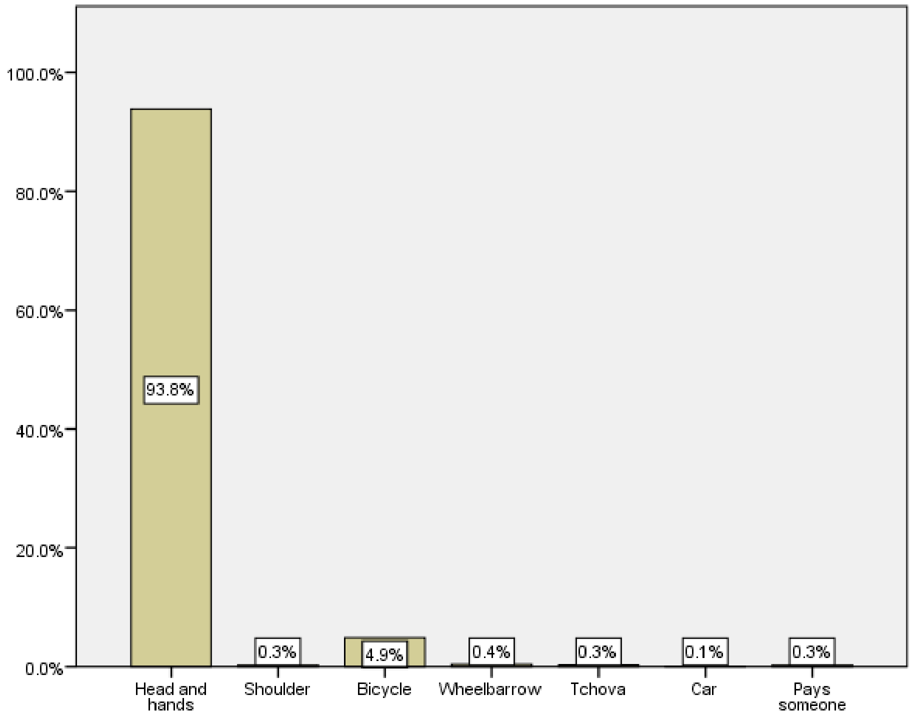


Figure I-2 Method most used to transport water

Figure I-3 A tchova in Maputo. Source: unknown.

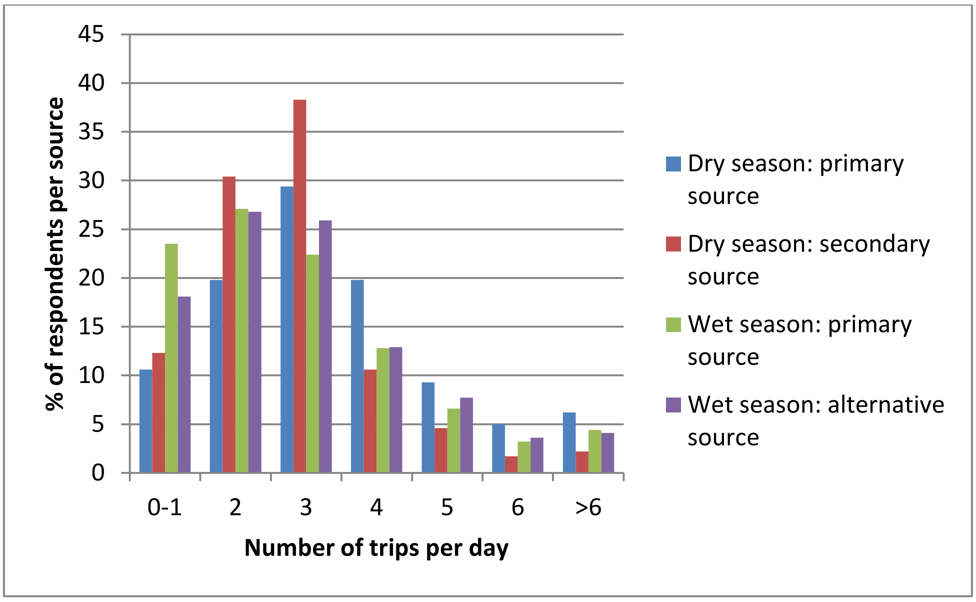


Figure I-4 Number of roundtrips per day, per household, per source

The reported distance in metres from the primary source in the dry season is for the majority less than 500 meters while the alternative source tends to be further away as well as the primary source in the wet season (Table I-1). Boreholes with handpumps are the furthest away source to access with a median of 334 metres (Figure I-5). However, as explained in the methodology chapter 4.6.1, distance masks the real problems faced by households to carry, queue and wait for water and reported time is a better proxy to access than reported distance.

Photo 7 Queuing to get water, peri-urban Maputo, Mozambique. Photo credit: Peter McIntyre

Table I-1 Reported distance, dry and wet season, primary and alternative source

Reported distance	Dry season (%)		Wet season (%)	
(*primary source was measured with GIS)	Primary source*	Alternative source	Primary source	Alternative source
Less than 100 meters	28.3	5.8	7.9	71.7
Between 101 - 250 meters	20.2	17.7	47.2	3.3
Between 251 - 500 meters	24.6	26.5	14.0	3.3
Between 501 - 1000 meters	12.4	22.8	14.6	6.7
Between 1001 - 2000 meters	8.5	16.8	9.0	13.3
More than 2000 meters	6.0	10.4	7.3	1.7
N	1221	536	178	60

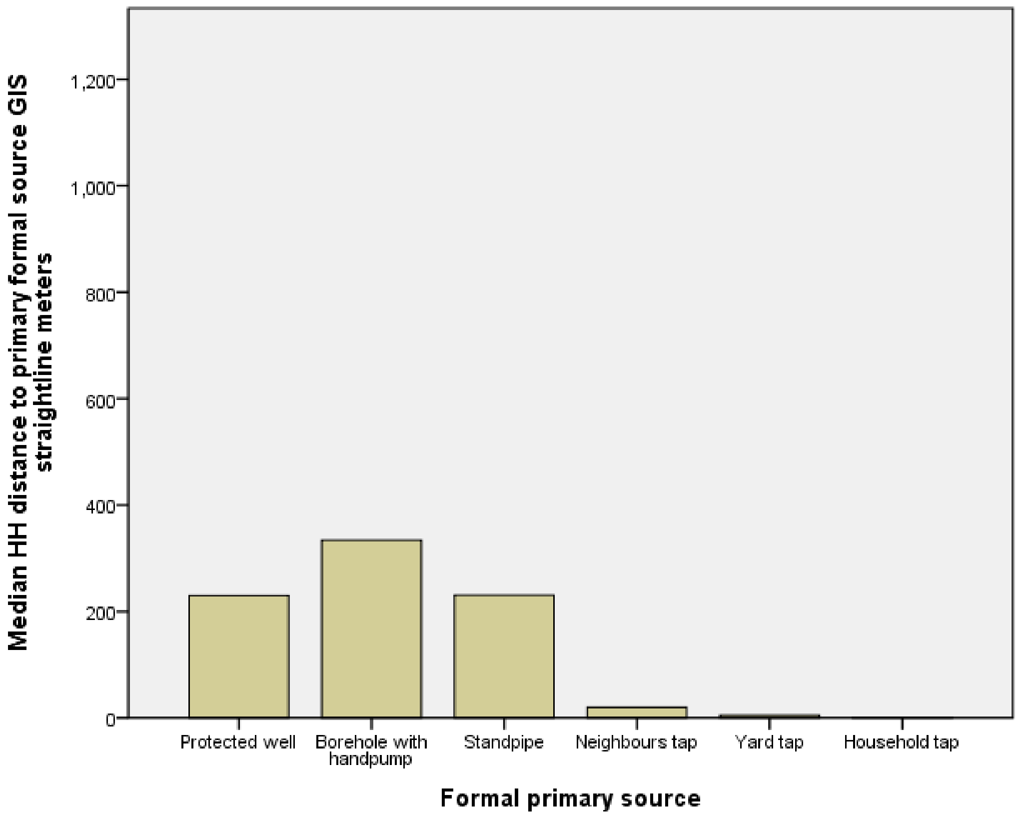


Figure I-5 Median distance meters per primary formal source, Mozambique

Correlating the reported distance with how many times a day a household collects water provides a statistically relevant result. Pearson's coefficient is 19.5% which means that the distance to the source measured in meters accounts for 3.8% (R^2) of the variability of the number of times spent collecting water in the primary source in the dry season (CI [-.319,-.145], p=.000). Similarly to the time spent per round trip, the lower the distance, the higher the number of roundtrips per day (Table I-2).

Table I-2 Round trips per day and distance reported with GIS

GIS straight line distance primary source, dry season	Roundtrips per day water collection	
	Mean	Median
Less than 100 meters	5	4
Between 101 - 250 meters	4	3
Between 251 - 500 meters	4	3
Between 501 - 1000 meters	3	3
Between 1001 - 2000 meters	2	2
More than 2000 meters	2	2

Using Kendall's test, the correlation coefficient is significant between the distance and the rural or peri-urban location (K=46.1%, CI [-4.96, -4.27], p=.000) as well as between the distance and the wealth status (P=24.6%, R^2=6%, CI [-.290,-.197], p=.000).

Regardless of whether we use the reported time spent by households per round trip (Figure I-6,

Table I-3) or the household distance (Table I-4) generally, the higher the wealth status the lower the distance to the primary source in the dry season.

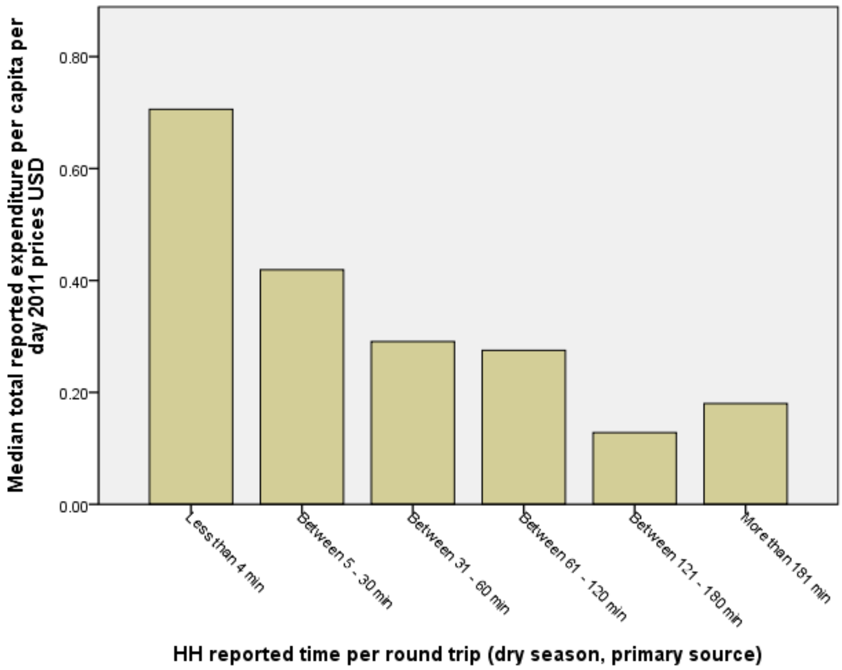


Figure I-6 Households reported time per round trip against reported expenditure

Table I-3 Reported time per round trip against reported expenditure (wealth status)

HH reported time round trip grouped (dry season, primary source with queuing)	Total household reported expenditure (per capita, per day, 2011 prices, USD)	
	Mean	Median
Less than 4 min	.86	.71
Between 5 - 30 min	.54	.42
Between 31 - 60 min	.39	.29
Between 61 - 120 min	.36	.28
Between 121 - 180 min	.28	.13
More than 181 min	.29	.18

Table I-4 HH distance to source against reported expenditure (wealth status)

HH distance to source, straight-line, meters grouped (dry season, primary source)	Total household reported expenditure (per capita, per day, 2011prices, USD)	
	Mean	Median
Less than 100 meters	.67	.57
Between 101 - 250 meters	.41	.29
Between 251 - 500 meters	.36	.24
Between 501 - 1000 meters	.31	.23
Between 1001 - 2000 meters	.25	.18
More than 2000 meters	.24	.19

Finally, correlating capital expenditure, operational/recurrent expenditure and capital maintenance with distance to source (or with overall time spent per day) does not provide statistically valid results.

The median capital expenditure with sources which are less than 100 meters away from the households are higher than expenditure with sources further away (Figure I-7) and operational/recurrent expenditure does not vary significantly with distance from source (Figure I-8).

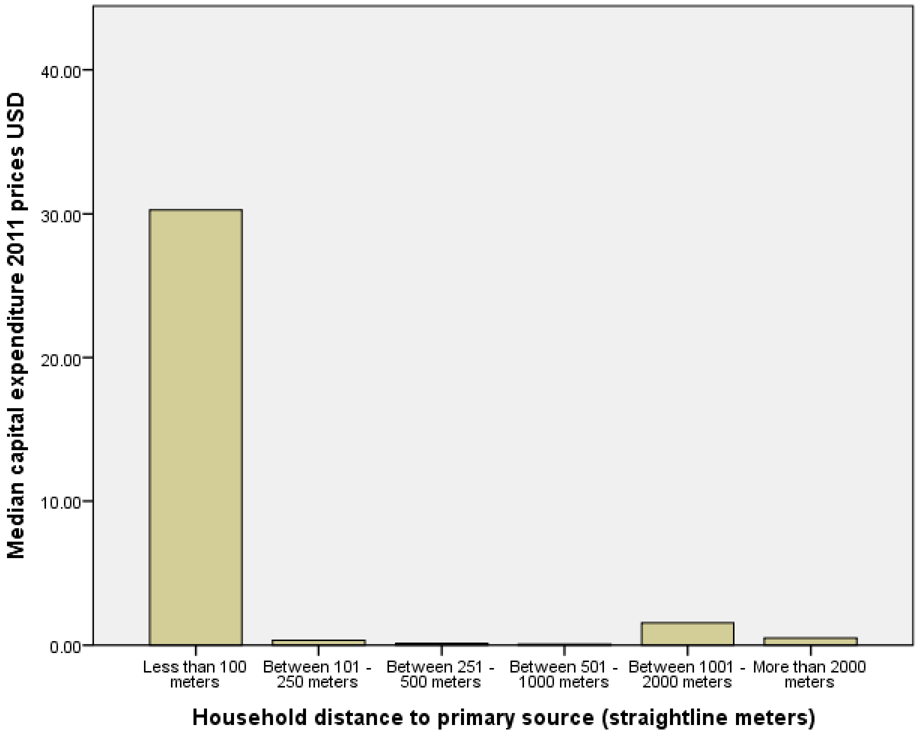


Figure I-7 Capital expenditure and household distance to primary source

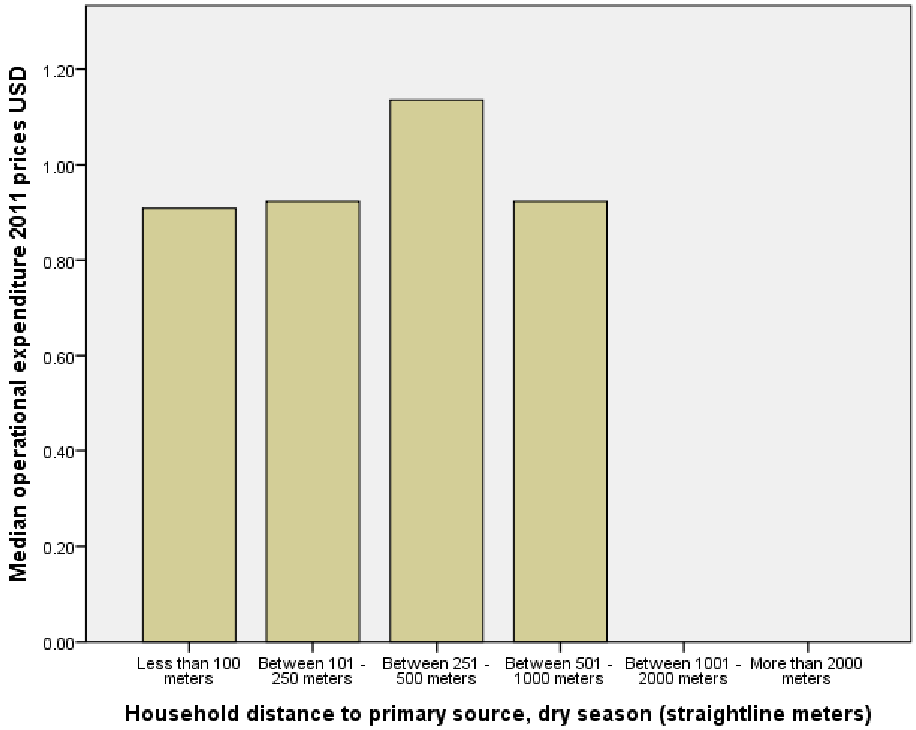


Figure I-8 Operational expenditure and household distance to primary source

Ghana

In Ghana water is collected mostly by women (63%, N= 839) and girls (50%, N=669) but also boys (32%, N=438). Only 3% of men (N=44) in the sample have reported collecting water.

The distance in metres measured with GIS straight line from the primary source to the formal water point is for the majority of households less than 250 meters (Table I-5). Boreholes with hand pumps are the furthest away source to access with a median of 197 metres (Figure I-5).

Table I-5 Distance from household to primary formal source, Ghana

Distance measured with GIS	Primary formal source
Less than 100 meters	31,5
Between 101 - 250 meters	32.9
Between 251 - 500 meters	13.4
Between 501 - 1000 meters	20.7
Between 1001 - 2000 meters	1.4
More than 2000 meters	0.1
N	1272

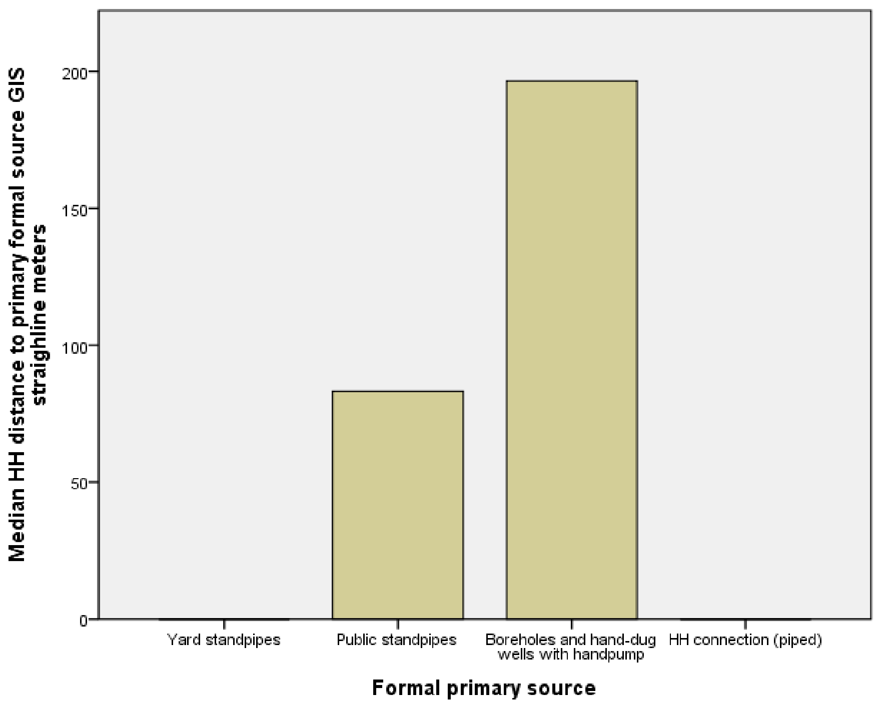


Figure I-9 Median distance meters per primary formal source, Ghana

Similar to Mozambique distance is higher in rural areas when compared with small towns (there is no distance data for small towns) but unlike Mozambique, the wealth status does not influence the distance, maybe because the majority of the households, being better off are selecting (paid) sources closer to their homes already.

The final correlation is between the payments for the formal sources and the distance. Overall, the median of water payments is higher for the sources less than 250 meters compared with the sources between 251-1000 meters. However, from 1000 meters up, the median of payments doubles (Figure I-10).

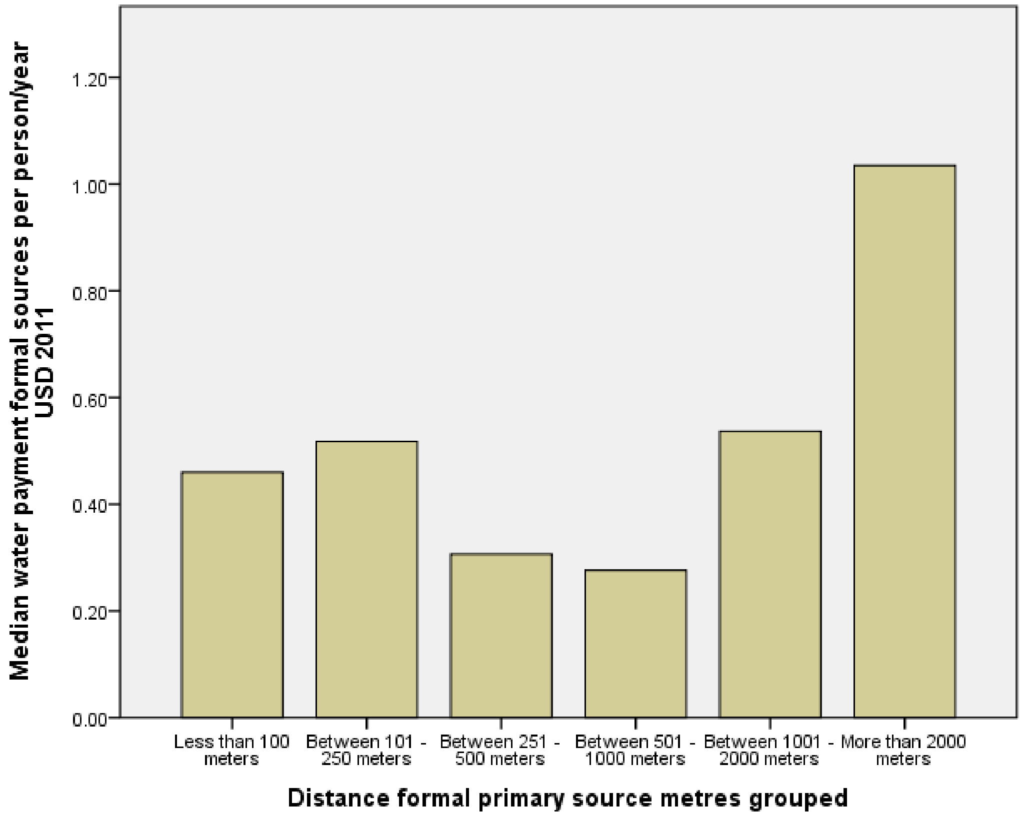


Figure I-10 Payments for formal sources and median distance meters per primary formal source, Ghana

I.1.2 Quantity of water

Mozambique

The large majority of households in the survey (N = 1638) collect water per day from all the sources compared with those that collect water per week or have a metered tap (Figure I-11).

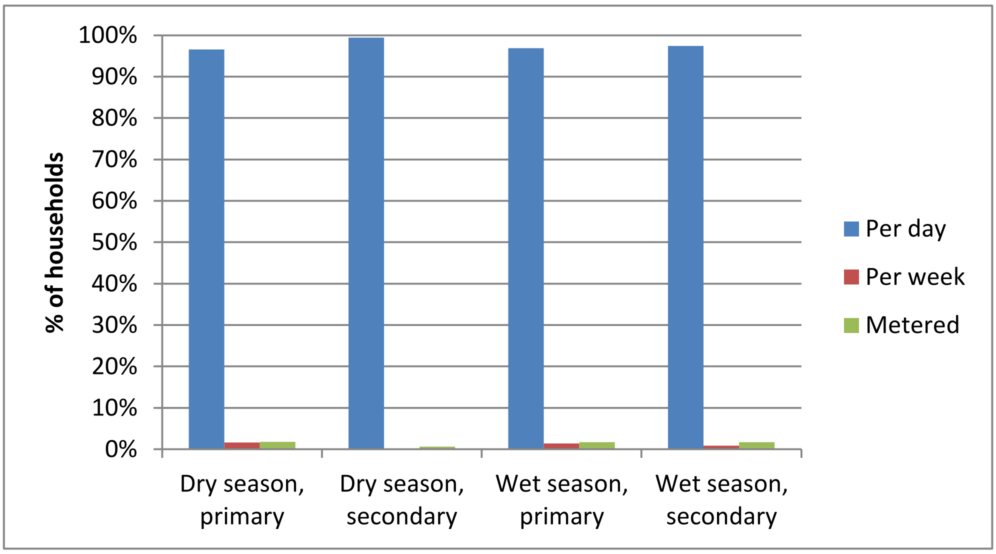


Figure I-11 Water collection frequency per source

There is a large difference in the quantity of water consumed per person per day depending if it's collected with containers (per day or per week) or if it is metered water. Those with metered water consume on average almost three times (Mean = 58 litres) more than those that have to fetch the water using containers and then carry them to the household (Mean = 20 litres). The litres per capita per day in the dry season for the water collected with containers is higher than the water collected in the wet season (Figure I-12). As described in chapter 5.2.1, in the wet season more non-formal sources are accessed given the availability of water.

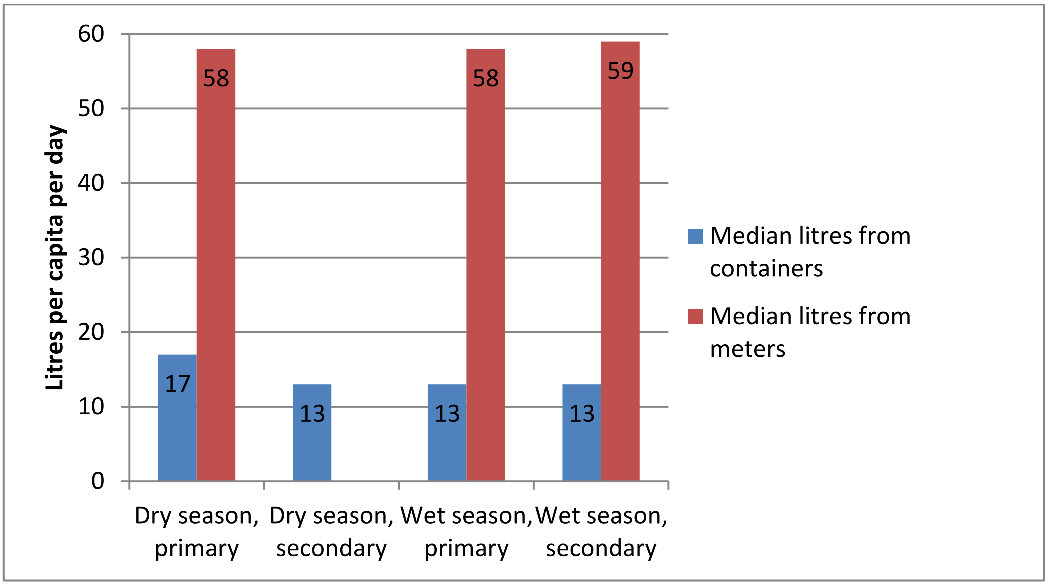


Figure I-12 Total litres per capita per day, per source, per type of water collection

For the overall consumption throughout the whole year, the analysis of medians and means hides the high disparity in the overall consumption intervals (For the correlations, given that all the metered taps are in peri-urban areas, the Kendall's correlation test provides a statistical valid correlation for between quantity and rural/peri-urban areas (respectively: K=15%, CI [.109,.189], p=.000 and K=12.5%, CI [.086, .165], p=.000).

Analysis of quantity per source also show a valid correlation for the dry season (K:17.3%, CI [.137, .206], p=.000) and the wet season (K:14.6%, CI [.106,.183], p=.000).

Table I-6). The majority of people consume between 11 and 20 litres per capita per day in the dry and wet season, followed by those that consume between 21 and 40 litres. However, in the wet season, consumption increases particularly above 20 litres per capita per day (Figure I-13).

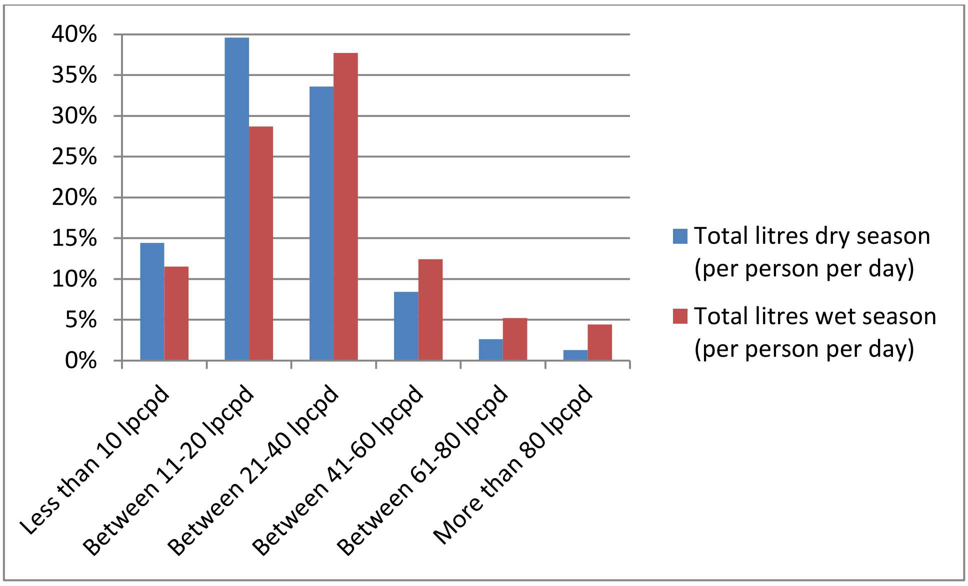


Figure I-13 Total litres per capita per day dry and wet seasons

For the correlations, given that all the metered taps are in peri-urban areas, the Kendall's correlation test provides a statistical valid correlation for between quantity and rural/peri-urban areas (respectively: K=15%, CI [.109,.189], p=.000 and K=12.5%, CI [.086, .165], p=.000).

Analysis of quantity per source also show a valid correlation for the dry season (K:17.3%, CI [.137, .206], p=.000) and the wet season (K:14.6%, CI [.106,.183], p=.000).

Table I-6 Measures of central tendency: total litres per capita per day dry and wet seasons

		Total litres per capita per day dry season	Total litres per capita per day wet season
N	Valid	1642	1603
	Missing	68	107
Mean		25.84	33.41
Median		20.00	26.67
Std. Deviation		18.073	25.804
Percentiles	4	6.67	6.67
	25	13.33	16.00
	50	20.00	26.67
	75	33.33	40.00

The median of litres per capita per day per water sources in the dry season has three clear intervals: until 20 litres per person per day for both informal and formal communal sources, from 21 to 40 litres per person per day for those that access standpipes, neighbours tap, yard taps and a much higher median of close to 80 litres per person per day for those which access a household tap (Figure I-14). In the wet season, litres increase for all sources except for protected wells. The highest increase is on those that access water from yard taps (Figure I-15).

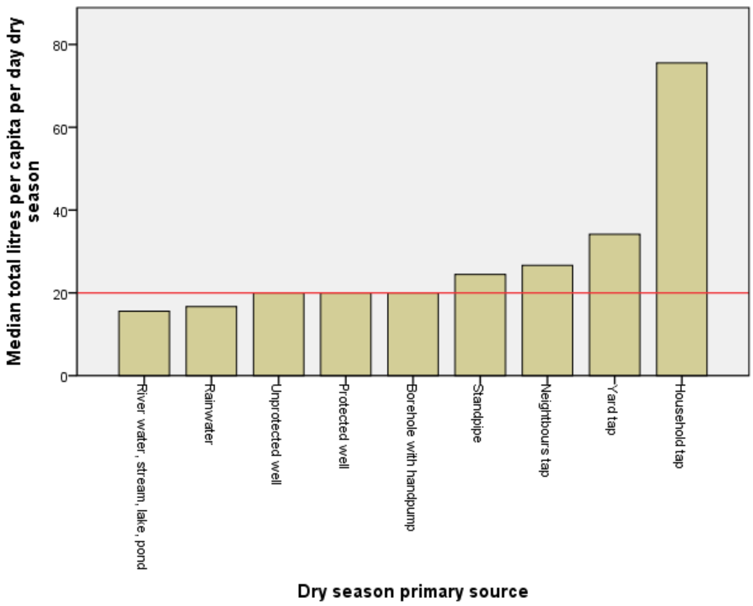


Figure I-14 Median total litres per capita per day, dry season

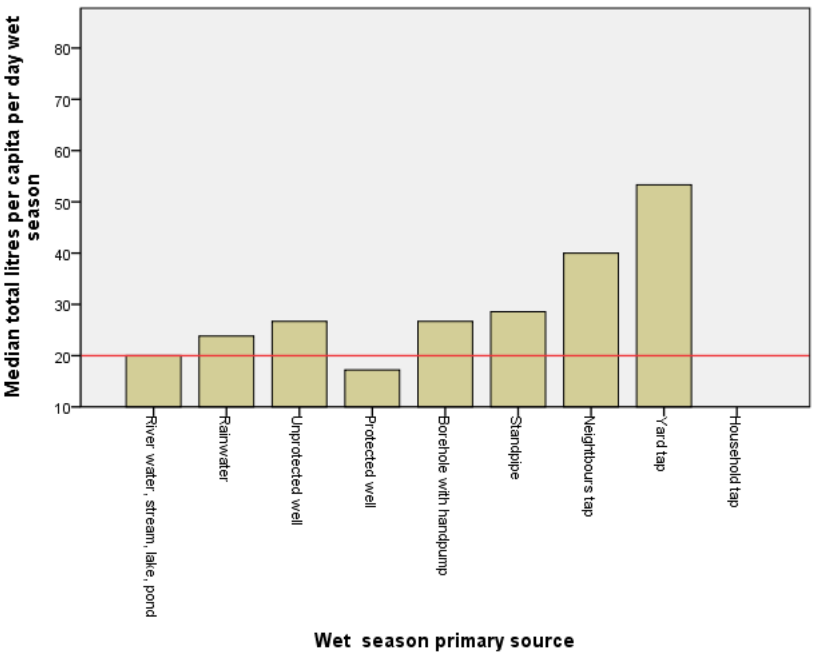


Figure I-15 Median total litres per capita per day, wet season

The litres used per day per person does not seem to impact on the uses, there is no significant variation in the proportions of uses among the different intervals. Aggregating some of the uses provides a clearer picture (Figure I-16). There is a slight increase in water for cooking and hygiene related uses between 21-40 litres per capita per day.

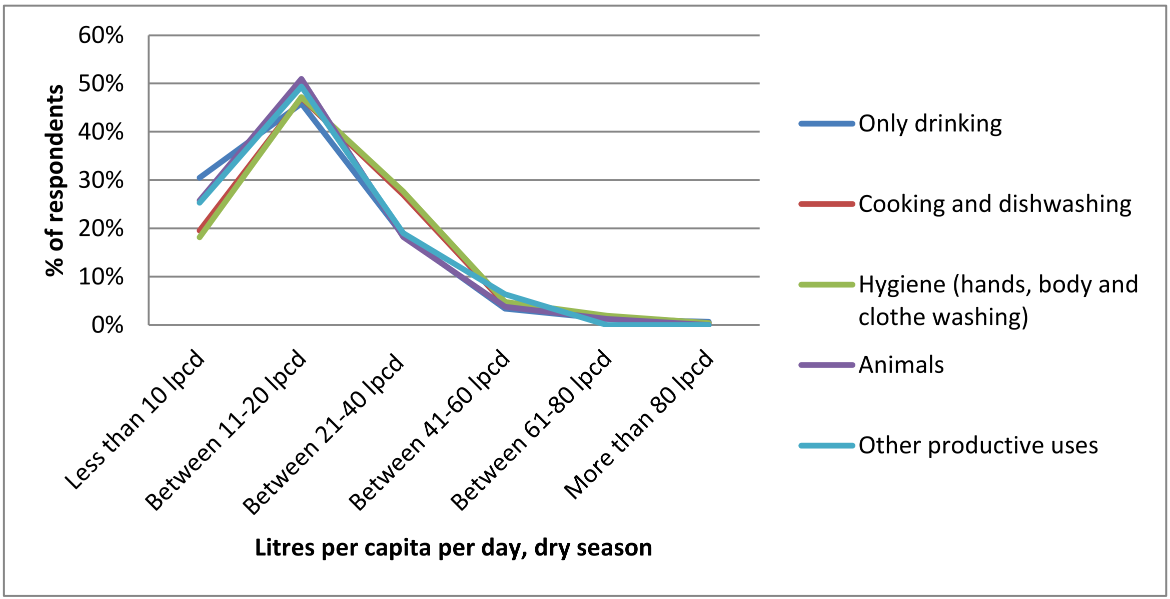


Figure I-16 Reported uses of water aggregated, primary source, dry season per consumption interval (litres per person per day)

Larger households are found to have greater water use and per capita consumption (Figure I-17). Using Pearson correlation coefficient also provides a significant correlation between the two variables: R^2 = 16.2%, P=-40.3%, CI [-.442, -.362], p=.000.

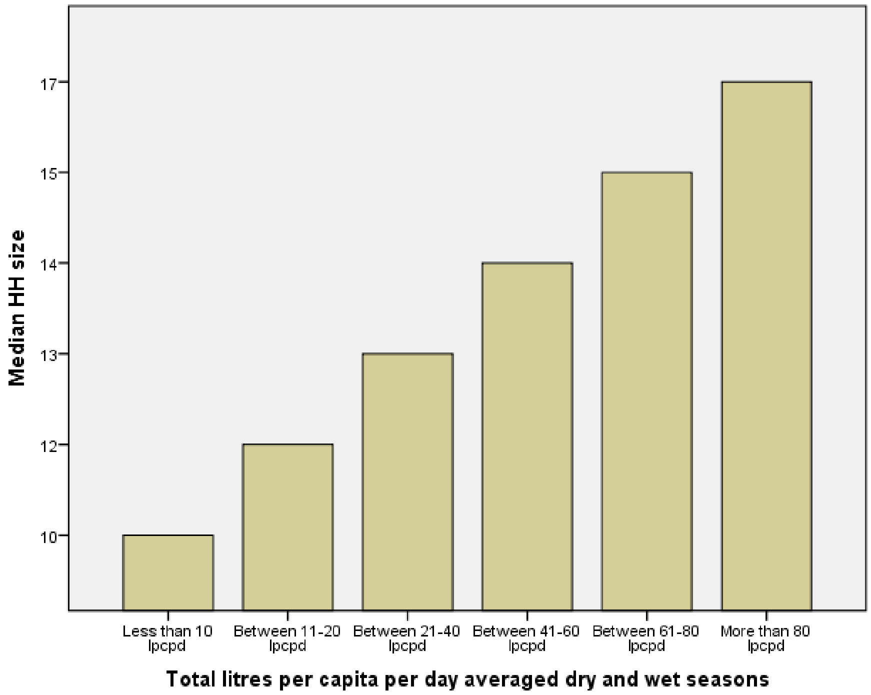


Figure I-17 Total litres per capita per day and median size of households

The quantity of water increases the shorter the distance from the household to the source independently if measured with the more conservative measurement of straight line in meters (Figure I-18) or the time spent reported by the households for all trips per day (Figure I-19). The correlation summary statistics is presented in Table I-7.

Table I-7 Correlation statistics summary quantity, distance and time

Method for reporting distance and time	Pearson correlation coefficient	R2	Confidence intervals	p
Straight-line measurement (meters), dry season, primary source	-18.7%	3.5%	[-.231,-.142]	.000
Time spent per day reported by households for all trips, dry season, primary source	38.6%	14.8%	[.315,.454]	.000

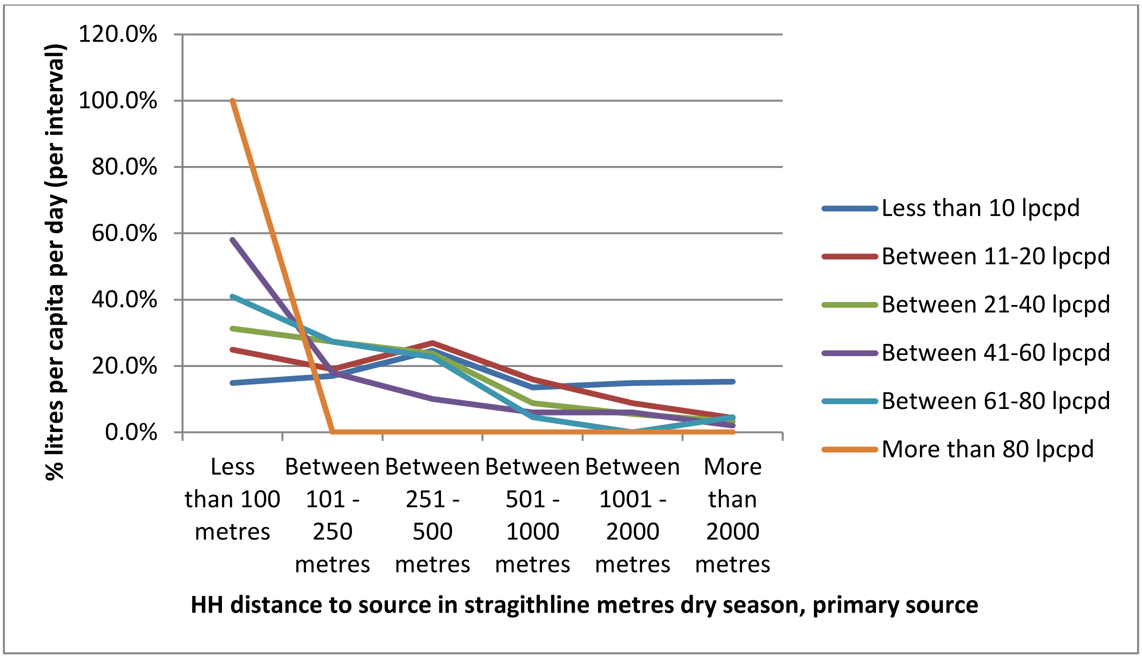


Figure I-18 Litres per person per day compared with the distance to source using straight line measurement in metres

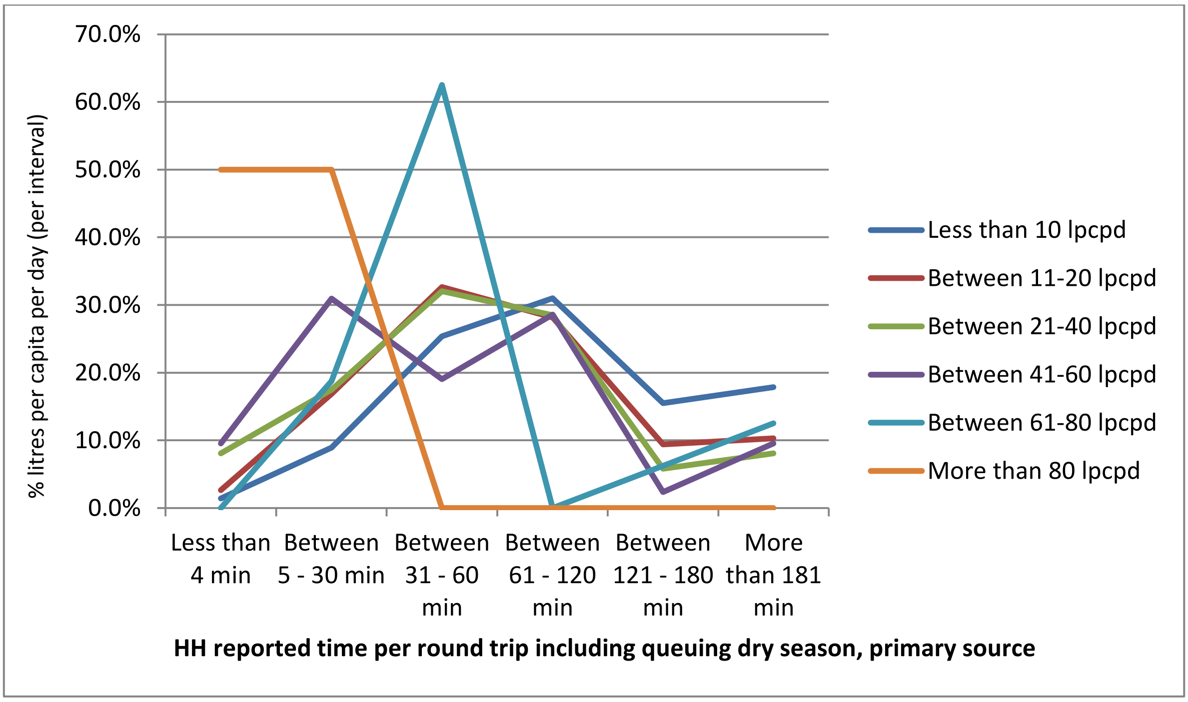


Figure I-19 Litres per person per day compared with the reported household time per round trip including queuing

There is also a statistically valid correlation between quantity and wealth status. The wealth status accounts for 9.7% (R^2) of the variance in the litres consumed per person per day (Pearson's correlation =31.1%, CI [.259, .361], p=.000).

And finally, for the correlations with costs, there are not enough data points to make a robust analysis with Pearson, but with a limited number of observations on costs above 80 litres per person per day, capital expenditure and capital maintenance expenditure are generally higher in these intervals compared with the other intervals.

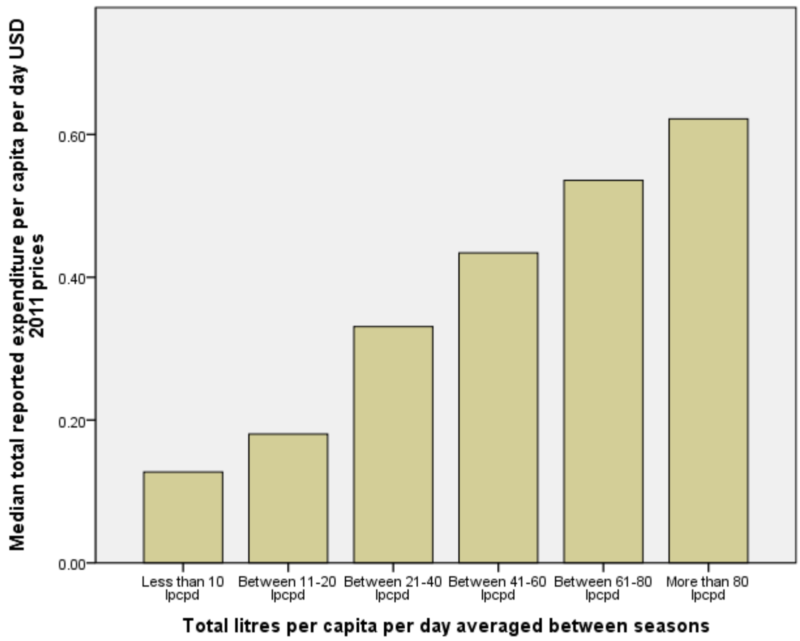


Figure I-20 Wealth status (median reported expenditure) and the total litres per capita per day

Ghana

In Ghana the overall median in the sample is 33 litres per person per day, but quantity varies according to the formal and informal sources (Figure I-21) and within formal sources (Figure I-22). The main difference is between those that access communal sources such as boreholes and hand-dug wells (N=1032) and public standpipes (N = 266, median 24 litres per person per day) and those that access private yard standpipes (N=7) and household connections (N=28) 45 litres per person per day). Households with rainwater systems reach a median of 87 litres per person per day (N=538).

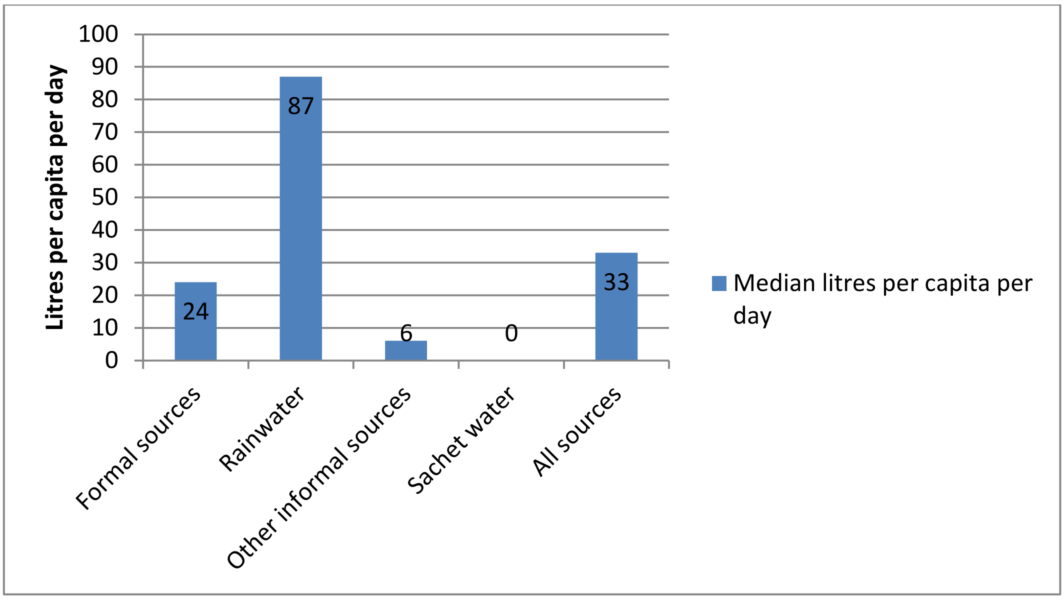


Figure I-21 Total litres per capita per day, formal and informal sources

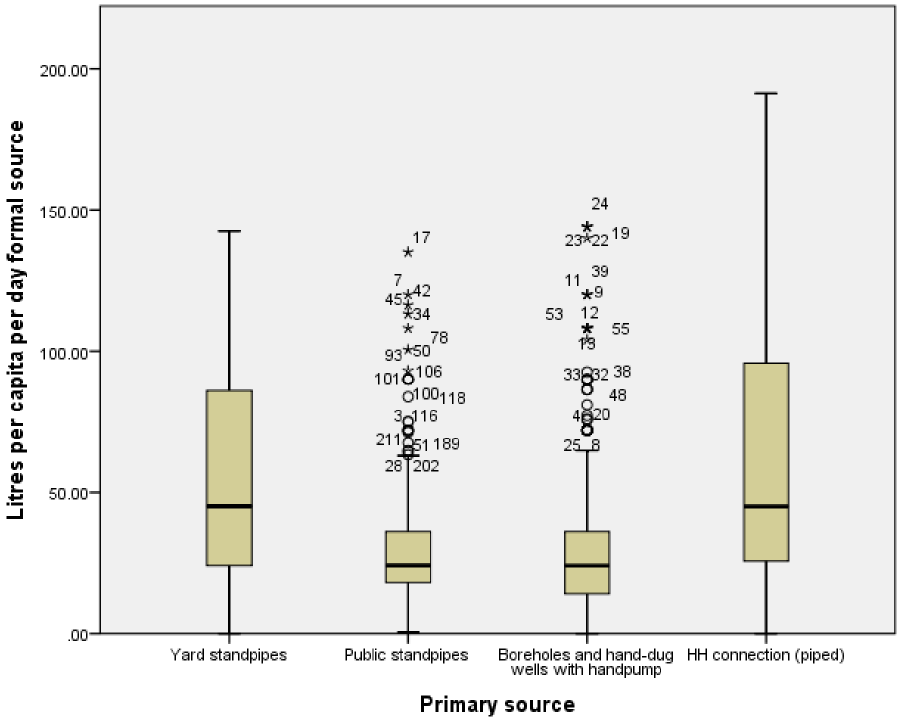


Figure I-22 Total litres per capita per day, formal sources

In Ghana the quantity of water is about 20 litres per person for sources lower than 250 metres, then decreases, but increases slight again after 500 metres. Checking quantity against other indicators we can conclude:

- The poor access slightly less quantity (23 litres per person per day) compared with the non poor (24 litres per person per day),

- Those in rural areas and small towns access less quantity (24) than those in peri-urban areas (32).
- There is a correlation between the quantity consumed and the amounts paid for the formal source only. Overall quantity and overall payment is less clearly correlated.
- More quantity is consumed when respondents are more satisfied with the quality of water (Figure I-22).

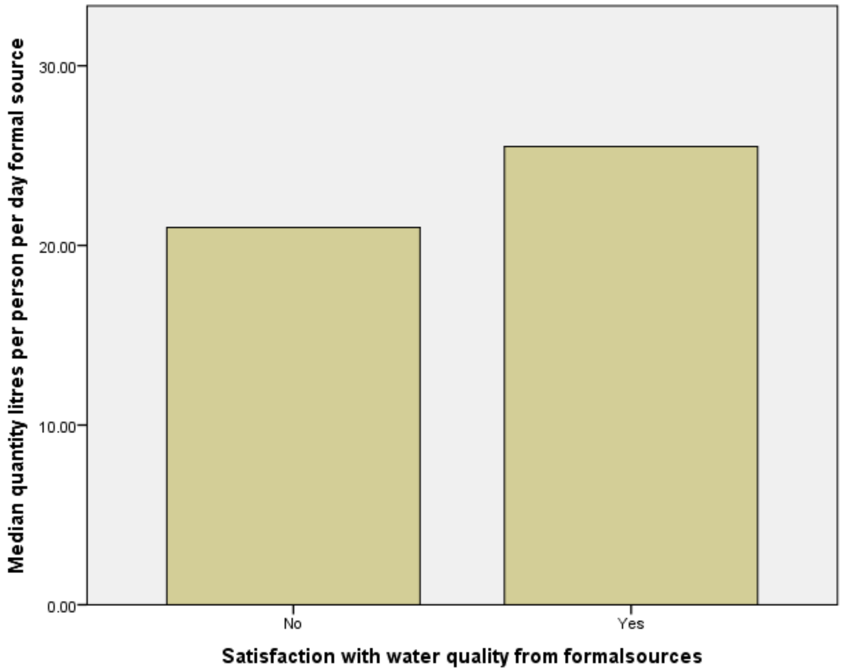


Figure I-23 Total litres per capita per day and satisfaction with water quality

I.1.3 Perception of water quality

Mozambique

Water quality testing was done one time for the sources acceded by 64% of the respondents, with acceptable results, but the parameters or results are not known. Mostly, the testing has been done on boreholes with handpumps (Figure I-24).

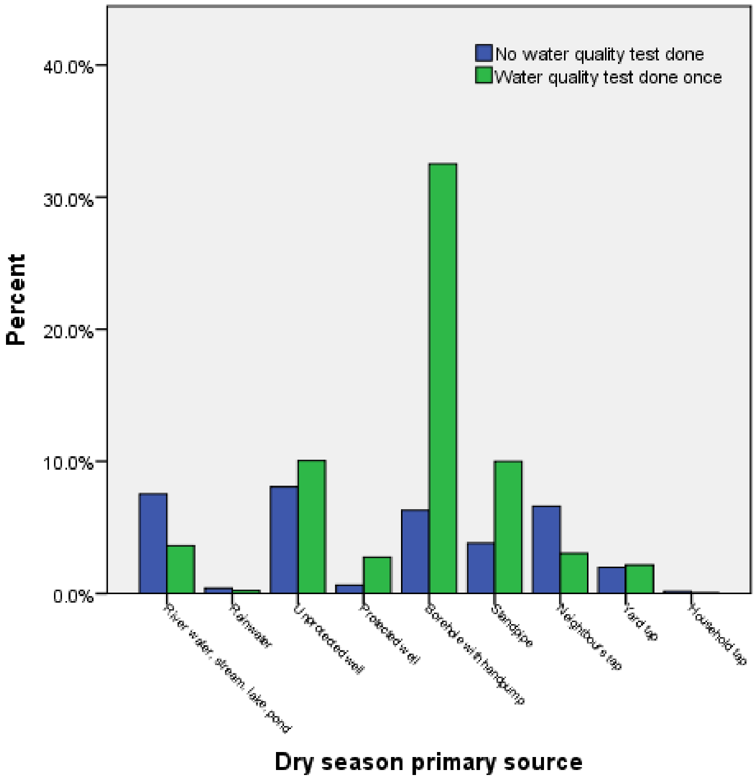


Figure I-24 Water quality testing per source

Table I-8 Primary sources dry season, per unimproved improved categories

	Technologies	Rural		Peri-urban	
Less-safe (unimproved)	River water, stream, lake, pond	150	8.8%	41	2.4%
	Rainwater	8	0.5%	3	0.2%
	Unprotected well	182	10.6%	128	7.5%
	Total unsafe	340	19.9%	172	10.1%
Safer (improve)	Protected Well	42	2.5%	16	0.9%
	Borehole	521	30.5%	143	8.4%
	Stand pipe	72	4.2%	164	9.6%
	Neighbours tap	3	0.2%	162	9.5%
	Yard tap	0	0.0%	71	4.2%
	Household tap	0	0.0%	4	0.2%
	Total safe	638	37.4%	560	32.8%

The perception for the majority of consumers is that the water is good in both wet and dry season with minimum variance between seasons (Figure I-25). A higher percentage of users in rural areas perceive water having bad quality than in peri-urban areas (Figure I-26).

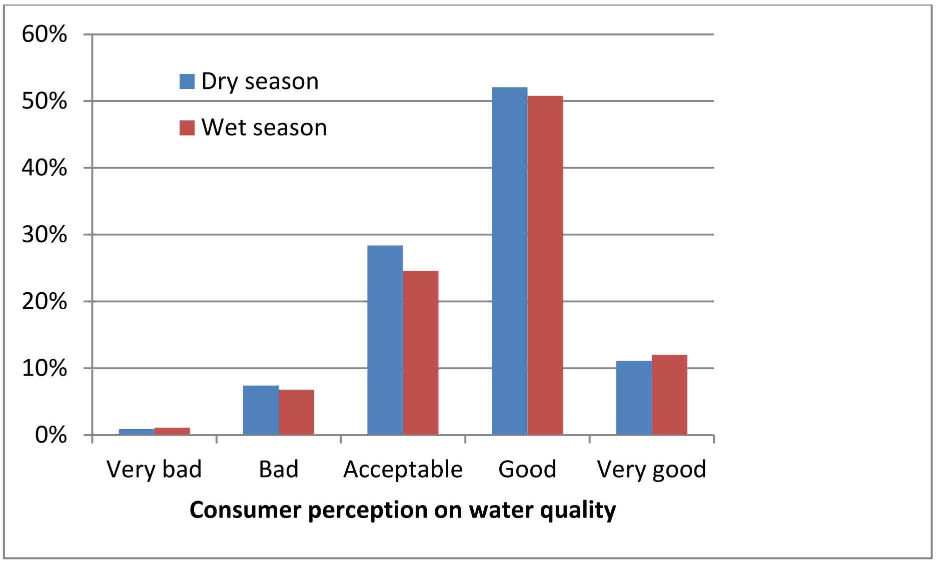


Figure I-25 Water quality perception per season

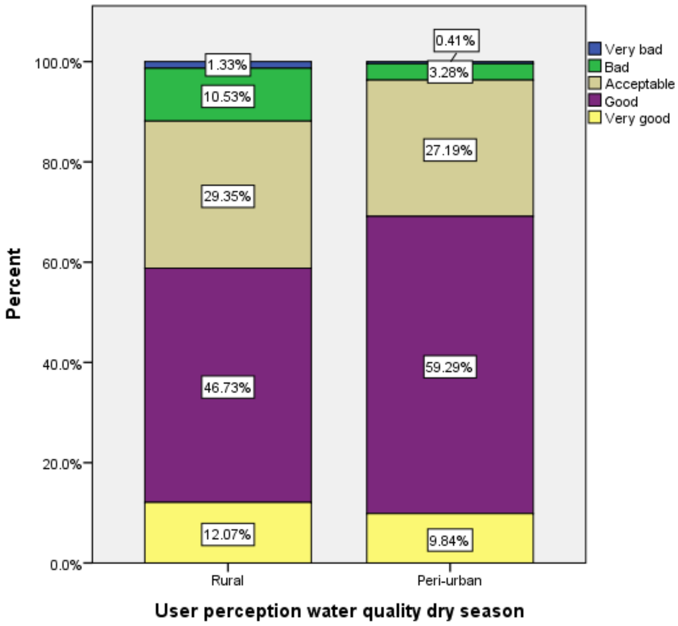


Figure I-26 User perception on water quality in rural and peri-urban areas

There is a lower perceived quality for water collected in rivers, streams of ponds, followed by unprotected wells, but also protected wells and boreholes. Protected wells, boreholes, and all the piped schemes are perceived in general to have better quality (Figure I-27).

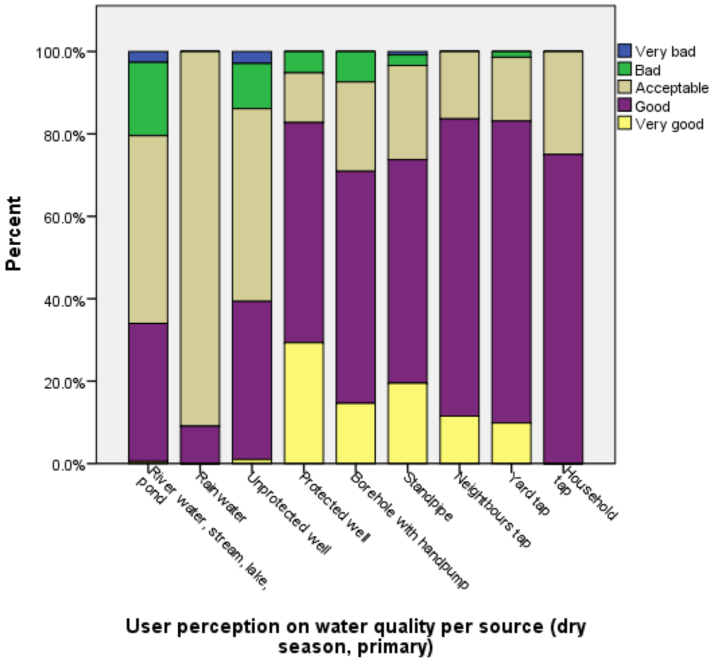


Figure I-27 User perception on water quality per source

Not surprisingly, the higher the perception on water quality, the higher the water consumed per litres per day (Figure I-28) and the closer is the source. This significant correlation is also demonstrated by Kendall's correlation tests (K= 5.9%, CI [.019,.096], p=.002 for quantity and K=13.4%, CI [-.179, -.090]. p=.000 for distance measured with straight line.

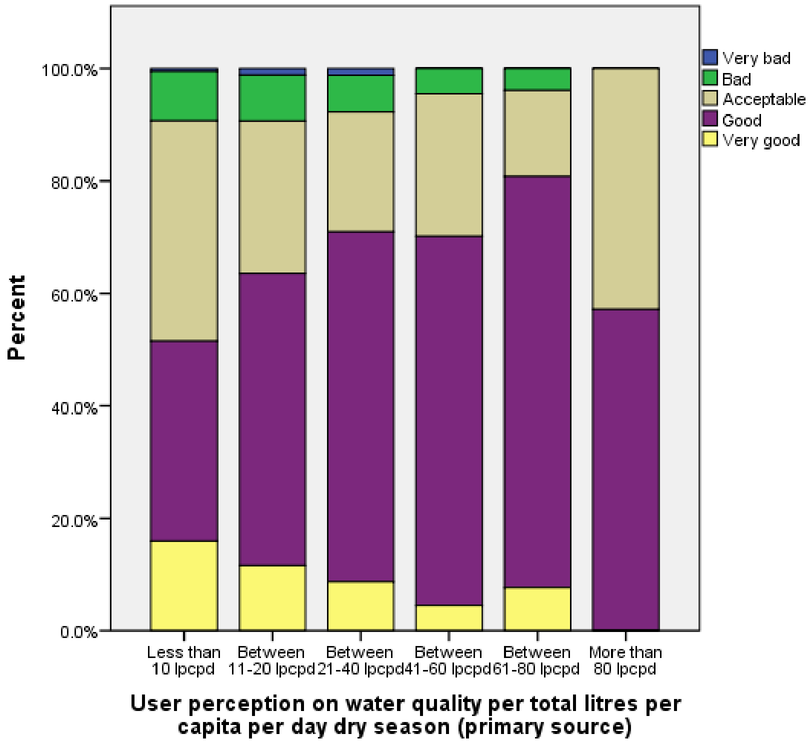


Figure I-28 User perception on water quality per litres consumed per day

There is also a statistically significant correlation with the wealth status (K=14.2%, CI [.107,.177], p=.000). The higher the perception on water quality the higher the wealth status (Figure I-29). No correlation was found between the amount spent per household and the perceived water quality.

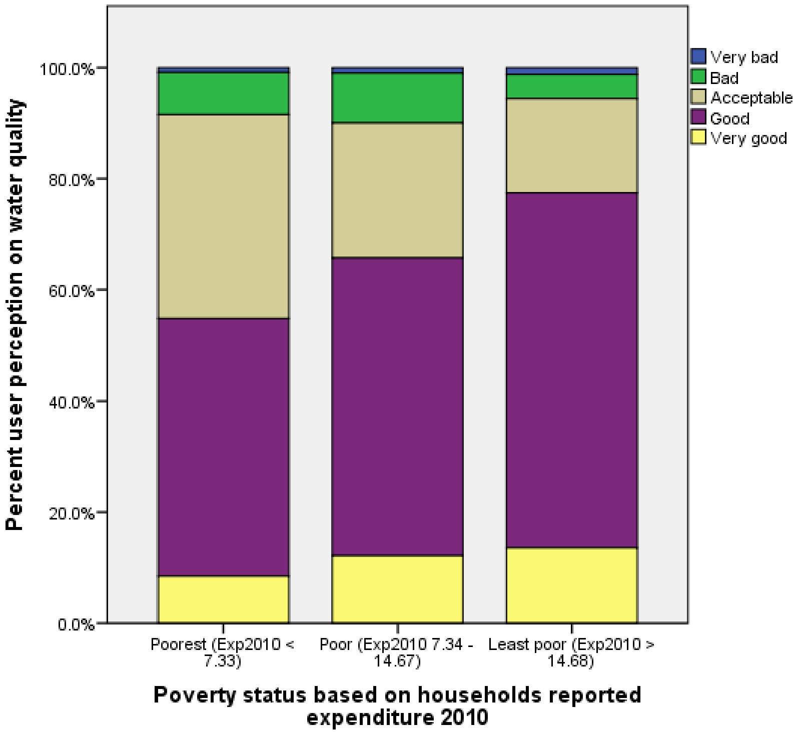


Figure I-29 User perception on water quality per wealth status

The top reasons for the perceived lack of water quality include turbidity and water looking dirty and contamination by animals (Figure I-30).

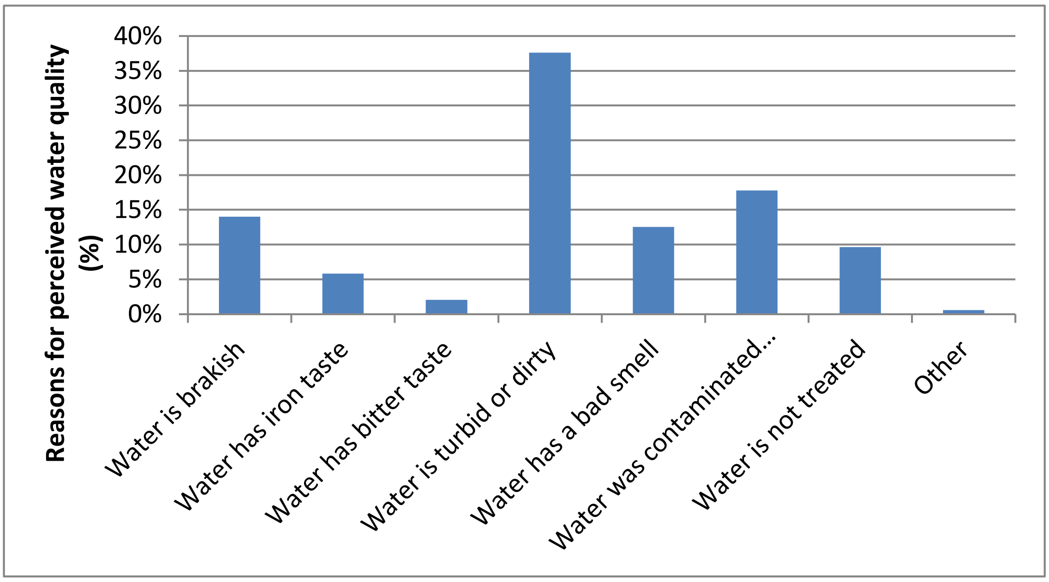


Figure I-30 Reasons for perceived lack of water quality

From all the respondents, only 7.5% treat the water (128 households out of 1710). Water treatment per source is mainly done on water coming from boreholes and unprotected wells but also neighbour's tap water (Figure I-31).

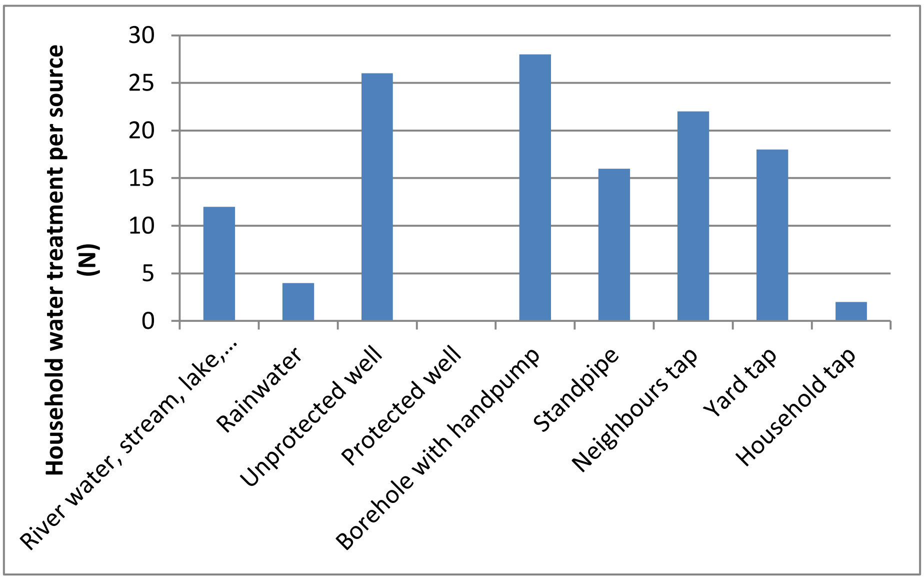


Figure I-31 Water treatment per source

The main methods for treating water are to add chlorine (3% of overall sample) or by boiling (1.2%) but the respondents that treat their water are in very small numbers (Table I-9).

Table I-9 Water treatment methods

Water treatment	N
Adds chlorine	52
Boiling	22
Ceramic or sand filter	5
Solar disinfection	5
Let water rest	1
Adds a spoon of petroleum	2
Other	8
Total respondents	95

Ghana

In the Ghana survey, all the formal sources are considered “safer” by WHO/UNICEF standards, and only 14% of respondents does not access a formal source.

Water quality was collected only through the perception of households with the formal sources. 67%of the households (897) are satisfied with the water quality from formal sources. The main reasons for non-satisfaction are the salty taste (N=139) and bad taste and odour (N=77) among other reasons.).

A higher percentage of users in rural areas perceive water having bad quality than in peri-urban areas and perception of quality is higher for piped connections. But a large percentage of households is satisfied with the quality from boreholes and hand-dug weels (Figure I-32). Lower perception of water quality is associated with lower quantity and higher distance to the sources.

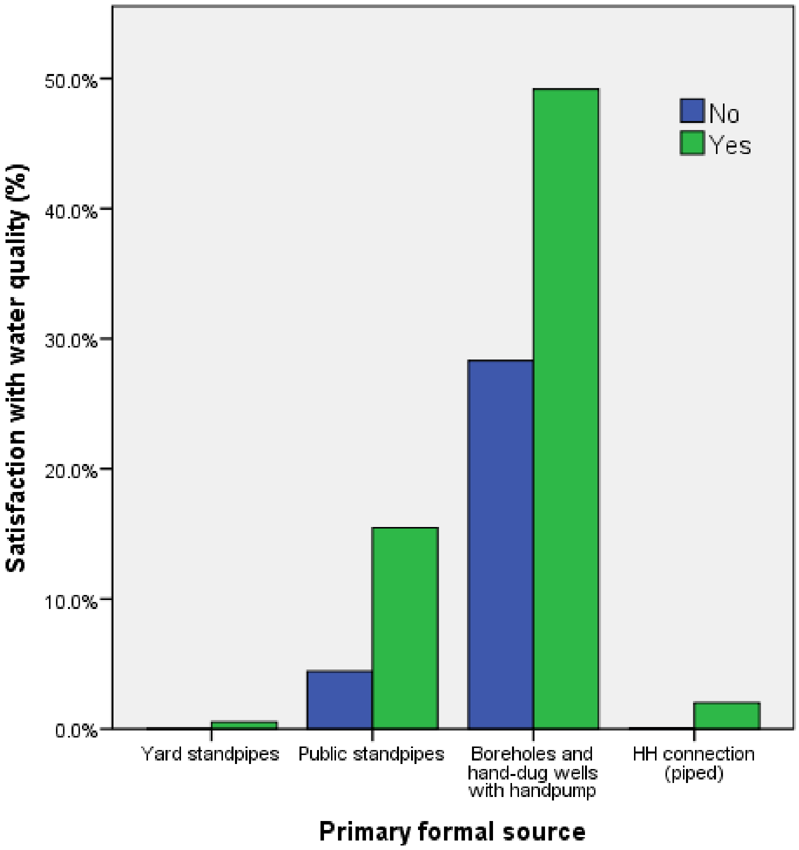


Figure I-32 User satisfaction with water quality per formal source

I.1.4 Reliability of water sources

Mozambique

The answers have been correlated with the rural/peri-urban division, the water source in the primary season, the quantity of water, the wealth status and costs. In peri-urban areas a very small percentage (1%) of households thinks problems are solved quicker than in rural areas and the most dissatisfaction overall in the dry and wet seasons relates with fixing problems related with boreholes (about 4% of the respondents) and unprotected wells (1.6%). The highest complaints (Figure I-33) come from those that consume between 21-40 litres per person per day (49.2% of the negative answers N=122) and those that consume between 11-20 litres per person per day (24.6% of the negative answers).

No correlation with the wealth status or any of the financial expenditure (point-biserial correlation for dichotomous variables was used).

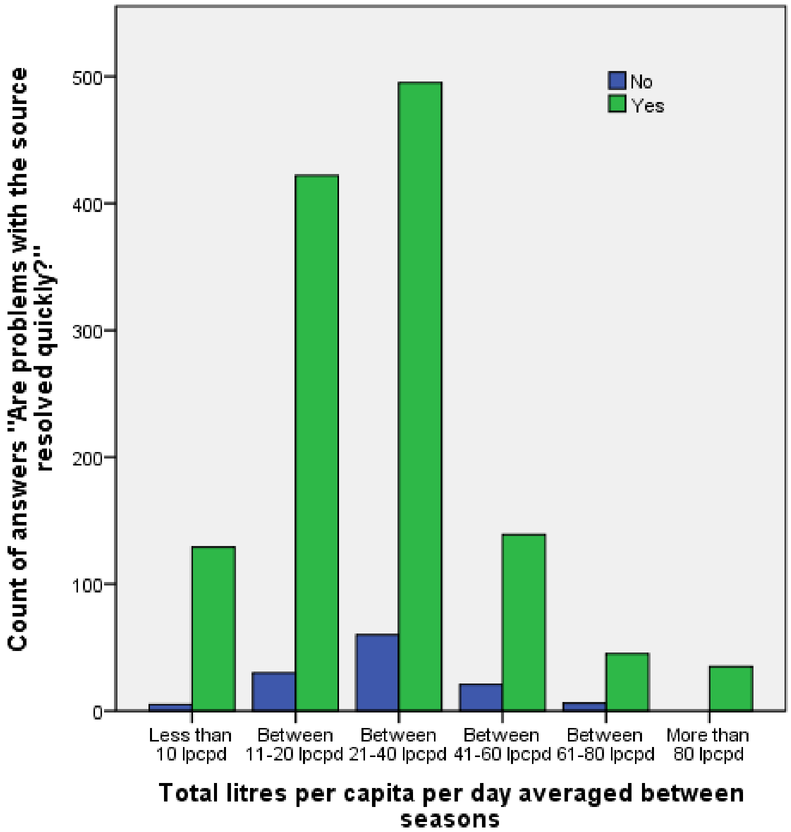


Figure I-33 Level of satisfaction with problems resolved per total litres consumed

Appendix J Mozambique household survey

Secção A-1: IDENTIFICAÇÃO (preenchido antes de começar o trabalho)		
A1	Província (nome e código)	
A2	Distrito (nome e código)	
A3	Posto Administrativo (nome e código)	
A4	Comunidade/ bairro (nome e código) - **AE**	
A5	Nº de ordem de AF dentro comunidade (01-20)	
Secção A-2: IDENTIFICAÇÃO (preenchido no campo)		
A6	Data de entrevista	....../............/..........(dia/mês/ano)
A7	Nome do entrevistador	
A8	Latitude	**S** ____ ____ **,** ____ ____ ____ ____
A9	Longitude	**E** ____ ____ **,** ____ ____ ____ ____ ____

Secção B: CARACTERÍSTICAS DO(A) INQUIRIDO(A)		
B1	Nome	
B2	Sexo	Masculino .... 1 Feminino.. 2
B3	Idade em anos completos	_____________anos Não sabe. .... -2
B4	Grau de parentesco com o chefe do agregado familiar	É o próprio Chefe do Agregado Familiar ...... 1 ⇨C1 Marido/Esposa.. 2 Pai/Mãe .... 3 Filho/Filha.. 4 Enteado(a)... 5 Genro/Nora.. 6 Irma/ irmão .... 7 Outro 8 especifica________________________ __
B5	Nome do Chefe do Agregado Familiar	
B6	Género da Chefe	HOMEM.. 1 MULHER 2

Secção C: INFORMAÇÃO GERAL SOBRE O AGREGADO FAMILIAR

C1 Diga-me o sexo e a idade de todas as pessoas que vivem habituelmente nesta casa?

(*No caso de não saber idade anote -2*)

Membro Nº	Sexo	Idade	Membro Nº	Sexo	Idade
1.	M / F		11.	M / F	
2.	M / F		12.	M / F	
3.	M / F		13.	M / F	
4.	M / F		14.	M / F	
5.	M / F		15.	M / F	
6.	M / F		16.	M / F	
7.	M / F		17.	M / F	
8.	M / F		18.	M / F	
9.	M / F		19.	M / F	
10.	M / F		20.	M / F	

C2 Diga me se a casa é?

Alugada..	1
Cedida ou emprestada	2
Próprio	3

C3 Há quantos anos vive nesta comunidade?

Vida inteira/sempre..	1
Mais de 10 anos	2
Entre 5 e 10 anos	3
Menos de 5 anos..	4

C4 Há quantos anos existe a casa principal?

Mais de 10 anos	1
Entre 5 e 10 anos	2
Menos de 5 anos..	3
Não sabem..	-2

Secção D: SITUAÇÃO DE ÁGUA PARA BEBER (tempo seco)		
D1	Onde é que a sua família **normalmente** busca **água para beber** no tempo seco? *Se a família busca água para beber de fontes múltiplas, procura saber qual é* ***a fonte mais utilizada*** *durante este epoca****.*** *Deve registar apenas uma resposta* *Utilize as folhas com figuras para identificar o tipo de fonte.*	Torneira dentro da casa. .... 1 Torneira no quintal. .... 2 Torneira do vizinho .... 3 Fontenário. .... 4 Furo. .... 5 Poço protegido.. 6 Poço não protegido. .... 7 Nascente protegida. .... 8 Nascente não protegida. .... 9 Água da chuva. .... 10 Carro tanque de água. .... 11 Carroça com tanque / tambor.................................... 12 Água de rio, riacho, lago, lagoa................................. 13 Outro, especifica ____________________________ 14
D2	Qual é o Nome e codigo da fonte (use ficha de atribução)	[ ] [ ]
D3	Qual é a quantidade de água que a família busca **normalmente** nesta fonte? ***<u>Preecenche sempre o valor calculado</u>*** ***<u>Só uma linha</u>***	1) Por dia_____ vezes, _____ bidões cada vez, dá (calcular) _____ litros cada dia 2) Por semana: ____ vezes, _______bidões cada vez, dá (calcular) _____ litros cada semana 3) Através contador: Por mês _________m^3 *(numa folha separado anota informação de outros meses se existe este informação)* Não sabe .... -2

D4	Para além de beber, para quê usa **normalmente** esta água? *Respostas múltiplas permitidas*	Nenhum/só para beber.	A	
		Cozinhar.	B	
		Lavar as mãos.	C	
		Lavar loiça.	D	
		Tomar banho.	E	
		Lavar roupas..	F	
		Pequenos animais (galinha, gato etc).	G	
		Grandes animais (vacas, cabrito etc)......................	H	
		Produção bebida..	I	
		Irrigação...	J	
		Construcção...		
		Outro, especifica: ________________________		
D5	Porquê buscam água para beber nesta fonte? *Respostas múltiplas permitidas*	É a fonte mais perto da casa..................................	A	
		Há pouco tempo de espera na fonte.	B	
		Sempre tem água na fonte......................................	C	
		Água é grátis..	D	
		Custo de água é razoável.	E	
		A fonte tem água de boa qualidade.........................	F	
		É única fonte..	G	
		Outro, especifica: _______________________		
D6	O que acha da qualidade da água desta fonte?	Muito má..	1	
		Má.	2	
		Razoável..	3	⇨ **D8**
		Boa.	4	⇨ **D8**
		Muito boa..	5	⇨ **D8**
		Não sabe.	-2	
D7	Porque considera a qualidade de água ***Muito má/Má/Razoável***? *Respostas múltiplas permitidas*	Água é salobra...	A	
		Tem sabor de ferro.	B	
		Tem sabor amargo..	C	
		Água é turva/suja..	D	
		Tem cheiro mau..	E	
		Contaminação por animais.	F	
		Outro, especifica: ____________________________	G	

D8	Você trata a água **normalmente** de alguma maneira para ela ficar segura para beber?	Sim, normalmente. .... 1 Sim, apenas no tempo de cólera .... 2 Não .... 3 ⇨ D11 Não sabe .... -2 ⇨ D11
D9	O que você **normalmente** faz para a água ficar segura para beber? *Respostas múltiplas permitidas*	Ferver .... A Adicionar lixívia / cloro .... B Filtrar com um pano .... C Usar filtro de água (cerâmica, areia, composto, etc). D Desinfecção solar .... E Deixar repousar e assentar .... F Outro, especifica: ____________ G Não sabe X
D10	Quais foram as despesas de tratamento dá água?	No último mês (no tempo seco) ________ Mt Só combustível (qualquer) para ferver água .... 1 Nenhuma .... 2 Não sabe .... -2
D11	Qual é a distância da casa até a fonte?	Menos de 250 metros .... 1 250 a 500 metros. .... 2 500 metros a 1 quilómetro. .... 3 1 a 2 quilómetros. .... 4 Mais de 2 quilómetros. .... 5 Dentro da casa .... 6 ⇨ E1 Dentro do quintal .... 7 ⇨ E1 Não sabe. .... -2
D12	Quanto tempo leva **normalmente** para:	Tempo de ida (minutos): ____ Tempo de espera (minutos): ____ Tempo de volta (minutos): ____ Não sabe. .... -2

D13 Quem é que **normalmente** vai buscar água nesta fonte? *Se varias pessoas buscam água para esta família, procura saber quem busca habitualmente. Resposta única.*	Mulher igual ou acima de 15 anos............................. 1 Homem igual ou acima de 15 anos. .... 2 Menina de menos de 15 anos. .... 3 Rapaz de menos de 15 anos. .... 4 Outro,especifica: ________________________ 5 Não sabe .... -2	
D14 Que tipos de recipientes a sua casa utiliza para buscar água nesta fonte? *Respostas múltiplas permitidas. Verifique visualmente os recipientes*	Bidões .... A Balde ou bacia .... B Panela de barro .... C Garrafas... D Outro, especifica: _______________________ E	
D15 Qual é o método **mais utilizado** para transportar água da fonte para a casa?	Na cabeça e na mão.. 1 No ombro.. 2 Com bicicleta .... 3 Com carrinha de mão .... 4 Com animal doméstico (p.ex. burro) .... 5 Outro, especifica: ________________________ 6 Não sabe. .... -2	*Se paga, preenche o valor aqui para cada viajem:* _____ *mt*

Secção E: PAGAMENTOS DE ÁGUA PARA BEBER (tempo seco)		
E1 Houve algum pagamento inicial, quer para instalaçao, ligação do sistema? *Respostas múltiplas permitidos*	Sim, contribuição comunitário .... Sim, pagamento do contracto .... Sim, compra do material .... Sim, mão-de-obra .... Não..	A _________Mt B _________Mt C _________Mt D _________Mt 2 ⇨ E3
E2 Em que ano foi feito o pagamento inicial?	☐☐☐☐	
E3 Paga alguma coisa pela água que o seu agregado consome?	Sim .... Não..	1 2 ⇨ E8

E4	Como é que é feito **normalmente,** o pagamento para água?	Paga-se por balde./Bidão .... Paga-se por reparação de avaria....................... Paga-se por mês valor fixo .... Através contador... Outro (especifica ______________________) Não sabe	1 2 3 4 5 -2
E5	Quanto é que pagou a última vez para a unidade indicada em E4? *(se o pagemento foi para mais do que um mês, preenche o valor equivalente a um mês)*	_______________________________ MT Não sabe	 -2
E6	Você fez algum investimento adicional para ter a água? Qual foi o valor? *Preenche -2 quando não sabe dizer o valor.*	Nenhum.. Tanque/cisterno.. Tanque elevado.. .... Electrobomba .... Canalização dentro casa .... Mão de obra pessoal	A B _________Mt C _________Mt D _________Mt E _________Mt F _________Dias
E7	Qual é a sua opinião sobre o custo de água?	Muito caro……………………………................... Caro…………………………………................... Razoável………………………………………... Barato……………………………………........... Muito barato ……………………………….......... Não sabe..	1 2 3 4 5 -2
E8	Quem é responsável pela gestão desta fonte?	Operador privado... AdM / FIPAG .... Comunidade/comité de água .... Administração... Município .... Não sabe	1 2 3 4 5 -2

E9	Qual é sua opinião sobre a gestão da fonte?	Muito boa.. Razoável .... Mau	1 ⇨ E11 2 3
E10	Quais são os assuntos principais que podem ser melhorados na sua opinão? *Respostas múltiplas permitidos*	Ser tolerante nos cortes da ligação/acesso.... Melhorar pressão de água .... Melhorar tempo de fornecemento .... Responder mais rápidos aos problemas........ Melhorar qualidade de água .... Melhorar a facturação................................... Deminiur o preço .... Baixar preço do contracto .... Melhorar prestação das contas...................... Outro, especifica: _____________________	A B C D E F G H I J
E11	Problemas com a fonte são resolvidos rapidamente?	Sim... Não... Não Sabe	1 2 3

Secção F: SITUAÇÃO DE ÁGUA DA FONTE ALTERNATIVA (tempo seco)		
F0	A sua família **normalmente** busca **água numa segunda fonte?**	Sim .... 1 Não .... 2 ⇨ **G0**
F1	De que tipo é a fonte secundária? *Se a família busca água em várias fontes secundárias, procura saber qual é* ***a fonte mais utilizada*** *durante o ano.* ***.*** *Deve registar apenas uma resposta* *Utilize as folhas com figuras para acertar o tipo de fonte.*	Torneira dentro da casa. .... 1 Torneira no quintal. .... 2 Torneira do vizinho .... 3 Fontenário........ 4 Furo. .... 5 Poço protegido........ 6 Poço não protegido. .... 7 Nascente protegida. .... 8 Nascente não protegida. .... 9 Água da chuva. .... 10 Carro tanque de água. .... 11 Carroça com tanque / tambor........ 12 Água de rio, riacho, lago, lagoa. .... 13 Outro, especifica: ________________ 14
F2	Qual é o Nome e codigo deste fonte (use ficha de atribução)	[ ] [ ]
F3	Qual é a quantidade de água que a família busca **normalmente** nesta fonte? ***<u>Preecenche sempre o valor calculado</u>***	1) Por dia: _____ vezes, _____ bidões cada vez, dá (calcular) _____ litros cada dia 2) Por semana: ____ vezes, _______bidões cada vez, dá (calcular) _____ litros cada semana 3) Através contador: Por mês _________m^3 Não sabe .... -2

F4 Para quê usa **normalmente** esta água? *Respostas múltiplas permitidas*	Beber (no caso de secar/avaria da fonte principal)...... Cozinhar. ...... Lavar as mãos. ...... Tomar banho. ...... Lavar as roupas ...... Pequenos animais (galinha, gato etc). ...... Grandes animais (vacas, cabrito etc) ...... Produção bebida...... Irrigação...... Construcção...... Outro, especifica: ______________________	A B C D E F G H I J H
F5 Porque busca a água na fonte? *Respostas múltiplas permitidas*	É a fonte mais perto da casa...... Há pouco tempo de espera na fonte. ...... Sempre tem água na fonte...... Água é grátis...... Custo de água é razoável. ...... A fonte tem água de boa qualidade...... Outro, especifica: ______________________	A B C D E
F6 Qual é a distância da casa até a fonte?	Menos de 250 metros ...... 1 250 a 500 metros. ...... 2 500 metros a 1 quilómetro...... 3 1 a 2 quilómetros. ...... 4 Mais de 2 quilómetros. ...... 5 Dentro da casa ...... 6 Dentro do quintal...... 7 Não sabe. ...... -2	 ⇨ G0 ⇨ G0
F7 Quanto tempo leva **normalmente** para chegar à fonte:	Tempo de ida: __________ minutos Tempo de espera: __________ minutos Tempo de volta:______ minutos Não sabe. ...... -2	

F8	Quem é que **normalmente** vai buscar água nesta fonte? *Se varias pessoas buscam água, procura saber quem busca o mais frequente. Pode só haver uma única resposta.*	Mulher igual o acima de 15 anos........................ 1 Homem igual o acima de 15 anos...................... 2 Menina de menos de 15 anos............................ 3 Rapaz de menos de 15 anos. .... 4 Outro, especifica: ____________________________ 5 Não sabe. .... -2
F9	Qual é o método **mais utilizado** para transportar água desta fonte para a casa?	Na cabeça e na mão................................ 1 No ombro.. 2 Com bicicleta .... 3 Com carrinha de mão................................ 4 Com animal doméstico (p.e. burro .... 5 Outro, especifica: _________________ 6 *Se paga, preenche o valor aqui para cada viajem: _____ mt* Não sabe. .... -2

Secção G: SITUAÇÃO DE ÁGUA PARA BEBER (tempo chuvoso)		
G0	A fonte de água para beber que usa no tempo chuvoso é differente da que usa no tempo seco?	Sim.......... 1 Não.......... 2
ATENÇÂO: se não tem diferença entre tempo chuvoso e seco, faça as perguntas G3, G12, H3, H4, H5 e continuar para secção I fonte alternativo		
G1	Onde é que a sua família **normalmente** busca **água para beber** nos tempos chuvosos? *Se a família busca água para beber de fontes múltiplas, procura saber qual é **a fonte mais utilizada.** Deve registar apenas uma resposta* *Utilize as folhas com figuras para identificar o tipo de fonte.*	Torneira dentro da casa.......... 1 Torneira no quintal.......... 2 Torneira do vizinho.......... 3 Fontenário.......... 4 Furo.......... 5 Poço protegido.......... 6 Poço não protegido.......... 7 Nascente protegida.......... 8 Nascente não protegida.......... 9 Água da chuva.......... 10 Carro tanque de água.......... 11 Carroça com tanque / tambor.......... 12 Água de rio, riacho, lago, lagoa.......... 13 Outro, especifica ____________ 14
G2	Qual é o Nome e codigo da fonte (usa ficha de atribução)	[ ] [ ]
G3	Qual é a quantidade de água que a família busca **normalmente** nesta fonte? ***<u>Preecenche sempre o valor calculado</u>*** ***<u>Só uma linha</u>***	1) _____ vezes, _____ bidões cada vez, dá (calcular) _____ litros cada dia 2) Por semana: ____ vezes, _______bidões cada vez, dá (calcular) _____ litros cada semana 3) Através contador: Por mês _________m^3 Não sabe.......... -2

G4	Para além de beber, para quê usa **normalmente** esta água? *Respostas múltiplas permitidas*	Nenhum/só para beber. .... Cozinhar. .... Lavar as mãos. .... Lavar loiça. .... Tomar banho. .... Lavar roupas........ Pequenos animais (galinha, gato etc). .... Grandes animais (vacas, cabrito etc)........ Produção bebida........ Irrigação........ Construcção........ Outro, especifica: ________________	A B C D E F G H I J
G5	Porquê buscam água para beber nesta fonte? *Respostas múltiplas permitidas*	É a fonte mais perto da casa........ Há pouco tempo de espera na fonte. .... Sempre tem água na fonte........ Água é grátis........ Custo de água é razoável. .... A fonte tem água de boa qualidade........ É única fonte........ Outro, especifica: ________________	A B C D E F G
G6	O que acha da qualidade da água desta fonte?	Muito má........ Má. .... Razoável........ Boa. .... Muito boa. .... Não sabe.	1 2 3 4 5 -2
G7	Porque considera a qualidade de água ***Muito má/Má/Razoável***? *Respostas múltiplas permitidas*	Água é salobra........ Tem sabor de ferro. .... Tem sabor amargo........ Água é turva/suja. .... Tem cheiro mau. .... Contaminação por animais. .... Outro, especifica: ________________	A B C D E F G

G8	Você trata a água **normalmente** de alguma maneira para ela ficar segura para beber?	Sim, normalmente. .... 1 Sim, apenas no tempo de cólera .... 2 Não .... 3 Não sabe .... -2
G9	O que você **normalmente** faz para a água ficar segura para beber? *Respostas múltiplas permitidas*	Ferver .... A Adicionar lixívia / cloro .... B Filtrar com um pano .... C Usar filtro de água (cerâmica, areia, composto, etc). .... D Desinfecção solar .... E Deixar repousar e assentar .... F Outro, especifica: ____________ G Não sabe X
G10	Quais foram as despesas de tratamento dá água?	No último mês ____________ Mt Só combustível (qualquer) para ferver água .... 1 Nenhuma .... 2 Não sabe .... -2
G11	Qual é a distância da casa até a fonte?	Menos de 250 metros .... 1 250 a 500 metros. .... 2 500 metros a 1 quilómetro. .... 3 1 a 2 quilómetros. .... 4 Mais de 2 quilómetros. .... 5 Dentro da casa .... 6 Dentro do quintal .... 7 Não sabe. .... -2
G12	Quanto tempo leva **normalmente** para:	Tempo de ida (minutos): Tempo de espera (minutos): Tempo de volta (minutos): Não sabe. .... -2

G13	Quem é que **normalmente** vai buscar água nesta fonte? *Se varias pessoas buscam água para esta família, procura saber quem busca habitualmente. Resposta única.*	Mulher igual ou acima de 15 anos............................... Homem igual ou acima de 15 anos............................ Menina de menos de 15 anos................................... Rapaz de menos de 15 anos.................................... Outro, especifica: ___________________________ Não sabe	1 2 3 4 5 -2
G14	Que tipos de recipientes a sua casa utiliza para buscar água nesta fonte? *Respostas múltiplas permitidas. Verifique visualmente os recipientes*	Bidões .... Balde ou bacia... Panela de barro .... Garrafas... Outro, especifica: ___________________________	A B C D E
G15	Qual é o método **mais utilizado** para transportar água da fonte para a casa?	Na cabeça e na mão.. No ombro.. Com bicicleta .... Com carrinha de mão .... Com animal doméstico (p.ex. burro) .... Outro, especifica: ___________________________ Não sabe.	1 2 3 4 5 6 -2

Secção H: PAGAMENTOS DE ÁGUA PARA BEBER (tempo chuvoso)			
H1	Houve algum pagamento inicial, quer para instalaçao, ligação do sistema? *Respostas múltiplas permitidos*	Sim, contribuição comunitário .... Sim, pagamento do contracto .... Sim, compra do material .... Sim, mão-de-obra .... Não..	A _________Mt B _________Mt C _________Mt D _________Mt 2 ⇨ H3
H2	Em que ano foi feito o pagamento inicial?	| | | | |	

H3	Paga alguma coisa pela água que o seu agregado consome?	Sim .... Não...	1 2 ⇨H8
H4	Como é que é feito **normalmente,** o pagamento para água?	Paga-se por balde./Bidão....................... Paga-se por reparação de avaria........... Paga-se por mês valor fixo .... Através contador................................... Outro (especifica ______________________) Não sabe	1 2 3 4 5 -2
H5	Quanto é que pagou a última vez para a unidade indicada em H4? *(se o pagemento foi para mais do que um mês, preenche o valor equivalente a um mês)*	______________________________ MT Não sabe	 -2
H6	Você fez algum investimento adicional para ter a água? Qual foi o valor? *Preenche -2 quando não sabe dizer o valor.*	Nenhum .... Tanque/cisterno .... Tanque elevado .... Electrobomba... Canalização dentro casa........................... Mão de obra pessoal	A B _________Mt C _________Mt D _________Mt E _________Mt F _________Dias
H7	Qual é a sua opinião sobre o custo de água?	Muito caro……………………………................... Caro………………………………..................... Razoável……………………………………….. Barato…………………………………........... Muito barato ………………………......... Não sabe...	1 2 3 4 5 -2
H8	Quem é responsável pela gestão desta fonte?	Operador privado. .... AdM / FIPAG.. Comunidade/comité de água .... Administração... Município	1 2 3 4 5

		Não sabe	-2
H9	Qual é a sua opinião sobre a gestão da fonte?	Muito boa...	1 ⇨ H11
		Razoável..	2
		Mau	3
H10	Quais são os assuntos principais que podem ser melhorados na sua opinão? *Respostas múltiplas permitidos*	Ser tolerante nos cortes da ligação/acesso....	A
		Melhorar pressão de água	B
		Melhorar tempo de fornecemento	C
		Responder mais rápidos aos problemas	D
		Melhorar qualidade de água..........................	E
		Melhorar a facturação	F
		Deminiur o preço	G
		Baixar preço do contracto	H
		Melhorar prestação das contas	I
		Outro, especifica: _____________________	J
H11	Problemas com a fonte são resolvidos rapidamente?	Sim	1
		Não..	2
		Não Sabe	3

Secção I: SITUAÇÃO DE ÁGUA DA FONTE ALTERNATIVO (tempo chuvoso)		
I0 A fonte de água alternativa que usa no tempo chuvoso é differente da que usa no tempo seco?	Sim .... 1 Não 2	⇨ **I1** ⇨ **I3 depois Z**
I1 De que tipo é a fonte secundária? *Se a família busca água em várias fontes secundárias, procura saber qual é **a fonte mais utilizada** durante o ano. Deve registar apenas uma resposta* *Utilize as folhas com figuras para acertar o tipo de fonte.*	Torneira dentro da casa. .... 1 Torneira no quintal. .... 2 Torneira do vizinho .... 3 Fontenário. .... 4 Furo. .... 5 Poço protegido. .... 6 Poço não protegido. .... 7 Nascente protegida. .... 8 Nascente não protegida. .... 9 Água da chuva. .... 10 Carro tanque de água. .... 11 Carroça com tanque / tambor. .... 12 Água de rio, riacho, lago, lagoa. .... 13 Outro, especifica: ____________________ 14	
I2 Qual é o Nome e codigo deste fonte (use ficha de atribução)	[ ] [ ]	
I3 Qual é a quantidade de água que a família busca **normalmente** nesta fonte? ***<u>Preecenche sempre o valor calculado</u>***	1) Por dia: _____ vezes, _____ bidões cada vez, dá (calcular) _____ litros cada dia 2) Por semana: ____ vezes, _______bidões cada vez, dá (calcular) _____ litros cada semana 3) Através contador: Por mês _________m^3 Não sabe .... -2	

I4	Para quê usa **normalmente** esta água? *Respostas múltiplas permitidas*	Beber (no caso de secar/avaria da fonte principal)...... Cozinhar. .... Lavar as mãos. .... Tomar banho. .... Lavar as roupas .... Pequenos animais (galinha, gato etc). .... Grandes animais (vacas, cabrito etc) .... Produção bebida.................... Irrigação.................... Construcção.................... Outro, especifica: ___________	A B C D E F G H I
I5	Porque busca a água na fonte? *Respostas múltiplas permitidas*	É a fonte mais perto da casa.................... Há pouco tempo de espera na fonte. .... Sempre tem água na fonte.................... Água é grátis.................... Custo de água é razoável. .... A fonte tem água de boa qualidade.................... Outro, especifica: ___________	A B C D E
I6	Qual é a distância da casa até a fonte?	Menos de 250 metros .... 250 a 500 metros. .... 500 metros a 1 quilómetro. .... 1 a 2 quilómetros. .... Mais de 2 quilómetros. .... Dentro da casa .... Dentro do quintal .... Não sabe.	1 2 3 4 5 6 7 -2
I7	Quanto tempo leva **normalmente** para:	Tempo de ida: _________ minutos Tempo de espera: _________ minutos Tempo de volta: _________ minutos Não sabe.	 -2
I8	Quem é que **normalmente** vai buscar água nesta fonte? *Se varias pessoas buscam*	Mulher adulta acima de 15 anos. .... Homem adulto acima de 15 anos.................... Menina de menos de 15 anos. .... Rapaz de menos de 15 anos.	1 2 3 4

	água, procura saber quem busca o mais frequente. Pode só haver uma única resposta.	Outro, especifica: ___________________________	5
		Não sabe.	-2
I9	Qual é o método **mais utilizado** para transportar água desta fonte para a casa?	Na cabeça e na mão..	1
		No ombro...	2
		Com bicicleta	3
		Com carrinha de mão	4
		Com animal doméstico (p.e. burro	5
		Outro, especifica: ___________________________	6
		Não sabe.	-2

PERGUNTA DO CONTROLO			
Z	Pensando em todo o tempo (Seco e Chuvoso), diga me qual é fonte de agua para beber que considera Principal? Nome e código da fonte (use ficha de atribuição)		
Z2	Pensando em todo o tempo (Seco e Chuvoso), você tem confiança para ter água para beber cada dia?	Sim	1
		Não, alguns dias no ano tem problemas	2
		Não, água saie muito irregular	3
		Não, algumas semanas no ano tem problemas	4
		Não, mais do que um mês tem problemas	5

Secção J: SANEAMENTO

J1	Para onde é que são evacuados os escretos?	*Utilize as folhas com figuras para identificar o tipo de sistema ou latrina que utilizam*	
		Sistema com água corrente ligado a sistema geral de esgoto	1
		Sistema com água corrente ligado a fossa séptica.	2
		Sistema com sifão a fosse séptica (usando balde)	3
		Sistema com sifão água corrente ligado a latrina..................................	4
		Sistema com água corrente ligado a (especifica ________________________..	5
		Sistema com água corrente onde não se sabe para onde escorre a agua..	6
		Latrina VIP	7
		Latrina com laje...	8
		Latrina tradicional melhorada	9
		Latrina tradicional..	10
		Latrina ecológica	11
		Balde..	12 ⇨K1
		Sistema de gato	13 ⇨K1
		Defecação a céu aberto	14 ⇨ K1
		Outro, especifica: ______________________________________	15
		Não querem dizer ou não sabem...	-2
J2	O sistema ou latrina é também utilizada por outras famílias?	Sim..	1
		Não	2
J3	Quantas famílias usam a latrina ou sistema, incluindo a sua família? *Se é entre 0 e 10 tem que especificar o número exacto.*	Número de famílias (se menos de 10) : _____	1
		10 ou mais	2
		Não sabe...	-2
J4	Onde fica a latrina ou sistema?	Na moradia	1
		No quintal..	2
		No quintal dos vizinhos......................................	3
		No bairro	4

J5	Em que ano foi construida a latrina?	☐☐☐☐			
J6	Quais foram os custos da latrina ou sistema? *Preenche -2 quando não sabe dizer o valor* *Preenche 0 quando não houve custo*		Preço effectivo	Preço imputado	Observações:
		Mão-de-obra			(institução do subsidio)
		Material			
		Subsidio			
		Outro			
		Não sabe.. -2			
J7	Quais são os custos para manutenção da latrina ou sistema? *Se não tem custos, preenche zero*	Ultimo semana	Ultimo mês	Ultimo ano	
		Não sabe.. -2			
J8	Quantas vezes você mudou do sítio da latrina?	Nunca .... 1 Uma vez.. 2 Dois a cinco vezes .... 3 Mais do que 5 vezes .... 4 Não sabem.. -2			
J9	Quantas vezes você vazou a latrina ou fossa séptica?	Nunca .... 1 Uma vez.. 2 Dois a cinco vezes .... 3 Mais do que 5 vezes .... 4 Não sabem.. -2			
J10	Quais foram os custos de vazar?	___________________________Mt			
		Fomos nos próprios.. A Não sabem.. -2			

Secção L: CARACTERÍSTICAS SOCIOECONÓMICAS

			Mais importante	2º
L1	Quais são as principais fontes de rendimento da família? *Deve-se indicar as duas fontes de rendimento mais importantes, começando com o mais importante na primeira coluna.* *Só utilizar a opção "Não aplicável" na coluna 2 e apenas quando a família não tem mais de uma fonte de rendimento.*	Agricultura..	1	1
		Pesca..	2	2
		Criação de animais..	3	3
		Retalho..	4	4
		Trabalho ocasional	5	5
		Remessas dos membros da família de fora.......	6	6
		Salário (emprego permanente)...........................	7	7
		Pensão..	8	8
		Negocio...	9	9
		Outro, especifica: ______________________	10	10
		Não aplicável..		-2

			Sim	Não
L2	O agregado familiar possui......? *Se a família tem p.ex. um rádio avariado, tem que indagarar desde quando ficou avariado. Se estiver mais de um ano, considere que não tem rádio.*	Electricidade..	1	0
		Rádio...	1	0
		Televisor...	1	0
		Telefone móvel..	1	0
		Telefone fixo..	1	0
		Geleira / congelador	1	0
		Relógio de pulso..	1	0
		Bicicleta...	1	0
		Mota	1	0
		Carroça de tracção animal.................................	1	0
		Carro / Camião..	1	0
		Barco com motor	1	0

L3	Despesas em Meticais	(*Preencher um valor para cada linha conforme informação que o inquerida tiver*)			
		Ultimo 7 dias	**Ultimo 30 dias**	**Ultimo 12 meses**	**Observação**

	Alimentação				
	Transporte				
	Social (casamentos, presentes, restaurant, barraca etc)				
	Renda				
	Escola/educação				
	Saúde				
	Energia (electricidade, carvão, lenha, gas, etc)				
	Outros (especificar) ……………				

L4	Qual é o rendimento em dinheiros total do agregado familiar estimado no **ultimo mês**?	< 500 meticais	1	
		500-1500 meticais	2	
		1500-2500 meticais	3	
		2500-10,000 meticais	4	
		> 10,000 meticais	5	
		Não querem dizer ou não sabem..................................	-2	
L5	Na sua opinião, como é o nível de pobreza em comparação com os vizinhos	Mais pobre	1	
		Igual	2	
		Menos pobre	3	
		Outro (________________________________)..	4	
		Não querem dizer ou não sabem..................................	-2	

Espaço para anotar observações adicionais sobre L3, L4, L5:

Secção M: OBSERVAÇÕES PELO ENTREVISTADOR			
M1	Material principal do telhado da moradia	Capim/colmo/palmeira... .	1
		Chapas de zinco...	2
		Chapas de lusalite...	3
		Telha..	4
		Laje de betão...	5
		Material improvisado (lata, cartão,papel, saco etc)	6
		Outro, especifica: _____________________________________	7
M2	Material principal das paredes da moradia	Bambu/Caniço/Palmeiras	1
		Paus maticados..	2
		Adobe / bloco de adobe..	3
		Madeira / zinco...	4
		Bloco de cimento / tijolo..	5
		Material improvisado (lata, cartão,papel, saco etc)	6
		Outro, especifica: _____________________________________	7
M3	Material da casota da latrina (paredes) *Se não tem latrina, faz não aplicavel (-2)*	Blocos de cimento	1
		Blocos queimados	2
		Blocos de adobe...	3
		Matope/argila e paus	4
		Bambu/Caniço/palmeiras..	5
		Material improvisado (lata, cartão,papel, saco etc)	6
		Outro, especifica: _____________________________________	7
		Não aplicável (não tem latrina)	-2
M4	A latrina é realmente utilizada? *Observação directa*	Sim...	1
		Não	2
M5	Condição dentro da latrina	Muito limpa	1

		Limpa	2
		Suja...	3
		Muito suja..	4
M6	Condição do edifício da latrina (qualidade da manutenção)	Muito bom	1
		Bom	2
		Razoável	3
		Mau..	4
		Muito mau	5

Appendix K Ghana household survey

Form No:	Date of survey:
Interviewer (name/code):	Region of survey:
Recorder (name/code):	Community/Town name:
District/Municipality:	Vetted by (name/code):

Respondent

1. What is your house number? ……………………………….

2. The respondent's gender (*observe and tick*)

(1) Male **(2)** Female

3. The respondent's age in years *(asks and record).*

………………………

4. Who is the main household breadwinner? (*the person who feeds or is in charge of the household's well-being*)

☐ Male(self, *husband, father, son, brother etc)* [**1**] ☐ Female (self, *wife, mother, daughter, sister, etc)* [**2]**

5. How many people live with you as a household? (*not entire compound or shared house members*): ……………………..

6. Who fetch water in the household? (*tick all if applicable*)

(1)women **(2)**girls **(3)**boys **(4)**men **(10)** all

7. What is the main economic activity of the household breadwinner? (*as the main livelihood)*

☐Public sector employment [1] ………………………………………………………

☐ Private formal employment [2] ………………………………………………………

☐ Private informal employment [3] ………………………………………………………

☐Cash crop farming [4] ………………………………………………………

☐ Food crop farming [5] ………………………………………………………

☐ Non-farm self employment [6] ……………………………………………………

☐ Unemployed [7] ……………………………………………………

☐ Other …………………… [8] ……………………………………………………

FORMAL WATER SUPPLY

8. Do you access any of the **Formal** water sources (point sources) in the community? ☐ Yes (1) ☐ No (0)

9. If **Q8** is **NO**, then why not? ………………………………………………………………………………………

10. If **Q8** is **YES,** then how many of the point sources does your household know that they are in this community? …………………

11. If **Q8** is **Yes**, then which of the formal water source(s) is/are accessed by the household?

☐PS1 ☐PS2 ☐PS3 ☐PS4 ☐PS5 ☐PS6 ☐PS7 ☐PS……..

12. If **Q8** is **YES**, then which of the point sources is mostly accessed by your household?

☐PS1 ☐PS2 ☐PS3 ☐PS4 ☐PS5 ☐PS6 ☐PS7 ☐PS……..

13. Can you state the reason(s) for mostly accessing this particular point source? (*tick all if applicable*)
    (1) They are free
    (2) The fee is less
    (3) Proximity (closer to me than the others)
    (4) Quality (better quality that is useful for all purposes unlike the others)
    (5) For other domestic chores but not for drinking
    (6) Reliability (water always available and adequate all seasons)
    (7) Saves time (no or less queues exist)
    (8) Other …………………………………..

14. Does your household pay for water from the point sources? ☐Yes (1) ☐No (0)

15. If **Q14** is **Yes**, then which of the point sources does your household pay to access? (tick all if applicable)

☐PS1 ☐PS2 ☐PS3 ☐PS4 ☐PS…….. ☐all PS

16. If **Q14** is **Yes**, then how much does your household spent on water in a **day**? (*ask for the average in wet/dry seasons)*

Wet Season: ……………/……………

Dry Season: …………../……………

17. What is the household impression about the water tariff? **(1)** High **(2)** Acceptable **(3)** Low

<table>
<tr><td>18. What is the mode of payment for accessing the water point source(s) in Q15?

(1)Pay-as-you fetch (2)Weekly (3)Monthly (4)Yearly</td><td>☐PS1</td><td>☐PS2</td><td>☐PS3</td><td colspan="2">☐PS….</td></tr>
<tr><td>19. How much (quantity) of water is accessed from the point source in a day? (l/day/hh)
(by the entire household)</td><td colspan="3">Wet season</td><td colspan="2">Dry season</td></tr>
<tr><td>20. Is your household satisfied with the quality of water from any of the point sources accessed?

(write 1 for YES and 0 for NO)</td><td>☐PS1</td><td>☐PS2</td><td>☐PS3</td><td>☐PS4</td><td>☐PS…</td></tr>
<tr><td>21. If Q20 is No, then why not?
(1)= has bad taste (2) = has bad odour (3)=it is turbid
(4)=has a salty taste (5)= other (specify)…………………..</td><td>☐PS1</td><td>☐PS2</td><td>☐PS3</td><td>☐PS4</td><td>☐PS…</td></tr>
<tr><td>22. How reliable are the point sources accessed by your household?
1) system works all the time
2) system works most of the time, and occasional breakdowns are quickly repaired
3) system works only some of the time, suffering from prolonged breakdowns
4) system works only seasonally (it fails consistently during the dry season)
5) system has broken down and has never been repaired (or has never worked)
6) other ………………………………………</td><td>☐PS1</td><td>☐PS2</td><td>☐PS3</td><td>☐PS4</td><td>☐PS…</td></tr>
<tr><td>23. What are the domestic water uses of the formal water sources?
(1) drinking only (2) cooking only (3) drinking/cooking
(3) other domestic chores (4) all domestic purpose</td><td>☐PS1</td><td>☐PS2</td><td>☐PS3</td><td>☐PS4</td><td>☐PS…</td></tr>
<tr><td colspan="6">24. Does your household use the water from the point sources for any productive (commercial) purposes?

☐ Yes (1) ☐ No (0)</td></tr>
<tr><td colspan="6">25. If Q24 is YES, then what are the productive water uses? (tick all if applicable)

(1) Cook and sell (canteen) (2) drinking bar/spot (3) salon (hairdressing) (4) farming (5) other…………</td></tr>
</table>

<table>
<tr><td>26. Are there queues at the point sources?</td><td>☐PS1</td><td>☐PS2</td><td>☐PS3</td><td>☐PS4</td><td>☐PS5</td><td>☐PS…</td></tr>
<tr><td>(write 1 for YES and 0 for NO) Wet Season</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>(write 1 for YES and 0 for NO) Dry Season</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

27. If **Q26** is **Yes**, then what is the average queuing time (in minutes)? **Wet Season**						
Dry Season						
28. What is the average travelling time (in minutes) to and from the PS(s) in fetching water?						

INFORMAL WATER SOURCES

29. Does your household harvest rain water for any use? ☐Yes (1) ☐No (0)

30. If **Q29** is **NO**, then why not? ………………………………………………………………………………………

31. If **Q29** is **YES**, then how much (quantity) of water is harvested for a period of use? (*average quantity per period*)

……………………………/……………………………………..

32. How does your household use the rain water harvested? (*choose only one applicable)*

(1) drinking only **(2)** cooking only **(3)** drinking and cooking only **(4)** other domestic chores

(5) all domestic uses **(6)** productive uses only **(7)** all domestic and productive uses

33. Does your household use any other water sources available apart from the point source(s)? (*ask about any water at all*)
(1) Yes **(0)** No Answer:YES >>>Q35

34. If **Q33** is **NO**, then why not? (*tick all if applicable)*
(1) There are no such other sources
(2) We get enough water and therefore do not need other sources
(3) They are not free
(4) The user fees are too high
(5) They are too far away from the house
(6) We are not satisfied with the water quality
(7) They are not reliable
(8) Long queues exist at these sources
(9) Other ………………………………………………………………………………………..

35. If **Q33** is **Yes**, then which of these Informal water sources are accessed by your household? (*tick all if applicable*)

☐open well ☐ hand-dug well ☐ pond ☐ dam

☐river/stream ☐ sachet ☐other……………………..

	open well	hand-dug well	pond	dam	river/stream	Sachet	other
36. Does your household pay to access any of these informal water sources?							
(*write 1 for YES and 0 for NO*) **Wet Season**							
(*write 1 for YES and 0 for NO*) **Dry Season**							
37. If **Q36** is **Yes**, then how is spent in day on the water? (*write 1 for YES and 0 for NO*) **Wet Season**							
write 1 for YES and 0 for NO) **Dry Season**							
38. What is the mode of payment for any of them? (**1)**Pay-as-you fetch **(2)**Weekly **(3)**Monthly **(4)**Yearly							
39. What is your household's impression about water tariff? **(1)** High **(2)** Acceptable **(3)** Low							
40. Do you have queues at these water sources? (*write 1 for YES and 0 for NO*) **Wet Season**							
(*write 1 for YES and 0 for NO*) **Dry Season**							
41. What is the average queuing time (in minutes)? **Wet Season**							
Dry Season							
42. What is the average travelling time (in minutes) to and from these informal/alt. sources?							
43. How do you use these informal water sources? ☐drinking only(1) ☐cooking only(2) ☐drinking and cooking only (3)							

□other domestic chores (4) □all domestic uses(5) □productive use(6) □all uses(7)							

44. Do you purchase water from vendors (tanker services/sachet/others) as alternative water sources?
□Yes (1) □ No (0) Answer: NO>>>>>53

45. If **Q44** is **Yes**, then how much money is spent on water from the vendor services? **Wet Season**	**Tanker services**	**Sachet water**	**Other ……… …….**
Dry Season			
46. What quantity of water do you buy from vendors (l/day/household)? **Wet Season**	**Tanker services**	**Sachet water**	**Other ………**
Dry Season			
47. What is the mode of payment for the water from these vendors? **(1)**Pay-as-you fetch **(2)**Weekly **(3)**Monthly (**4)**Yearly			
48. What is your impression about the tariff from the vendors? **(1)** High **(2)** Acceptable **(3)** Low			
49. Are you satisfied with the quality of water from these services? **(1)** Yes **(0)** No			
50. If **Q49** is **No**, then what is the quality of the water? **(1)=** has bad taste **(2) =** has bad odour **(3)=**it is turbid **(4)**=has a salty taste **(5)**= other (specify)……………			
51. How reliable are these water vendor services?			

(1)=always available **(5)**=available every 3 weeks **(2)=**available twice a week **(6)**=available every month **(3)=**available ones a week **(7)**=availability is erratic **(4)=** available every 2 weeks **(8)**=other ……………			
52. What do you use the water from these vendors for? **(1)** drinking only **(2)** cooking only **(3)** both drinking/cooking **(4)** other domestic chores **(5)** all domestic purpose **(5)** productive (something for money)			

SANITATION

53. Do you have a household toilet? **(1)** Yes **(0)** No

54. If **Q53** is **YES**, does your household use this toilet? ☐ Yes (1) ☐No

55. If **Q54** is **Yes**, what type is the household toilet? **(*visual inspection should be made*)**

(1) VIP **(2)** KVIP **(3)** Mozambique **(4)** Traditional pit latrine **(5)** Other……………

56. How much did it cost to construct the household? GH¢ ……………… Year of construction:…………

Cost breakdown

Super structure GH¢………………… Year:……………………

Substructure GH¢…………………. Year:……………………

57. Did you receive any subsidy (ies) for household toilet construction? Yes (1) No (0)

58. If **Q57** is **Yes,** then how much was given as subsidy? Year:……………………	☐ Cash to the tune of GH¢………… ☐ Cost of the superstructure (GH¢ …………) ☐ Cost of the substructure (GH¢ …………) ☐ Cost of labour (GH¢ ………...)

	☐ Materials (1) Vent pipe (2) cement, (3) sand (4) iron rods (5) others (…………………………..)
59. Who provided the subsidy in **Q56**? ☐ GoG/DA (1) ☐CWSA (2) ☐ NGO (……………(3) ☐ Other ………(4)	
60. Do you have any operations and maintenance (O&M) cost incurred on the toilet? ☐ Yes (1) ☐ No (0)	
61. If **Q60** is **Yes**, then what O&M activities are carried out and at what cost?	☐ Cleaning toilet. Cost (GH¢)…………… **Frequency** …………….. ☐ Disinfection. Cost (GH¢)…………… …………….. ☐ Other ……………… Cost (GH¢)…………… ……………..
62. What replacement (CapManEx) activities are carried out on household toilet and how much does it cost?	☐ Desludging. Cost (GH¢)…………… **Frequency** ……… ☐ Replacement of vent pipes. Cost (GH¢)…………… …………… ☐ Repair of slabs/Concrete works. Cost (GH¢)…………… …………… ☐ Other (………………………) Cost (GH¢)…………… ……………
63. If **Q53** is **No** household toilet, then where does the household defecate?	☐Public toilet ☐Neighbour's toilet (shared) ☐Dig and burry ☐Open defecation
64. If **Q63** is a **public toilet**, then do you pay for using the public toilet?	**(1)** Yes **(0)** No
65. If **Q64** is **Yes**, then how much is paid for using the public toilet?	……..Gp/…………
66. How many of your household members pay to use the public toilet? …………………………..	
67. What is your impression about public toilet user fee?	**(1)** High **(2)** Acceptable **(3)** Low
68. What is your impression about cleanliness of the public toilet? (**1**) Very clean (**2**) Fairly clean (**3**) Poor	
69. If **Q63** is neighbour's toilet, then do you pay for using the toilet facility? **(1)** Yes **(0)** No	

70. If **Q69** is **Yes**, then how much is paid for using neighbour's toilet?	……..Gp/………
71. How many of your household members pay to use the neighbour's toilet? …………………………………	
72. What is your impression about neighbour's toilet user fee?	**(1)** High **(2)** Acceptable **(3)** Low
73. What is you impression about cleanliness of the neighbour's toilet? (**1**)Very clean (**2**) Fairly clean (**3**) Poor	

74. If **Q63** is dig and burry/open defecation, then why this practice by the household? (**tick all applicable responses**)

(1) They are free
(2) Cannot afford household toilet construction
(3) Household toilet available but failed to function
(4) Household toilet available but in a poor/dilapidated condition
(5) Neighbour's toilet facility not allowed to be shared
(6) Public toilet available but uncomfortable to use
(7) Public toilet available but too far from the household
(8) Cannot afford toilet user fee (for public toilet or shared)
(9) No public toilet available
(10)Other ……………………………………………………………….

GPS Coordinates

Description	**ID**	**North**	**West/East**
House			
Household toilet (if available)			
Household water point			
Soakage pit			
CALCULTE FROM THR GPS coordinates	**Meters**		**Minutes**
Distance to formal water source		Time to formal water source	
Distance to informal water source		Time to informal water source	

The end.