WASHCost

Working Paper 8

Applying a life-cycle costs approach to water

Costs and service levels in rural and small town areas in Andhra Pradesh (India), Burkina Faso, Ghana and Mozambique

Peter Burr and Catarina Fonseca

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This working paper draws from detailed analysis done at country level. All country level reports, which explain the details and context of data collection and analysis, are available within the country pages at www.washcost.info

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Contact details of authors
Peter Burr: burr@irc.nl
Catarina Fonseca: fonseca@irc.nl

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Clockwise from left: group of children accompanying parents in fetching water (by Jeske Verhoeven); and snapshots of water collection from different sources: from a borehole (by Peter McIntyre), from a water kiosk (by Marieke Adank) and from piped water systems in India (Peter McIntyre) and Ghana (Lamisi Dabire).

Design and layout
Tasja van der Veen, info@bingo-graphicdesign.com

About WASHCost
WASHCost is a five-year action research project investigating the costs of providing water, sanitation and hygiene services to rural and peri-urban communities in Ghana, Burkina Faso, Mozambique and India (Andhra Pradesh). The objectives of collecting and disaggregating cost data over the full life cycle of WASH services are to be able to analyse expenditure per infrastructure, by service level, per person and per user. The overall aim is to enable those who fund, plan and budget for services to understand better costs and service levels to enable more cost effective and equitable service delivery. WASHCost is focused on exploring and sharing an understanding of the costs of sustainable services (see www.washcost.info).

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Acronyms

AP	Andhra Pradesh (state in India)
BN	Briefing note
CapEx	Capital expenditure
CapManEx	Capital maintenance expenditure
CoC	Cost of capital
CWSA	Community Water and Sanitation Agency (Ghana)
DNA	National Directorate of Water (Mozambique)
DWST	District Water and Sanitation Teams (Ghana)
ExpDs	Expenditure on direct support
ExpIDS	Expenditure on indirect support
GDP	Gross Domestic Product
HH	Household
HUDCO	Housing and Urban Development Corporation (India)
IDA	International Development Association
INE	National Bureau of Statistics (Mozambique)
JMP	Joint Monitoring Programme (UNICEF and WHO)
LCCA	Life-cycle costs approach
lpcd	Litres per capita (person) per day
M-BH	Mechanised borehole
MDG	Millennium Development Goals
MPS	Mixed piped supply
NA	Not available
NGO	Non-governmental organisation
OpEx	Operational and minor maintenance expenditure
PPP	Purchasing Power Parity
SINAS	National Information System for Water and Sanitation (Mozambique)
UNICEF	United Nations Children's Fund
US	United States
WASH	Water, sanitation, and hygiene
WHO	World Health Organization
WATSAN	Water and Sanitation Committee
WSDB	Water and Sanitation Development Board (Ghana)
WSP	Water and Sanitation Program (World Bank)

How to read this working paper

The executive summary of this working paper contains the main findings and conclusions of WASHCost research in applying a life-cycle costs approach to water. The executive summary is also available as a stand-alone paper. We recommend that those who are considering adopting a life-cycle costs approach or similar approaches in their own work read the full paper which contains greater levels of background information and explanation.

The Introduction, **Chapter 1** of this working paper, explains how and why the WASHCost project came about, and gives a brief explanation of a life-cycle costs approach and costing framework as well as the service levels by which service delivery is evaluated. It includes some basic explanation of the service delivery approach and other concepts.

Chapter 2 describes the sampling approach and the methodology for analysing costs and service levels.

Chapters 3 to 6 describe the main findings from each of the WASHCost countries: Andhra Pradesh (India), Burkina Faso, Ghana and Mozambique. Each country section is divided into four main broad areas of analysis:

- Description of sampling strategy
- Description of the context of water service delivery
- Cost per service area: capital and recurrent costs of all schemes in a community or small town are accounted for and per person costs are calculated according to the overall population. Similarly, service levels for the whole area are calculated.
- Cost per service delivery model: capital and recurrent costs of the different water supply models are calculated per person or per user as described above. The recurrent costs of supply are compared with the service level delivered by each approach.

Chapter 7 summarises and compares the costs and service levels of point sources and piped schemes across the four research countries, and discusses (largely inconclusive) findings on cost drivers.

Chapter 8 extrapolates the findings from the study to create cost benchmarks for a basic level of water services.

Chapter 9 draws together key conclusions from the implementation of a life-cycle costs methodology; findings from the cross-country comparisons; and recommendations for the sector, in countries and internationally.

When analysis is conducted by service delivery model, the model may take account of community size. Some analysis refers to service areas and communities as small, medium, intermediate and large. In this paper, small communities are considered to have less than 500 residents; medium communities have between 500 and 5,000 residents; intermediate communities have between 5,000 and 15,000 residents; and large communities have more than 15,000 residents. However, there is no difference in principle between a service for a large village or a small town. In some settings, either term might be used; what might be referred to as a village in one country, might be classified as a small town in another.

Executive summary

This working paper presents findings and recommendations from the application of a life-cycle costs approach (LCCA) to water supply services in rural communities and small towns[1] in four countries – Andhra Pradesh (India), Burkina Faso, Ghana and Mozambique.

The WASHCost project[2] has analysed actual financial expenditure made in each country on point sources (boreholes with handpumps) and on a range of small, medium and larger scale small town piped networks. Expenditure on each of these models of water supply is compared to the level of service actually provided to users.

This paper concludes that there is chronic underfunding of rural water services, to meet the costs required to provide and sustain a basic level of service that meets national norms and standards. Even where communities appear in national or international databases as having access to an improved water source and therefore as "covered", most people who live there do not receive a minimum basic level of service. There are large data gaps that need to be filled so that plans and budgets prepared by governments and donors can be based on the realities of water service provision.

From the research, the project has calculated benchmark figures that give the best available guide to what is required to achieve a basic level of service as defined by WASHCost in terms of quantity, quality, accessibility and reliability.

The capital cost benchmarks for preparing and installing a borehole and handpump (at 2011 prices) range from US$ 20 per person[3] to just over US$ 60 per person. For small piped schemes, including mechanised boreholes, costs range from US$ 30 to just over US$ 130 per person. For intermediate and larger schemes, benchmark capital costs vary widely from US$ 20 to US$ 152 per person.

Recurrent costs benchmarks range from US$ 3 to US$ 6 per person per year for boreholes and handpumps, and from US$ 3 to US$ 15 per person per year for piped schemes. Actual expenditure on recurrent costs is a tiny fraction of these amounts.

Background to the WASHCost project

Over the last two decades, large-scale investment in water supply infrastructure has resulted in substantial increases in the number of people with access to improved water services. However, high levels of hardware failure mean that many people in the developing world still experience poor and unreliable services, although they are considered in official statistics to be 'covered' by an improved supply. The research strongly suggests at least some of this has been caused by a failure to finance essential recurrent expenditure required to maintain water services.

There has been – and still is – lack of financial data about the actual and realistic costs of providing and maintaining a rural water service over time. The WASHCost project addressed this knowledge gap through the development of a methodology to collect detailed information on both the initial and recurrent expenditure on different options for rural water service delivery. The project aimed to provide a better understanding of how much is actually being

1 The definition of what is considered a small town or a rural community varies greatly from country to country and depends on a number of factors including the number of inhabitants, the location and the type of water supply system in place.

2 WASHCost is a five-year (2008-2012) action research programme gathering information related to the life-cycle costs of providing water, sanitation, and hygiene services in rural and peri-urban areas of Burkina Faso, Ghana, India (Andhra Pradesh), and Mozambique. IRC International Water and Sanitation Centre led the WASHCost programme working with partners in countries.

3 In this report, monetary sums for capital costs are rounded to the nearest dollar, while recurrent costs are rounded either to the nearest dollar or, where decimal places are shown, to one decimal place.

spent currently on water service delivery, as a first step in determining the required expenditure to ensure improved sustainability and to inform better planning and investment practices.

Methodology and key concepts

Over a period of two years (2010-2011) data on actual expenditure and actual service levels was collected in India (Andhra Pradesh), Burkina Faso, Ghana and Mozambique by a team of more than 100 people. Unless expressly mentioned as otherwise, all analysis in this paper comes from these four country data sets. Water service delivery models[4] analysed in this working paper include those based on the following technologies: boreholes with manual handpumps; mechanised boreholes which provide a small piped network to point sources; single-town piped networks; multiple-town piped networks and various combinations of these main types. For each of these, actual service levels and the actual expenditures made across the full life cycle of the service were analysed.

Life-cycle costs

The cost components that have been analysed make up a life-cycle costs approach, the core methodology adopted and developed[5] by the WASHCost project. Life-cycle costs comprise capital expenditure; minor operation and maintenance expenditure; capital maintenance expenditure; expenditure on direct support (sometimes known as post-construction support); expenditure on indirect support and the cost of capital.

Little data was available on indirect support costs, which are the costs at national and regional level of developing a legal and policy framework for rural water services delivery, and of relevant staff and training at those levels. The cost of capital remains an important concept as countries move towards financing water services themselves. This however does not feature in WASHCost headline figures as there were virtually no loans to finance the services sampled, having been financed from government allocations or transfers from donors or by NGOs, and to some extent by user fees.

Direct support refers to the back-up services that are critical to keeping services running, including monitoring, training and technical support. Expenditure on district (or equivalent) teams to provide support to communities and service providers comes under this heading.

Capital maintenance expenditure covers the cost of major repairs (beyond the scope of minor maintenance), as well as the cost of rehabilitation and replacement of assets to ensure that systems continue to provide the level of service for which they were designed. This allows future capital expenditure to be used to extend and improve services, rather than to replace systems that fail prematurely.

Capital costs can be thought of as one-time costs, while the remainder are the recurrent costs that need to be budgeted for every year. WASHCost emphasises the need to cover recurrent costs; current planning and budgeting is often focused only on capital expenditure.

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4 A water "service delivery model" refers to a coherent set of service levels, technology types, and management models covering the means and method by which the service is delivered in a national and local context—including the legal and institutional frameworks for delivering services—commonly understood and accepted roles and the levels of support to local providers. Community management of boreholes with handpumps to provide a basic level of service is one service delivery model; delegated management of small town piped networks to deliver basic and improved service levels is another. The life-cycle costs approach developed and used by WASHCost seeks to collect data covering the whole service delivery model, not only the costs of the water system.

5 Life-cycle costing is used in systems engineering and for calculating the total cost of ownership of an asset. The life-cycle costs approach developed by WASHCost disaggregates costs in a specific manner appropriate for WASH service delivery. References to a life-cycle costs approach in this document relate to the approach developed by WASHCost. A detailed explanation is presented in Briefing Note 1a - *Lifecycle costs approach: costing sustainable services*, published by IRC in November 2011, at http://www.washcost.info/page/1557 [Accessed 29 November 2012].

Service levels

Services provided by different water supply systems and models were assessed against four service delivery criteria: quantity of water, quality of water, accessibility to users, and reliability. Indicators were based on the norms and standards set by governments in the research countries.

A basic level of service is assumed to be achieved when all the following criteria have been realised by a majority of the population in the service area:

- people access a minimum of 20 litres per person per day;
- water is of acceptable quality (judged by user perception and country standards);
- water is drawn from an improved source, which functions at least 350 days a year without serious breakdowns; and
- people spend no more than 30 minutes per day per round trip (including waiting time) to access water.

The WASHCost water service ladder[6] also sets criteria for higher levels of service, but the focus of WASHCost research has been on the basic level of service defined by country norms and standards.

Data collection and representativeness

Geo-referenced data was collected through a process that included more than 10,000 household surveys, as well as technical surveys and key informant interviews. Where data was not available, additional targeted research was carried out.

WASHCost was first and foremost interested in improving the accuracy of and promoting the collection and use of cost data in the countries where it worked to enable and facilitate improvements in service delivery. Systems of governance, service delivery levels and the current state of knowledge about costs and expenditure vary between countries. To match these differences, survey designs were adjusted to reflect the local context and the specific interests of country stakeholders. In India and Mozambique data sets were constructed across all agro-climatic regions, while the Ghana country team focused on three broadly representative regions and the Burkina Faso country team collected very detailed data in three communes. Data was collected from more communities in India than in the other countries to meet the aspirations of the Andhra Pradesh state government and other key stakeholders to make the data more representative of this large and diverse state.

The large database of actual expenditure on service delivery and of actual service levels collected by WASHCost teams is representative at the level of the communities, technologies and service areas where it was collected. Efforts were made to ensure that these were in turn representative of the country (or State) as a whole, or that they at least represented a range of typical service delivery areas reflecting a range of challenges. Data on expenditure was not always available for the same communities where data on service delivery was assessed, while service areas are typically poorly defined. Given these and other realities of data collection in the field, WASHCost cannot claim that this data is statistically representative at a national level. However, the WASHCost data set is the most complete of its kind that currently exists, and the WASHCost team is confident that the ranges identified are valid indicative ranges for the focus countries as a whole, and indeed for similar countries. WASHCost found local contexts to be very important in determining expenditure patterns and service levels, so comparisons to other countries should be made with care.

Costs per person and costs per user

An underlying WASHCost assumption is that large-scale water service delivery requires an ability to identify and compare costs of service delivery per capita. If the costs per head of population are known, governments and service providers can better examine the avenues open to them to achieve the levels of service they require based on their

6 See WASHCost Working Paper 2 - *Ladders for assessing and costing water service delivery*, November 2011. Available at http://www.washcost.info/page/753 [Accessed 20 November 2012].

available resources. This requires the data to be analysed by service area[7]. All the expenditure on water services within a service area is divided by the total number of people living in that area, to arrive at a per capita figure (expenditure per person).

WASHCost also set out to compare expenditure on different service delivery models so that it becomes possible to make a judgement about the cost effectiveness of different models. This requires the data to be analysed differently; for all the expenditure on a particular service delivery model to be divided by the number of users of that service (expenditure per user).

This report usually gives expenditure per person first, and costs per person are used in the benchmarks developed by WASHCost. In some cases expenditure per user is highlighted and it will be seen that there can be dramatic differences between the two. Readers should keep this distinction in mind. The relationship between expenditure per person and per user is complicated since it is not unusual, particularly in India and Burkina Faso, to find a mix of systems and/ or management models in one service delivery area such as a district, commune, town or community; while in Ghana, most rural communities have a single model of service. However, even when there is only one model, not everyone within a service area chooses to use the official improved service. They may regard it as too expensive or may prefer to make their own arrangements (self-supply or buying water). Calculating the cost per user required WASHCost to uncover the main source of drinking water for each household. This was challenging given that service areas are poorly defined and that communities often use multiple sources, for multiple uses, in a pattern that may differ from design expectations.

Limitations of cross-country comparisons

WASHCost focused on the needs of national partners and systems of governance with a critical aim of embedding a life-cycle costs approach and good practices in respect to monitoring costs. Although each country had a variety of different service delivery models and types of technology for rural water service delivery, the focus was on the most common in each study area. The cross-country comparisons presented in this paper are for boreholes with handpumps, and for small, medium and larger small town piped networks. For other technology types, such as boreholes with solar pumps, there was not enough data gathered to allow a comparative analysis between countries.

Findings from country studies

The most conspicuous finding from all four countries was the poor level of water services delivered to rural populations. WASHCost data demonstrates a completely inadequate level of expenditure on recurrent costs following initial construction associated with low service levels.

According to the criteria used by the Joint Monitoring Programme of UNICEF/ WHO (2008) and to national government data on "coverage", all the sampled villages and districts in the four countries were considered covered by improved water supplies. When service levels were analysed using country norms for each of the four principal criteria (quantity, quality, accessibility and reliability), the actual population accessing a basic or better level of service ranged from 2% of those nominally served by particular point sources in Mozambique to a maximum of 73% in a particular piped network in Ghana. Overall, the vast majority of users across the countries had an inadequate water supply service that failed to meet country standards and norms.

7 A service area is the area of jurisdiction and population covered by a service authority. Service areas are typically linked to the boundaries of human settlements: towns, villages, hamlets and scattered rural settlements, but may not correspond precisely with administrative boundaries.

Providing these low levels of service was also very costly across all countries. Capital expenditure on boreholes with handpumps ranged from US$ 19 to US$ 76 per person and provided a generally low level of service. Piped networks, with a somewhat higher level of service, showed expenditure of between US$ 21 and US$ 193 per person. Expenditure per user (i.e., only those who used these services) ranged from US$ 19 to US$ 63 for boreholes with handpumps[8] and from US$ 39 to US$ 512 for piped schemes. Andhra Pradesh has, in all comparisons, the lowest cost of building and maintaining a water infrastructure.

Recurrent expenditure per user on hand pump schemes is very low – between US$ 0.10 and US$ 0.50 per user. Recurrent expenditure per user on all the piped schemes ranged from US$ 2.70 to US$ 6.60 for most schemes.

In Ghana, a five-fold increase is needed in capital expenditure to change from a borehole delivery model to a piped supply (from a mean of US$ 19 per user to US$ 97 per user). This doubles the number of users who achieve a basic level of service, but even so, this is still less than 50% of users. In Burkina Faso, users of small mechanised borehole systems receive a much better service than those using a borehole with handpump, but this comes at much higher (per user) capital expenditure, an eightfold increase from US$ 63 to US$ 512.

The Burkina Faso example is a perfect illustration of the sometimes dramatic difference between cost per person (considering everyone in the area covered by the facility) and cost per user. Although a small piped system is more costly to construct it generally covers a larger population and therefore expenditure per person is only US$ 56; less than the cost per person of a borehole and handpump. However, the cost per user in this data is nine times higher, at US$ 512. This is because the piped systems sampled in Burkina Faso were underused, and people used other sources either completely or in combination with the official supply. These piped systems provide a basic level of service to a comparatively high percentage of those who use them but fail to attract most people in the area to become users. This was, however, a small sample of such systems.

Although piped networks generally provide a higher level of service than point sources this is not always the case. In Andhra Pradesh, single-town piped networks with recurrent expenditure of US$ 3 per person per year, provide a basic level of service to a lower percentage of users than a borehole and handpump system achieves, with recurrent expenditure of US$ 0.10 per person per year. In many places point sources and piped networks exist side by side. Sometimes they are almost in competition with each other, and sometimes they are complementary. Boreholes with handpumps continue to play an important role in communities with piped networks, serving both as a main source and as an alternative when the piped network is considered inadequate; for example, due to predictable seasonal source failure, poor perception of water quality, perception that user tariffs are too high, or regular and prolonged mechanical breakdown. In Andhra Pradesh, high numbers of residents do not use the piped scheme as their main supply even though one is present. One reason for this is the chronic unreliability of much of the formal piped infrastructure. The number of people who reject the piped system as their main source varies from community to community but in Andhra Pradesh, looking at (mean) averages for different piped delivery systems, the proportion of residents using other sources was never lower than 37%, and reached as high as 85%.

Findings for users of boreholes and handpump schemes

Boreholes and handpumps fail to supply what WASHCost considers a basic level of service[9] to more than 36% of users in any of the countries and in the African countries below 30% overall.

8 The "per user" data for boreholes and handpumps is based on a large amount of data. The highest "per person" figure came from Burkina Faso where there was only one service area in the sample that was covered by boreholes with handpumps alone, with no other service present. In this area, costs were relatively high. This explains the counter-intuitive finding that the upper limit per person is higher than the upper limit per user.

9 WASHCost basic service levels are based on an aggregation of the service norms in the four research countries.

There were some examples of better service delivery. In 22 villages in Andhra Pradesh, 51% of the population received a basic level of service, although they had only handpumps or informal community wells. In this case only 2% of people bought water from other sources; it seems that the community wells played a large role in satisfying their needs.

In African countries boreholes often fail to deliver the basic quantity of 20 litres per person per day because of problems with accessibility, rather than because of "failure" of the system. People do not use what the service could deliver for a variety of reasons, such as cost, the siting of the source, or not liking the taste when cooking.

In Andhra Pradesh the main barriers to service, are not the quantity of water received by users, but frequent breakdowns of boreholes with handpump sources due to water resource failure, regular mechanical breakdown and slow repair times. Comparing across countries, the lowest mean capital expenditure was US$ 19 per user for borehole and handpump schemes in Ghana and Andhra Pradesh, which may be regarded as the absolute minimum for planning purposes. Mean actual expenditure on recurrent operations and minor maintenance for boreholes with handpumps are of a similar order of magnitude in all countries, ranging from US$ 0.20 to US$ 1.10 per user per year; for the majority of schemes studied expenditure was well below US$ 0.50 per user per year. Variations in the number of users of each supply in each country mean that capital expenditure per user for boreholes with handpumps ranges from the lowest values in Ghana (interquartile range US$ 17 to US$ 21) and Andhra Pradesh (interquartile range US$ 11 to US$ 22), to the highest values in Burkina Faso (interquartile range US$ 45 to US$ 192). In Andhra Pradesh, where the cost of building and maintaining water infrastructure is lowest, the mean capital expenditure for a borehole with a handpump built with government funds was US$ 1,820. In the sample areas of the three other countries, the mean cost of a borehole with handpump was highest in Burkina Faso at US$ 12,507, more than 40% higher than the US$ 8,922 spent in Ghana and the US$ 8,660 spent in Mozambique, and almost seven times higher than what the state government spends per borehole in Andhra Pradesh.

Findings for users of piped schemes

Most piped schemes also fail to provide what WASHCost considers a basic service supply to more than 50% of the population. The two exceptions are intermediate sized single-town piped networks in Ghana and small single-town piped networks in Burkina Faso. The range of mean capital expenditure on small and medium-sized piped schemes ranged from US$ 30 to US$ 130 per person (US$ 44 to US$ 512 per user), compared to a mean expenditure US$ 21 to US$ 193 per person (US$ 39 to US$ 333 per user) for intermediate and large schemes. Piped networks in Burkina Faso are responsible for the very high per-capita cost of small to medium piped networks, essentially due to their being underused.

Across all sampled countries, users tend to receive a better service from piped networks in comparison to borehole with handpumps; yet this comes at a cost of higher initial capital expenditure as well as higher recurrent expenditure. Although there is wide variation of expenditure between different schemes, it is apparent that due to the benefits of economies of scale, larger piped schemes tend to be 25–50% cheaper to construct than those of a smaller size.

The actual recurrent operational and minor maintenance expenditure for all piped schemes was found to be between US$ 0.40 and US$ 4.80 per person, per year. Operational expenditure per user was of course higher, ranging between US$ 0.80 and US$ 6.60 per year for all schemes except the underused small mechanised borehole systems in Burkina Faso where expenditure was much higher at US$ 33 per user per year. Thus, annual operational expenditure is between 1% and 8% of the initial capital expenditure for all piped networks, and the average percentage for all supplies was 4%. Per capita operational expenditure on piped networks is roughly 5-8 times higher than that for boreholes with handpumps. These operational costs, along with capital maintenance and direct support make up the total annual recurrent expenditure. Taking the piped schemes samples as a whole, values ranged between US$ 1.40 and US$ 5.80 per person, and between US$ 1.80 and US$ 6.70 per user (excluding the exceptionally high figures from Burkina Faso due to low usage).

A further consideration, notably in Andhra Pradesh, concerns household capital expenditure. In many communities this can represent a significant proportion of total capital investment for water supply infrastructure. In larger communities, many households have a private source, in some areas more than 50% of sampled households. This percentage was much lower in small (<500 residents) communities with piped networks, which generally also had lower levels of household income. Extrapolating this level of private expenditure across different communities, expenditure by private individuals ranged from 20% to more than 150% of government expenditure.

Findings on cost drivers

Various cost drivers were analysed for capital expenditure in the research countries, including materials used in construction, contract arrangements, depth of boreholes, and remoteness of location. The influence of each is hard to isolate and none provides a consistent explanation. There is no single strong cost driver either for capital expenditure or for recurrent expenditure. Some of the data on cost drivers found by WASHCost cannot be extrapolated between regions within the same country, let alone from one country to another, due to the context specific characteristics that define the costs of each component.

WASHCost in Mozambique found contract size was important for borehole costs. Larger contracts for 100 boreholes or more were found to be 17% cheaper per borehole than smaller contract packages. WASHCost Ghana found that the type of water scheme, the size of contracts and the hydrology of the area were key factors in determining capital expenditure costs for rural piped water schemes. In India, the team found that demographic and economic factors, even the level of education, were factors in influencing levels of expenditure as well as service levels.

Water cost benchmarks for a basic level of service

Minimum benchmark ranges for capital and recurrent expenditure have been developed based on the dataset from the four WASHCost countries, complemented by additional datasets. This has been done by selecting only those water facilities providing a basic level of service. These are based on interquartile ranges from the data. WASHCost research shows that local context is highly significant in determining costs. Many social, institutional and political factors influence the level of services and value for money achieved. However, we can say with some confidence that where expenditure is lower than the benchmarks, the services being planned or delivered have a high probability of being unsustainable.

The capital cost benchmarks (Tables ExecSum1 and 2) for preparing and installing a borehole and handpump range from US$ 20 per person to just over US$ 60 per person at 2011 prices. For mechanised boreholes and other small piped supplies, costs range from US$ 30 to just over US$ 130 per person. For intermediate/ larger schemes, benchmark capital costs vary from US$ 20 to US$ 152 per person.

Table ExecSum1: Capital and recurrent expenditure benchmarks for water services (2011)

Cost component	Primary formal water source in area of intervention	Cost ranges* [min-max] in US$ 2011
Total capital expenditure (per person)	Borehole and handpump	20-61
	Small schemes (serving less than 500 people) or medium schemes (serving 500-5,000 people) including mechanised boreholes, single-town schemes, multi-town schemes and mixed piped supply	30-131
	Intermediate (5,001-15,000) or larger (more than 15,000 people)	20-152
Total recurrent expenditure** (per person, per year)	**Borehole and handpump**	**3-6**
	All piped schemes	**3-15**

* Benchmark cost ranges given in all tables are based on interquartile values from the data.
**See breakdown of recurrent expenditure below (Table ExecSum2).

Source: WASHCost, 2012, p.2.

Table ExecSum2: Breakdown of recurrent expenditure benchmarks for water services (2011)

Breakdown of recurrent expenditure*	Cost ranges [min-max] in US$ 2011 per person, per year	
	Borehole and handpump	All piped schemes
Operational and minor maintenance expenditure	0.5-1	0.5-5
Capital maintenance expenditure	1.5-2	1.5-7
Expenditure on direct support	1-3	1-3
Total recurrent expenditure	**3-6**	**3-15**

* 'Cost of capital' and 'expenditure on indirect support' are not included in Table ExecSum 2 or in the total recurrent expenditure figures in Table ExecSum 1 owing to insufficient and unreliable sources of information.

Source: WASHCost, 2012, p.2.

Recurrent costs benchmarks (covering operation and maintenance, capital maintenance and direct support) range from US$ 3 to US$ 6 per person per year for boreholes and handpumps, and from US$ 3 to US$ 15 per person per year for piped schemes.

We believe these benchmarks to be the best available, providing reliable guidance for planning, implementing and monitoring WASH services. They cannot be regarded as precise for every setting, as local factors must be taken into account. In the WASHCost research, lower cost ranges were generally, but not always found in India, while cost data from Latin America made available to WASHCost tends to be higher than the maximum ranges, but usually relates to higher service levels[10]. If expenditure is lower than the minimum, there is a risk of reduced service levels whereby one or more service criteria is not fulfilled, or of long-term failure. If expenditure is higher than the maximum range, an affordability check (for both users and providers) might be required to ensure long-term sustainability. However, there may be context-specific reasons why a basic level of service is delivered with expenditure outside the cost

10 Data from Latin American can be found in Verhoeven, J. and Smits, S., 2011. *Post-construction support for sustainable rural water supply services. Expenditure on direct and indirect support.* In: RWSN-Rural Water and Sanitation Network, 6th Rural Water and Sanitation Network Forum. Kampala, Uganda 29 November - 1 December 2011. [online] St. Gallen: RWSN Secretariat. Available at: http://rwsnforum.files.wordpress.com/2011/11/193-post-construction-support-for-sustainable-rural-water-supply-services.pdf [Accessed 15 November 2012].

benchmarks. Low costs can occur in a densely-populated area with economies of scale, while costs are likely to be high in areas that are difficult to reach or where the population is very spread out.

Conclusions

The data, overall, confirms that rural water services are chronically underfunded. Low levels of recurrent expenditure on direct support and capital maintenance contribute to high observed levels of breakdown and low service delivery. Very low levels of service in rural water services are related to these high levels of non-functionality. Costs remain high and some users cease to use services that do not meet their needs. Based on country sector reports and non-functionality data, we consider that on average, at any one time, 40% of schemes are not functioning so that at any time, 40% of investments are being wasted. This situation can be remedied if, following construction of new infrastructure, there are the people, systems and finances in place to ensure that systems continue to function and assets are maintained. WASHCost analysis shows that recurrent expenditure on operations and capital maintenance is extremely low, especially for boreholes and handpumps, and this is assumed to be strongly linked to the high observed levels of non-functionality and poor service delivery.

There seems to be a threshold of funds that needs to be allocated per person per year as a necessary condition for sustainability. The reported recurrent expenditure on both direct support and capital maintenance per person per year are remarkably low. A relatively small amount of additional money is required in absolute terms per person to achieve and sustain a basic service level. The conundrum is that, because existing expenditure is so low, this "relatively small amount" for rural services based on boreholes and handpumps is 6-12 times current spending levels, requiring an increase from an observed recurrent expenditure of about US$ 0.50 per person per year to some US$ 3 to US$ 6 per person per year. For piped schemes this means more than a doubling of current recurrent expenditure to US$ 3 to US$ 15 per person per year; although this very much depends on the size of schemes.

While these amounts do not seem much for a year-round supply of good quality and reliable drinking water, for many countries they are too much for available budgets and the current level of economic development. An important message emerging from WASHCost is that without a clear commitment from governments, NGOs and donors to subsidise part of the recurrent costs over the long term, sustainable water services for the rural poor in developing countries will remain unachievable.

WASHCost data shows that in almost all cases, actual expenditure did not achieve national aspirations for service levels, and strongly suggests that actual expenditure is less than the realistic cost of providing a basic level of service. Evidence-based knowledge of the range of current actual expenditure, as well as the service levels actually provided, is a critical first step towards determining the required expenditure (i.e., the real costs) to improve service delivery: either through making existing services more sustainable; and/ or by raising the level of service.

Covering recurrent costs can improve value for money by protecting assets and preventing waste of capital expenditure. A system where life-cycle costs are transparent and covered, and water services are well managed, can be one where capital investments can be used to extend and improve services rather than replacing those that have broken down prematurely.

What is needed to continue the work that WASHCost has started?

A life-cycle costs approach developed by the WASHCost team is one way to analyse and address some of the key reasons for non-functional or underperforming water services. By bringing costs and service levels together, it is possible to calculate:

- How much does it cost, on a yearly basis, to provide a specific level of service?

- Who is paying – or should be paying – for each of the cost components?
- What modalities will be used to fund recurrent expenditures, every year?
- Is it affordable for all the stakeholders involved?
- Do service delivery models need to be revisited to ensure they last?
- Can we get more value for money from existing capital investments?
- Can we provide at least a real basic level of service to everyone?

A life-cycle costs approach and methodology have enabled the comparison of expenditure against service levels in each of the sampled countries. The approach is flexible enough to be adapted to different contexts and organisations that wish to understand better the sustainability of their service delivery models. The most complex aspect of applying the methodology relates to making costs explicit for a specific geographic area where multiple different services operate in parallel.

Data was readily available at household and community level and provided good quality and relevant data on real service levels. Families and communities have a clear view of which services deliver an adequate service, and which do not. However, comprehensive and reliable expenditure data at national, regional and district level is not readily available. Getting hold of good quality, completed project reports is difficult.

Most NGOs that installed the water points surveyed by WASHCost no longer exist, taking their cost knowledge with them. Finding cost data older than three years is also a problem even when the projects were implemented by governments, donors or the private sector. Even where information on costs and expenditure is available, data typically shows lump-sum amounts rather than disaggregated costs, especially for water point sources.

In some countries, bills of quantities or schedules of rates guide budgets and contract arrangements. These documents refer only to capital expenditure and often underestimate what is actually needed, with the exception of Burkina Faso[11]. Nevertheless, some of these documents are taken very seriously in budgeting processes and provide parameters for what are considered to be the acceptable costs of providing rural water services.

Adopting a life-cycle costs approach can trigger necessary changes and speed up improvements that can lead towards sustainable services. Making these changes will require many challenges to be overcome.

- The only way to have relevant, up to date costs which relate to actual service levels is for reporting systems to change considerably to accommodate indicators of sustainability or serviceability over time, together with actual costs made per person per year. There is no cost data available in the WASH sector because no one is asking; governments, donors and NGOs need to ask the right questions and then set up the means to deliver the answers.
- The challenge of financing post-construction elements of a life-cycle costs approach in areas with very low income levels is real. Direct support and capital maintenance are costly but they are not budgeted for and are not happening. How can the sector finance these expenditures? Work in Ghana is continuing to address these questions there, but this is probably a problem in every low- and middle-income country.
- Defining accountability mechanisms towards recurrent expenditure to ensure (financial) sustainability is complex. Contracts between donors and service providers are in practice limited to five years maximum. In many instances, monitoring systems at national level are weak and no one monitors what happens after implementation. Monitoring usually ceases three to five years after the contract has been signed.

11 In Andhra Pradesh, Standard Scheduled Rates are used to arrive at unit costs. These are revised regularly but are often found to be lower when compared with market prices. In Mozambique and Ghana, engineer estimates are used to fill in project-specific Bills of Quantities, which are usually lower than the actual expenditure, and can be found only in completion reports. By contrast, in Burkina Faso, boreholes with handpumps actually cost less to install and restore than the guiding official rates for capital investment and rehabilitation. For small network schemes, investment costs are sometimes higher and sometimes lower than the guiding rates. None has been rehabilitated yet and there is no guidance for the minor operational expenditure of these schemes.

However, limited, incomplete cost data is better than no cost data at all. Once gaps in data sets have been identified, realistic costs can usually be calculated. Sector professionals who are experienced in running water services can be brought together to build up and agree on a realistic budget for meeting recurrent costs, notably the extent and cost of direct support, post-construction, including the costs of monitoring, training, and providing technical support and back up to service providers.

Using the WASHCost life-cycle costs approach and focusing on delivering services rather than just delivering technologies have significant programmatic implications. Not least of these are the changes required in the design, scale and timing of contractual arrangements for all those involved: service authorities, service providers and external support agencies. The costs of WASH have to become transparent and widely known if the chasm between aspirations of water for all and the delivery of at least a basic level of service for all is to be bridged.

1 Introduction

1.1 Justification for the study

Investment in water supply infrastructure over two decades has seen more than two billion people gain access to improved drinking water sources, and the Millennium Development Goal for water being achieved globally three years ahead of the 2015 target (WHO/ UNICEF, 2012)[1]. However, despite increases in nominal coverage, high levels of service breakdown mean that for many, the benefits of an improved water supply will be short lived.

Estimates suggest that at any given moment 30-40% of rural water supply systems in developing countries are not working, with many others characterised by unreliable and intermittent supply (Evans, 1992; Haysom, 2006; Taylor, 2009; Mackintosh and Colvin, 2003). One way to improve the sustainability and quality of service delivery is to ensure that infrastructure hardware is adequately maintained, and community and civil structures are adequately supported to manage service delivery (DFID, 2001; Lockwood, 2004; Prokopy et al., 2008). However, within the sector, very little is known about how much it costs to achieve service sustainability (Pezon, 2010; Van Ginneken, Netterstrom and Bennet, 2011). Consequently, the necessary expenditure on maintenance, renewal and eventual replacement, as well as in providing the policy environment, institutions and civil services to support service delivery, rarely feature in planning and investment decisions (Albee and Byrne, 2007; Fonseca and Cardone, 2005). When provided, the true costs of achieving service outcomes are often "grossly underestimated" (Fonseca, 2007).

1.2 WASHCost and a life–cycle costs approach

Within the sector there is a lack of financial data on the realistic costs of maintaining a service over time. The WASHCost project aimed to address this knowledge gap through the development of a methodology that collects detailed information on the initial and ongoing recurrent costs of different water supply interventions, and the corresponding level of service delivered. One of the project's objectives was to provide a better understanding of the costs required for sustainable service delivery to inform better planning and investment practices.

Over a period of two years (2010-2011) data on costs and service levels were collected in India[2] (Andhra Pradesh), Burkina Faso, Ghana and Mozambique by country teams—comprising over 100 people—in partnership with local and national level governments, statistic institutes, NGOs and research institutions. The resulting methodology was called a "life-cycle costs approach" which not only identifies and analyses all the essential costs of services, but links the cost of service to the service levels achieved.

1.3 Costing framework

To capture and understand the costs of a water service, it is important to be aware of the different elements associated with delivering a service, beyond accounting for capital investment. Life-cycle costs are the costs of ensuring adequate

1 The Joint Monitoring Programme (JMP) of the World Health Organization and UNICEF defines drinking water as water used for drinking, cooking and personal hygiene. It defines access to drinking water being able to reliably obtain at least 20 litres per member of a household per day from an improved source less than one kilometre away. Safe drinking water has microbial, chemical and physical characteristics that meet WHO guidelines or national standards. The JMP considers the following as improved drinking water sources: household connections, public standpipes, boreholes, protected dug wells, protected springs, and rainwater. See: *www.who.int/water_sanitation_health/mdg1/en/index.html* for more information. The WASHCost water service ladder (see Table 2) combines national and international standards for quantity, quality, accessibility and reliability.

2 WASHCost research in India took place in the state of Andhra Pradesh, although there was also interaction between WASHCost and the Government of India. For ease of reference in graphs and tables, we generally refer to data and information from India simply as 'Andhra Pradesh'.

water, sanitation and hygiene (WASH) services to a specific population in a determined geographical area - not just for a few years but indefinitely (Fonseca et al., 2011). The term life-cycle costs should be understood as the costs of providing and sustaining a service, rather than the "cradle-to-grave" costs of individual components on which it relies.

Life-cycle costs encompass operation, maintenance, management and the financial costs incurred during the different stages of service delivery, both hardware and software. The WASHCost research teams have categorised these cost components to include all expenditure undertaken by the whole range of stakeholders throughout the asset life-cycle. The approach offers a financial perspective on challenges faced by the water and sanitation sector, which also entail complex and unpredictable change processes and are exacerbated by limited resources. However, unlike most life-cycle cost assessments, the WASHCost analysis is purely financial and is relatively easy for sector professionals without economic or financial expertise to understand and work with.

The components defined in the WASHCost approach can be broadly divided into the initial costs (capital expenditure) and the recurrent costs needed to sustain service levels[3]. These are summarised in Table 1.

Table 1: **Main cost components of a life-cycle costs approach for the water sector**

Cost components		**Brief description**
Capital expenditure The costs of providing a service where there was none before; or of substantially increasing the scale or level of services.	Capital expenditure hardware (CapEx)	Capital invested in constructing or purchasing fixed assets such as concrete structures, pumps and pipes to develop or extend a service.
	Capital expenditure software (CapEx)	The costs of one-off work with stakeholders prior to construction or implementation, extension, enhancement and augmentation (including costs of one-off capacity building activities).
Recurrent expenditure[4] Service maintenance expenditure associated with sustaining an existing service at its intended level.	Operational expenditure (OpEx)	Operating and minor maintenance expenditure: typically comprises regular expenditure such as labour, fuel, chemicals, materials, and purchases of any bulk water.
	Capital maintenance expenditure (CapManEx)	Asset renewal and replacement cost: occasional and 'lumpy' costs that seek to restore the functionality of a system, such as replacing pump rods or foot valves in handpumps, or a diesel generator in motorised systems.
	Cost of capital (CoC)	Cost of interest payments on micro-finance and loans used to finance capital expenditure. Cost of any returns to shareholders by small-scale private providers.
	Expenditure on direct support (ExpDS)	Expenditure on support activities for service providers, users or user groups.
	Expenditure on indirect support (ExpIDS)	Expenditure on macro-level support, including planning and policy making to decentralised district, municipal or local government.

Source: Based on Fonseca et al., 2011.

3 Further details on cost components are found in: Fonseca, C., et al., 2011. *Life-cycle costs approach: costing sustainable services.* (WASHCost Briefing Note 1a) [online] The Hague: IRC International Water and Sanitation Centre. Available at: <http://www.washcost.info/page/1557> [Accessed 15 January 2013].

4 In much of the WASH literature, costs associated with maintaining an existing service at its intended level are referred to as 'post-construction' costs. This usage reflects the historic tendency of the sector to focus on providing hardware where none had previously existed (hence 'construction costs' and subsequently 'post-construction' costs). This is not a term usually used in the WASHCost approach as it seems to undervalue the variety and importance of recurrent costs. Once a service has been provided for the first time, all costs become 'post-construction'.

1.4 Determining service levels

The service delivery approach is a strategic concept for improving long-term rural water services at scale and ensuring sustainability. The approach puts the emphasis on the water service received by a population, rather than only on the systems by which services are being provided. Researchers involved in the WASHCost project developed a framework for analysis, which examines service levels for a specific area according to the following four main criteria: quantity of water, quality of water, accessibility, and reliability (summarised in Table 2). Taken together, these are considered the key characteristics of a water service which the study has used as a framework when comparing expenditure. The indicators for each level are based on country and international norms[5], while the service level for each household and for the area of analysis is determined by the lowest service indicator achieved[6].

Table 2: WASHCost water service ladder

<table>
<tr><th>Service level</th><th>Quantity (lpcd)</th><th>Quality</th><th>Accessibility distance and crowding (minutes per round trip)[7]</th><th>Reliability[8]</th></tr>
<tr><td>High</td><td>> = 60 litres per person per day</td><td>Meets or exceeds national norms based on regular testing</td><td>Less than 10 minutes per round trip

(Alternatively, water is available in the compound or household)</td><td>Very reliable = works all the time</td></tr>
<tr><td>Intermediate</td><td>> = 40 litres per person per day</td><td rowspan="2">Acceptable user perception and meets/ exceeds national norms based on occasional testing</td><td rowspan="2">Between 10 and 30 minutes per round trip

(Alternatively, less than 500 metres to source AND less than the normative population per functioning water point)</td><td rowspan="2">Reliable/ secure = works most of the time</td></tr>
<tr><td>Basic (normative)</td><td>> = 20 litres per person per day</td></tr>
<tr><td>Sub-standard</td><td>> = 5 litres per person per day</td><td>Negative user perception and/ or no testing</td><td>Between 30 and 60 minutes per round trip

(Alternatively, between 500 and 1,000 metres to source, OR exceeds the normative population per functioning water point)</td><td>Problematic = Suffers significant breakdowns and slow response time to repairs</td></tr>
<tr><td>No service improvement</td><td>< 5 litres per person per day</td><td>Fails to meet national norms</td><td>More than 60 minutes per round trip

(Alternatively, more than 1,000 metres from the household)</td><td>Unreliable/ insecure = completely broken down</td></tr>
</table>

Source: Adapted from Moriarty et al., 2011, p. 12.

5 This WASHCost framework is used for the comparison of services in different countries and is partly based on standards in WASHCost research countries, and partly on international norms (see footnote 1, page 1). It is understood that a single country analysis criteria can be adjusted in accordance with the national policy norms of the country.

6 See: Moriarty, P., et al., 2011. *Ladders for assessing and costing water service delivery.* (WASHCost Working Paper 2, 2nd ed.) [online] The Hague: IRC International Water and Sanitation Centre. Available at: <http://www.washcost.info/page/753> [Accessed 17 December 2012] for a detailed explanation on the four criteria and indicators used by WASHCost in its application of a life-cycle costs approach.

7 In rural Burkina Faso, the normative value for accessibility distance to achieve a basic and intermediate service level is less than one kilometre. A distance of less than 500 metres is considered acceptable in urban areas.

8 In Burkina Faso, because functionality data was not available, reliability was measured by proxy according to the availability of two formal water points.

1.5 Service delivery approach, service authority, service area and service delivery model

This paper analyses costs and services in a number of ways; including by service delivery area and service delivery model. These should be seen in the context of the service delivery approach, for which accurate information on costs and service levels is a key requirement.

A service delivery approach promotes a planned approach to a district-wide (or equivalent) population, with attention paid to maintaining service at an acceptable level indefinitely (de la Harpe, 2011; Lockwood and Smits, 2011). The service authority is often a local government body with legal responsibility for guaranteeing a WASH service in a defined area, fulfilling functions such as planning, coordination and oversight. The service authority may also be the legal owner of assets, or may have delegated functions of regulation and/ or be responsible for technical assistance.

A service area is the area of jurisdiction and population covered by a service authority. Service areas are typically linked to the boundaries of human settlement: towns, villages, hamlets and scattered rural settlements, but may not always correspond precisely with administrative boundaries. A service agreement area is the agreed area and defined population to be covered by a water service provider. In the WASHCost research, service delivery areas were often found to be poorly defined and not well understood.

The service delivery model is the particular application of the service delivery approach in a national and local context – the way a water or sanitation service is provided. It covers everything from the legal and institutional frameworks for delivering services to the technology adopted. Service delivery models differ by *level of service provided; type of infrastructure; and management system.*

In the WASHCost countries, the service delivery models examined were community-based management or public sector operators. These have been analysed by the type of technology used.

In this paper we refer to borehole with handpumps, single-village/town system, multi-village/town system and mixed piped supplies as service delivery models. In many villages the core service is provided solely through boreholes with handpumps, and these also exist (and are used) in many communities that have piped supplies. A single-village/town system is one where the source is developed locally and where water runs to standposts or households through piped networks inside the community. A multi-village/town system is piped from an outside source serving several towns or villages, and is distributed by an internal network. In these cases, responsibility for operating and servicing the distribution within the community is often separated from the responsibility for the major piped supply.

A mixed piped supply means that there is more than one parallel system, although they may be run by the same authority and they may be part of the same service delivery model. Mixed piped supplies have more latency in the system; one may continue to work when another breaks down. However, maintenance and repairs may be less assiduously undertaken where there is more than one system.

The distinction between town and village is not always clear, particularly as villages grow in size and some are absorbed into the fringes of the nearest large town.

2 Methodology

2.1 Fieldwork sampling and research approach

Over a period of two years (2010-2011) data on costs and service levels were collected in India (Andhra Pradesh), Burkina Faso, Ghana and Mozambique by teams that together, comprised more than 100 people. All data and analysis reported in this paper is primarily derived from the four country data-collection processes, unless expressly referenced as coming from elsewhere.

WASHCost research countries were selected in part because of the diversity of their respective WASH services. This allowed for data collection across numerous supply systems, the services they provide, and their associated costs. However due to context-specific variation, not all data is comparable. Table 3 below details the water service delivery models that have been costed as part of this study and outlines the cross-country comparisons that have been made.

Table 3: **Definition of service delivery models showing countries where sufficient cost information was collected for analysis**

Service Delivery Model	Sources	Population of service area	Andhra Pradesh[9]	Burkina Faso	Ghana	Mozambique
Borehole and handpump	Ground water		●	●	●	●
Mechanised borehole Water is supplied through a small distribution network and connected public stand posts. Water storage is limited, typically to an overhead storage tank[10] directly connected to the pump. Household connections are rare.		< 500	●			
		500-5,000	●	●		
Single-village (town) supply Reticulated supply with pumping, storage and distribution through public stand posts with provision for house connections.	Ground water and Surface Water	< 500	●			
		500-5,000	●		●	●
		5,001-15,000	●		●	●
		> 15,000			●	●
Multi-village (town) supply Reticulated supply with pumping, storage and distribution supplied to a number of interconnected towns or villages. Each village with its own storage and distribution network.		< 500	●			
		500-5,000	●			
		5,001-15,000	●		●	
		> 15,000			●	
Mixed piped supply (MPS)[11] Water is supplied through a combination of separate, often overlapping, service delivery systems.		< 500	●			
		500-5,000	●			
		5,001-15,000	●			

9 Borehole and handpump systems were found in all communities sampled in Andhra Pradesh, Burkina Faso and Ghana.

10 Normally with a capacity less than $30m^3$.

11 Andhra Pradesh was found to be the only location with mixed piped supplies. In all other research countries, a mix of service delivery models with piped supplies and handpumps with boreholes were found.

Geo-referenced information about service levels was collected from more than 10,000 household surveys, and from technical surveys and key informant interviews. Where expenditure data was not explicitly available, information was collected by reviewing contract completion reports and by interviewing stakeholders at household, district, regional and national levels[12].

A common approach to data collection was agreed through international research team meetings but the detail was determined by the needs of stakeholders in each country. A significant aspect of this kind of action research is the need to embed the approach a methodology within the local context. The differing interest of the various stakeholders resulted in very different sample sizes for household surveys and water point studies in each country (Table 4). The India and Mozambique country teams collected extensive data sets across all agro-climatic regions, the Ghana country team focused on three regions and the Burkina Faso country team collected very detailed, census type data from three districts.

Table 4: **Data sample from the four WASHCost research countries**

Data Sample	Andhra Pradesh	Burkina Faso	Ghana	Mozambique
Communities visited	187	9	35	67
Piped networks sampled (with valid[13] cost data)	165 (165)	5 (2)	5 (3)	21 (13)
Borehole and handpump sampled (with valid cost data)	1,319 (1, 319)	59 (38)	74 (57)	91 (52)
Detailed household surveys	5,242[14]	3,046	1,273	1,010
Additional data sources	-	-	122 borehole and handpump contracts; 63 financial records of small town systems	352 borehole and handpump contracts; financial records of 3 small town systems outside the original study area

Efforts were made to ensure that the data collected was representative of a range of typical service delivery areas, and reflected diverse challenges. Data on expenditure was not always available for the same service areas where data on service delivery was collected. Moreover, service areas were typically defined poorly. Given these and other realities of field data collection, WASHCost cannot claim that the data is statistically representative at a national level. However, the WASHCost data set is the most complete of its kind that currently exists. The WASHCost team is confident that the ranges identified are valid indicative ranges for the focus countries as a whole, and indeed for similar countries. However, WASHCost found local contexts to be very important in determining expenditure patterns and service levels, so comparisons to other countries should be made with care.

12 Methodological details from each WASHCost research country are available in the following country-levels methodological reports. For **WASHCost (Andhra Pradesh) India**, see: http://www.washcost.info/page/1642 (Ramachandrudu, 2008); **WASHCost Ghana**, see: http://www.washcost.info/page/1440 (Moriarty, et al., 2010); and **WASHCost Mozambique**, see: http://www.washcost.info/media/files/washcost_moz_sampling_methodology (WASHCost Mozambique, 2010).

13 Data collected in countries was subjected to several rounds of cleaning before analysis. Some systems were excluded because of lack of data, and in some cases data was discarded as it was deemed to be unreliable. Analysis of the remaining systems was based on data considered by WASHCost to be valid.

14 We excluded 501 household surveys from this final report due to unreliable data.

This working paper initially presents the main findings on costs and service levels for each country. These findings are later brought together as part of a cross country analysis in Chapter 7. Given the differences in sample sizes and types of infrastructure found in each country, the cross-country analysis is limited to the following comparisons:

- **Boreholes with manual handpumps**: available cost data in all four countries.
- **Mechanised boreholes:** cost data was available in three countries; cost data from Ghana was too limited to allow for a comparison to be made; only Andhra Pradesh and Burkina Faso had enough data for analysis (see Table 4).
- **Single-village/town systems:** cost data was available from Andhra Pradesh, Ghana and Mozambique.
- **Multi-village/town systems and mixed piped supplies:** cost data was available mainly from Andhra Pradesh.

2.2 Methodology for analysing costs and service levels

For each water system, research teams collected as much life-cycle cost data as they could. The following five steps were undertaken to facilitate the collation and comparison of information gathered.

Bringing all data to current value in US dollars

Researchers collected actual expenditure at various dates, including some capital costs incurred several years earlier. All expenditure collected was brought to their current value (in 2010), in US dollars, using Gross Domestic Product (GDP) deflators.

Determining capital maintenance expenditure

The focus of the study is on actual expenditure. Capital expenditure is a one-off sunk cost and does not occur annually. However, under a life-cycle costs approach it is important to take into account the manner in which the effectiveness, efficiency and reliability of capital assets reduce over time. This varies between water systems, depending on the mix of assets that make up the overall system. There should be a charge set aside in any given year for capital maintenance, which allows for major repairs and the eventual renewal of infrastructure. In accounting terms, this charge is referred to as depreciation; in a life-cycle costs approach, as capital maintenance expenditure (CapManEx). Over time, the CapManEx that is set aside each year should—within an appropriately managed scheme—approximate to the necessary but occasional and often unpredictable actual expenditure on major repairs and replacements.

2.2.1 Annualising recurrent expenditure

The recurrent costs of operational expenditure (OpEx), direct and indirect support (ExpDS/ ExpIDS) and the cost of capital (CoC) are typically accounted for on an annual basis. When data is available over a number of years, an average of these values can be taken. Direct and indirect support expenditure relate to expenditure at many different governance levels. To bring this to a per person expenditure, each annual support cost allocation has been divided by the number of people in the relevant geographical area at national, regional or district level.

Capital maintenance expenditure (CapManEx) does not necessarily occur annually for individual water systems, particularly not in the early years of operations. For borehole and handpumps and for piped networks, CapManEx is highly variable. For this analysis, capital maintenance expenditure, where found, has been annualised by dividing by the age of the system at the time of data collection; or, where sufficient information was available, by the average age of a number of similar systems.

Some rural systems have been financed through loans from multi-lateral development agencies. A limited number were privately financed. In both cases the providers of the loans and/ or the providers of investment equity (the owners or shareholders of private systems) have to be compensated through interest payments. This is termed as the cost of capital[15].

15 For a discussion on the cost of capital, refer to Section 8.3 of this paper: *Financing services through loans comes at a cost.*

Taken together, these costs—OpEx, CapManEx, ExpDs, ExpIDs and the cost of capital—represent the annual financing (total annual recurrent expenditure) required to sustain rural and small town water systems, either through government support (from taxation), through user tariffs, through direct donor budgetary support or through a combination of all three.

2.2.2 Comparison of expenditure using the purchasing power parity (PPP)

An additional analysis has been made using the purchasing power parity adjustments to compare expenditure in 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. Any apparent difference in expenditure levels across the WASHCost project's four focus countries may partly be explained by the 'undervaluation' of one currency in comparison with another. This difference is made visible with the PPP analysis[16] which is compiled in the Annex section.

2.2.3 Determining per person expenditure and service levels

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. One of the challenges of establishing per person costs lies in determining the number of people who can be considered to fall within the service area; for per user costs, the task in establishing how many actual users there are of any particular system, at any particular time, is even more difficult. In a large number of the areas sampled residents sourced their water from multiple formal and informal sources at different times of the day and for different purposes. This picture is further complicated in service delivery models where multiple separate systems provide overlapping services in the same area; for example, where boreholes and handpumps function alongside a piped water network. This is the norm in India and this model is increasingly found in Africa as piped networks become more common.

In recognition of this challenge, per person costs are presented in two ways in this working paper.

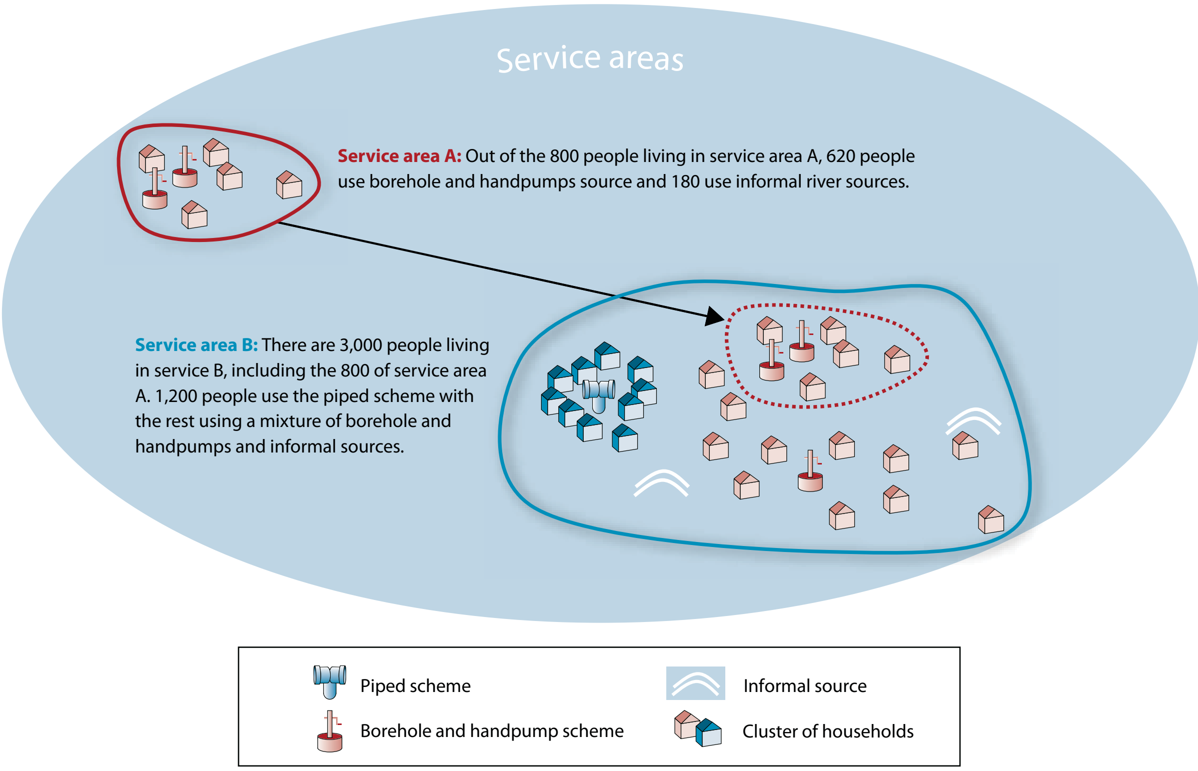
> The first; **cost per user per service delivery model,** takes the recorded expenditure on the water supply infrastructure of the service delivery model (which may be made up of single or multiple water supply systems) divided by the 'users' - defined as those who regularly use sampled sources for (mainly) drinking purposes.
>
> The second; **cost per person per service delivery area,** takes all the expenditure on water infrastructure from a defined service delivery area (this might include more than one service delivery model) divided by the population in the study area; even if some do not have access to the water supply system.

The combination of these analyses allows for an examination of the service delivery effectiveness of stand-alone supply options while recognising how issues of source accessibility and reliability affect usage, costs and service levels within and across defined geographic areas. The strength of this approach is that it recognises the complexities of water delivery in each context and seeks to compare the amount spent in supplying a service from all formal sources with the corresponding service levels achieved.

The visualisation of service areas demonstrates the real challenges in drawing service area boundaries for different supply systems, especially in rural areas where populations can be more dispersed. When boundaries are eventually drawn, these may have a significant effect on expenditure and service level findings. It should also be noted that the practice of using a combination of formal and informal sources to meet household needs may make good sense to the household; but an informal source often substitutes for water from an 'improved' source. In these cases service level figures, which are discussed later in this report, are adversely affected.

16 All data used to undertake purchasing power parity and currency deflations was obtained from the World Bank data repository: http://databank.worldbank.org/ddp/home.do

Figure 1: **Example of determining per user and per service area population**



Service area A: Two boreholes with pumps are managed by the same community water committee. They were installed at a cost of US$ 8,000 each. Pump X is difficult to pump and has a slow flow rate. Consequently, it gives a sub-standard level of service to the 120 people who use it. **Capital cost per user is US$ 67.**

Pump Y has a good flow, has not broken down and is easy to pump. It is used by 500 people. Because of its popularity it suffers from crowding and collecting water can take a long time because of queuing. It too therefore delivers a sub-standard level of service. **Capital cost per user for this pump is much lower at US$ 16.** Taken together the **capital cost of both these pumps is: US$ 16,000/ 620 = US$ 26 *per user*.**

However there are 180 people in this service area who use none of these sources. Rather, they use traditional informal sources, which provide a very low level of service. **Capital cost for the area is US$ 16,000/ 800 = US$ 20 *per person* in service area A.**

Service area B: A medium-sized piped system built at a cost of US$ 100,000 serving 1,200 people out of the 3,000 people in service area B results in a **capital cost of US$ 83 *per user.*** The piped system is reliable with a mixture of household connections and public stand posts and users tend to receive a basic level of service.

In addition to the piped system, there are three boreholes in service area B, each costing US$ 8,000. Therefore the mixture of services provided in service area B has come at a **capital cost of US$ 124,000/ 3,000 = US$ 41 *per person*.**

2.3 Limitations

This working paper draws on aggregated data collected from specific regions of the four WASHCost research countries, but for the sake of simplicity we refer to the countries as a whole (and in India, simply to Andhra Pradesh). Some contextual details which explain the findings are absorbed in the aggregation. Various country level reports linking findings with specific policy implications are available from the project website[17].

The findings in this working paper are based on extensive surveys and data collection at household, district, regional and national level. The findings have necessarily relied on a combination of these sources, often referring to water systems outside the original area of primary data collection in order to determine per user and per person costs of different methods of service delivery. The boundaries of service areas (areas where investment and operating costs were collected) and population statistics rarely coincide as conveniently as researchers and analysts might like.

One specific limitation has been the absence of reliable information on the cost of capital (expenditure on interest payments on loans); this has not been included in the main analyses but is dealt with in chapter 7 of this paper. In countries where services are normally financed from government revenue or by transfers from donors or by NGOs, and to a lesser extent by user fees, there has been little reliance on loans that require interest payments to be made. The cost of capital remains an important concept as countries move towards financing water services themselves, but this did not emerge as a significant cost in WASHCost data.

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 many years previously. 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.

A question remains over whether data collated from contracts, project completion reports and governmental accounts for and accurately reflects field expenditure. Where possible, researchers triangulated documented expenditure with evidence of work undertaken. This could not be achieved in all cases due to a variety of factors including lack of accounting transparency, the involvement of multiple stakeholders, and difficulties encountered in travelling to remote rural areas more than once to check data. These challenges would largely disappear if a life-cycle costs approach were to be routinely collected by governmental and non-governmental agencies.

17 Visit WASHCost's website at: http://www.washcost.info

3 India (Andhra Pradesh)

This section summarises findings from the implementation of a life-cycle costs approach to water supply in Andhra Pradesh, India[18].

3.1 Water service delivery in Andhra Pradesh and study sample

Water service delivery in Andhra Pradesh reflects a legacy of repeated efforts to improve water supplies in rural India through enhancement and renewal, which has resulted in a complex pattern of boreholes with handpumps in every community where WASHCost research took place, often alongside piped networks supplying water to standpipes and household connections. These services are usually funded and constructed by governmental agencies. They are often augmented by private household water sources, as those with more resources in villages/towns seek to secure their own supplies.

Many residents access water from multiple informal and formal water sources at different times of the day and for different purposes, making it challenging to disaggregate expenditure and service levels for and by a particular source. To calculate expenditure per service delivery model, a distinction has been drawn between service areas supplied by a single piped network, complemented by the ever present borehole and handpump, and those supplied by multiple, overlapping, piped networks, known as mixed piped supplies. With single piped supplies, (whether to a single-village/town or multiple communities), water points can be directly attributed to the network and can ultimately be costed independently. This form of attribution is problematic where multiple overlapping piped supplies exist. In such cases, this service delivery model is costed as a mixed piped supply without further disaggregation.

Most of the data collected in India was from rural areas or from peri-urban areas around towns and cities. Villages may cover more than one habitation, separate from each other, but having the same village government (*Gram Panchayat)*. The research focused on rural habitations and for ease of reference, we refer to these as villages.

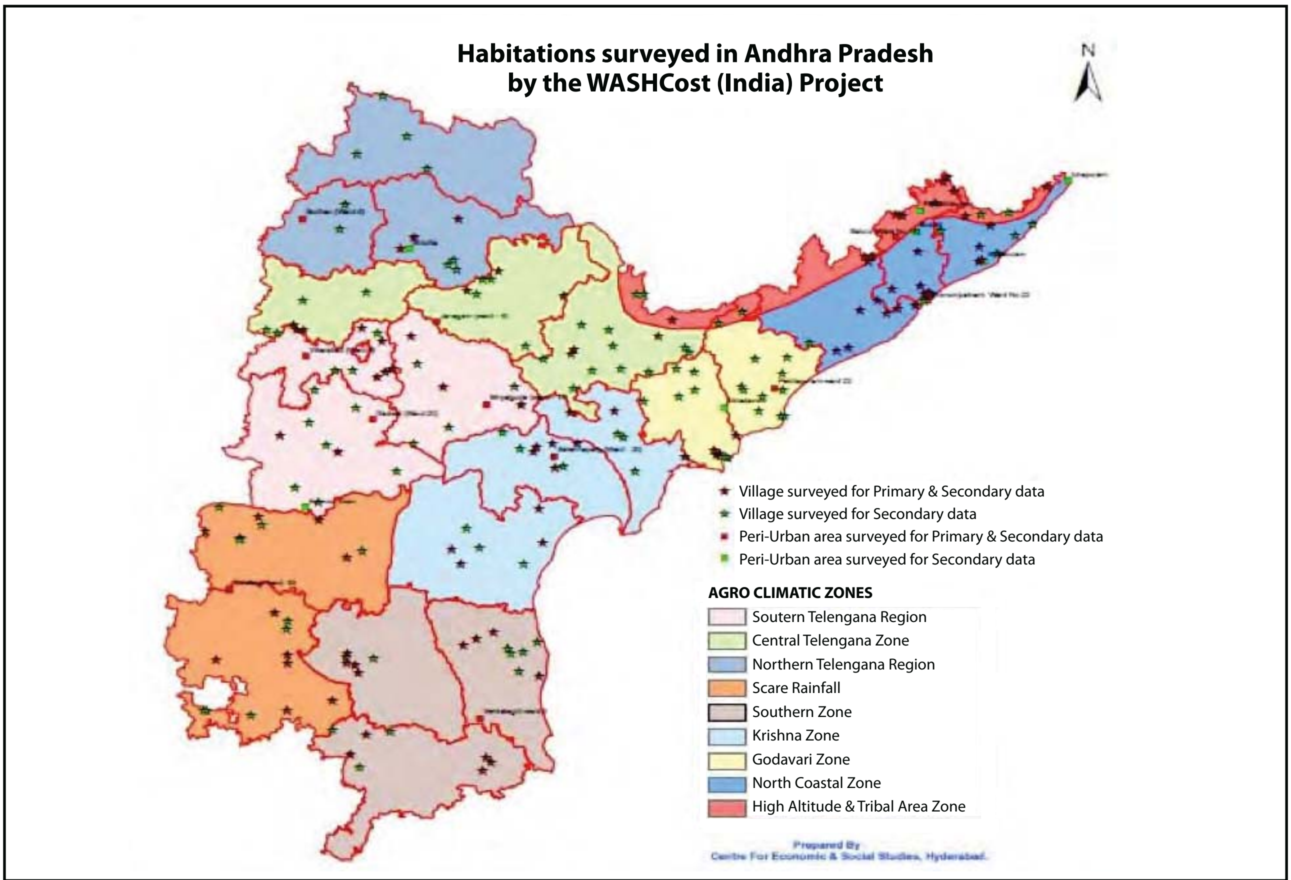
Government expenditure on WASH infrastructure was collected from 187 villages across nine agro-climatic zones (Figure 2). In addition, valid information about household expenditure and the service levels accessed by residents was collected in 5,242 household surveys covering 103 of these villages (Table 5).

Table 8 details the data collected for each service delivery model and shows how they have been subdivided according to the size of community they are designed to serve: small (less than 500 residents); medium (between 500 and 5,000 residents) and intermediate (between 5,000 and 15,000 residents).

Of rural Andhra Pradesh villages sampled, 12% were supplied through traditional boreholes and handpumps alone; 45% through single-village or multi-village piped networks; and 43% through a mix of piped networks.

18 Andhra Pradesh-specific research results cover the following topics in detail: **institutional mapping**, see http://www.washcost.info/page/1642 (Ramachandrudu, 2009); **rural water drinking service levels**, see http://www.washcost.info/page/1665 (Snehalatha et al., 2011); **financing and allocations of funds**, see http://www.washcost.info/page/1650 (Reddy and Jayakumar, 2011) and **state level analysis on unit costs and services**, see: http://www.iwaponline.com/washdev/002/washdev0020279.htm (Abstract only; Reddy et al., 2012).

Figure 2: **An overview of Andhra Pradesh showing climatic zones and research villages**



Source: Snehalatha et al., 2011.

Table 5: **Andhra Pradesh WASHCost sample per agro-climatic zone: number of villages and towns with reliable data**

Agro-climatic zone	Nº of communities		Nº of detailed household surveys undertaken
	With valid expenditure data	With valid service data	
Central Telangana	22	9	499
Godavari	20	8	500
High Altitude	21	11	474
Krishna	20	12	650
North Coastal	20	17	842
North Telangana	20	11	550
Scarce Rain Fall	20	11	538
Southern Telangana	21	10	479
Southern	23	14	700
Total	**187**	**103**[19]	**5,242**

19 107 villages were originally sampled at the household level but four were excluded from the analysis due to unreliable and unclear data. For the final analysis, all 501 household surveys corresponding to the four villages were not included.

Table 6: Service delivery models found in Andhra Pradesh

Service delivery model	Service area size	Nº of service areas with expenditure data	Average service area size	Nº of service areas with service level data	Average community size
Borehole and handpump		22	482	12	475
Mechanised borehole	Small	17	262	4	247
	Medium	17	1,128	8	1,509
Single-village/town network	Small	2	441	-	-
	Medium	28	1,559	14	1,389
	Intermediate	3	9,771	-	-
Multi-village/town network	Small	6	308	5	291
	Medium	11	1,591	8	1,697
	Intermediate	1	5,234	1	5,234
Mixed piped supply	Small	8	351	1	422
	Medium	66	1,510	47	1,414
	Intermediate	6	6,929	3	6,875

3.2 Expenditure per service area

3.2.1 Capital expenditure per person per service area

Expenditure per service area represents the financial commitment undertaken by the service provider, in this case the state government, to provide services in an area to the whole population. To determine the expenditure per person per service area, the total of capital and recurrent expenditure on building and maintaining water services in the area is divided by the total number of people living in the area, regardless of whether they access services or not.

The mean capital expenditure for different systems varied from US$ 21 per person for an intermediate-size mixed piped supply network to US$ 81 per person for a small single-village/town network. This difference is most evident when comparing small networks (serving less than 500 residents) with intermediate-sized networks (serving between 5,000 and 15,000 people); the smaller networks are two to four times more expensive. There are clearly economies of scale that benefit larger networks. Typically, the total capital expenditure on intermediate networks is six to ten times higher than that for small networks but the population they serve (5,000 to 15,000 people) is 10 to 30 times higher than the small single-village/town network (up to 500 people).

The small single-village/town network is also three times more expensive than the borehole and handpump service for which the capital expenditure was US$ 26 per person. Both of these service models serve similar sized populations: the mean size of communities using boreholes and handpumps was 482 people while the small-village/town network is designed for up to 500 people.

Boreholes with handpumps remain the primary back-up supply option for residents in most communities to the extent that 20% of total state capital expenditure in sampled villages was spent on handpumps. In villages served by mechanised boreholes a third of capital expenditure goes on handpumps.

The variation in expenditure per person is greatest for smaller community systems, as a relatively small change in capital investment has a marked impact on per person expenditure.

Per person capital expenditure made by the state government on a range service delivery models is illustrated in Figure 3.

Figure 3: **Mean government capital expenditure per person per service delivery area in Andhra Pradesh, with interquartile ranges[20] (US$ 2010)**

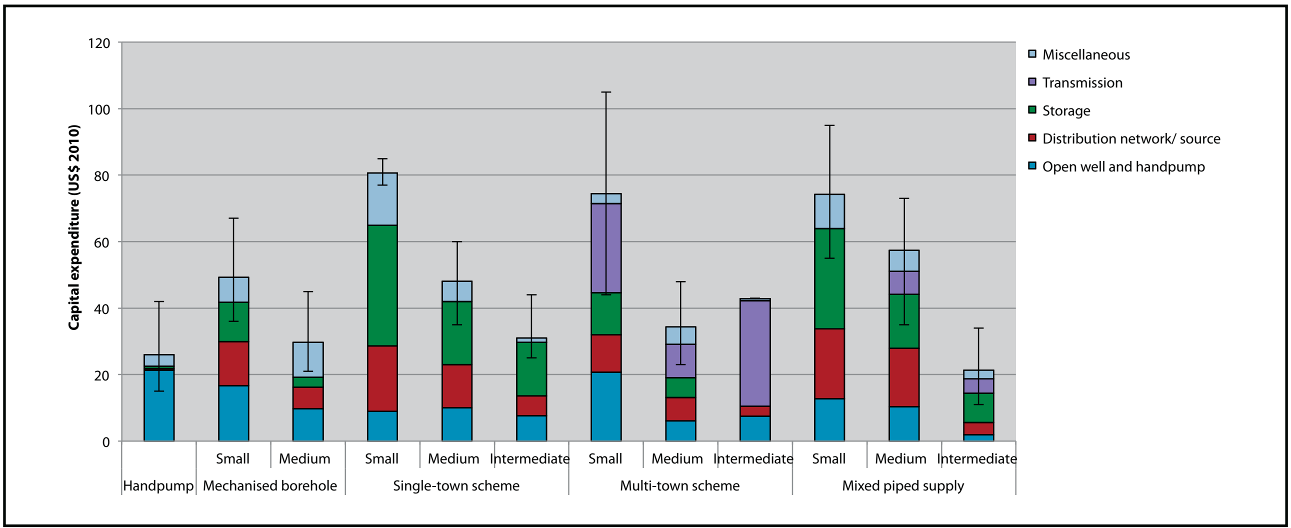


Table 7: **Government capital expenditure per person per service delivery area in Andhra Pradesh, with minimum, maximum and interquartile ranges (US$ 2010)**

Service delivery model	Service area size	Nº of service areas	Min	Max	Interquartile range	Mean
Handpump		22	$ 3	$ 92	$ 15 - 42	$ 26
Mechanised borehole	Small	17	$ 2	$ 107	$ 36 - 67	$ 49
	Medium	17	$ 0	$ 54	$ 21 - 45	$ 30
Single-village/town network	Small	2	$ 73	$ 89	$ 77 - 85	$ 81
	Medium	28	$ 2	$ 103	$ 35 - 60	$ 48
	Intermediate	3	$ 20	$ 57	$ 25 - 44	$ 31
Multi-village/town network	Small	6	$ 26	$ 124	$ 44 - 105	$ 74
	Medium	11	$ 2	$ 106	$ 23 - 48	$ 34
	Intermediate	1	$ 43	$ 43	$ 43 - 43	$ 43
Mixed piped supply	Small	8	$ 38	$ 179	$ 55 - 95	$ 74
	Medium	66	$ 2	$ 166	$ 35 - 73	$ 57
	Intermediate	6	$ 7	$ 42	$ 11 – 34	$ 21

20 The interquartile range bars have been placed on the bars in Figure 3. However, due to the variations in the number of systems sampled for different service delivery models, these bars do not indicate the statistically significant differences between the delivery models. Rather, they act as a guideline in understanding how values fluctuated for each model.

Capital expenditure to develop the network source and facilitate storage and transmission[21] varies in a predictable manner between service delivery models. A single-village/town network requires greater onsite storage than a mechanised borehole, while expenditure on storage constitutes 16–36% of total CapEx for single-village/town networks compared to 5–12% for mechanised boreholes. The main expenditure on multi-village/town networks relates to the additional costs of connecting to a centralised water source; this represents between 30% and 70% of overall capital expenditure. These values vary greatly according to the distances between a community and centralised source, as distance drives up overall expenditure.

The majority of capital expenditure (82%) for a borehole with handpump is spent on developing and drilling the source. Another 13% relates to survey, planning or siting activities that are often not incorporated into published construction expenditure figures.

According to this indicative sample, the average CapEx on more technologically complex piped networks (single-village/town networks, multi-village/town networks and mixed piped supplies) is greater than on mechanised borehole networks, but for each service area size they are remarkably similar to one another, as shown in Table 8. At the per person level, there is no great difference in terms of capital expenditure requirements between piped options, although the amounts vary between different service area sizes.

Table 8: **Mean capital expenditure per person for service delivery models based on piped networks for service areas of varying sizes (US$ 2010)**

Size of service delivery area	Single- village/ town network	Multi-village/ town network	Mixed piped supply	Range of capital expenditure
Small (< 500 people)	$ 72	$ 54	$ 61	$ 54-72
Medium (500 – 5,000 people)	$ 38	$ 28	$ 47	$ 28-47
Intermediate (5,000 – 15,000 people)	$ 23	$ 35	$ 19	$ 19-35

3.2.2 Household capital expenditure (self-supply)

In Andhra Pradesh and across India as a whole, self-supply through private boreholes and open wells is common. Evidence from the 103 communities where detailed household surveys were undertaken, shows that household expenditure on private sources varies greatly and appears to depend on two interrelated factors: community size and household income. Smaller communities have a lower median household income (between US$ 700 and US$ 900 per year), and these areas have also the lowest expenditure rates on private sources at US$ 2–3 per person. Median incomes in communities of 5,000–15,000 residents are nearly double those found in the smaller communities, and expenditure on private sources is much higher, between US$ 30 and US$ 40 per person. Household expenditure, mainly on private borewells and storage facilities, takes place despite the existence of official services and represents a significant proportion (15-40%) of the total capital investment in water supply infrastructure in medium-sized communities, but only 4–8% of CapEx in small service areas. In some communities more than 50% of households have a private source (Figure 4), adding an extra layer of complexity to service delivery in Andhra Pradesh. Over all the sampled service areas, 9% of households have constructed a private source, taking advantage of the huge private sector capacity available in India, driven by agricultural borehole development, which has relentlessly driven down drilling costs.

21 In this context, the term "transmission" is used to refer to expenditure on connecting a community as a whole to a centralised surface water or ground water source. Piped infrastructure within the community to take the water to households or individual water points is described in this paper as network distribution.

Figure 4: **Relationship between capital expenditure on source, storage etc. by households and number of households with a private supply**

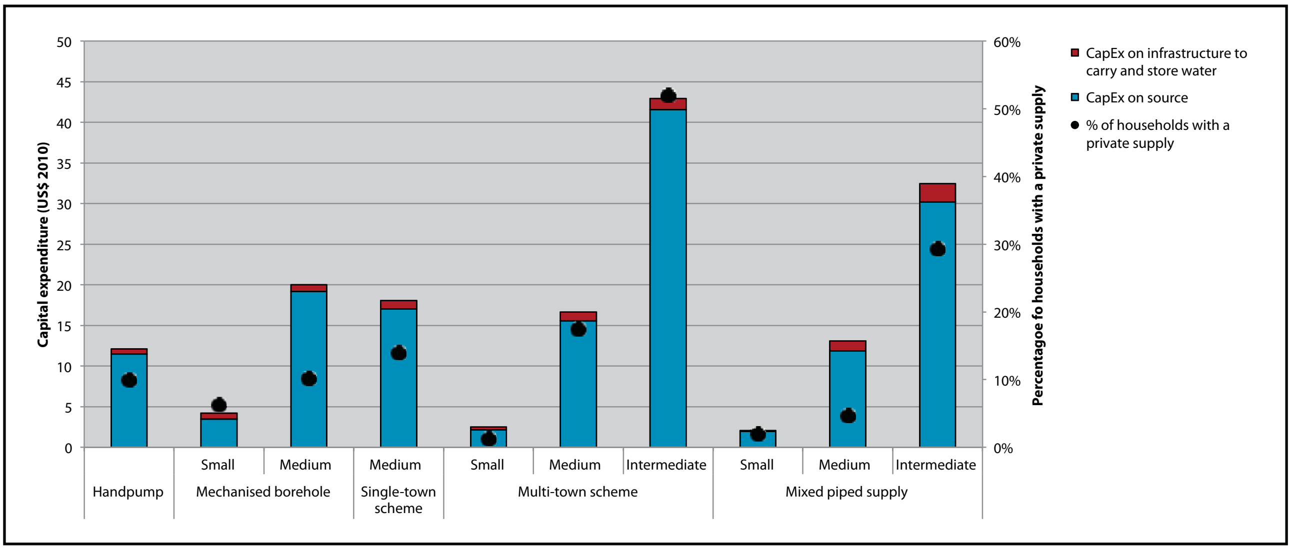


Table 9: **Household capital expenditure on self-supply**

Service delivery model	Community size	Nº of households sampled	Median annual household income	% of households who have a private supply	CapEx on source	CapEx on infrastructure to carry and store water
Handpump		482	982	10%	$ 11	$ 1
Mechanised borehole	Small	190	875	6%	$ 3	$ 1
	Medium	401	1142	10%	$ 19	$ 1
Single-village/town network	Medium	749	1247	14%	$ 17	$ 1
Multi - village/town network	Small	231	716	1%	$ 2	$ 0
	Medium	400	1312	18%	$ 16	$ 1
	Intermediate	50	1596	52%	$ 42	$ 1
Mixed piped supply	Small	50	831	2%	$ 2	$ 0
	Medium	2328	1312	5%	$ 12	$ 1
	Intermediate	150	1443	29%	$ 30	$ 2

3.2.3 Recurrent expenditure per service area

Recurrent expenditure is made up of day to day operating costs, such as salaries, electricity and routine maintenance (OpEx), as well as the cost of periodic major maintenance and renewal of the fixed asset base (CapManEx). Data collected under each of the identified delivery models in Andhra Pradesh is shown in Table 10. In many cases, data on recurrent expenditure was not available, with CapManEx being especially difficult to find.

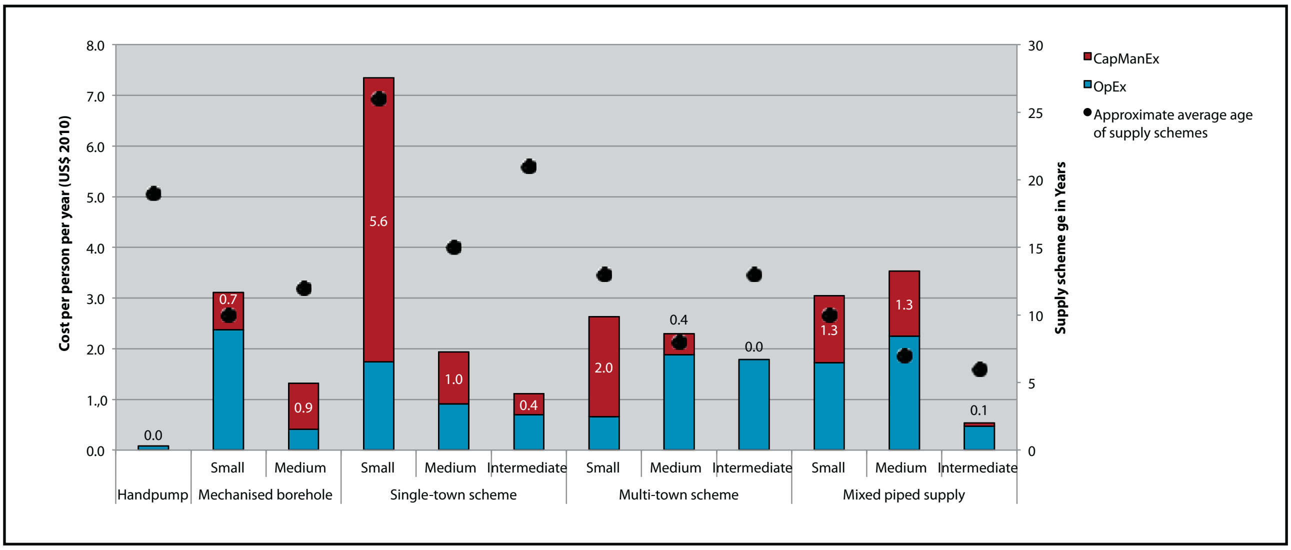
Table 10: **Mean annual recurrent maintenance expenditure per person per year on rural water systems in Andhra Pradesh (US$ 2010)**

Service delivery model	Service area size	Nº of service areas	Approximate mean system age	Operational expenditure (OpEx)		Capital maintenance expenditure (CapManEx)	
				% of service areas with data	Interquartile range	% of service areas with data	Interquartile range
Handpump		22	19	14	$ 0.0 - 0.0	0	$ 0.0 - 0.0
Mechanised borehole	Small	17	10	76	$ 0.4 - 3.4	29	$ 0.0 - 0.3
	Medium	17	12	94	$ 0.2 - 0.3	35	$ 0.0 - 1.2
Single-village/ town network	Small	2	26	100	$ 1.4 - 2.1	100	$ 4.9 - 6.5
	Medium	28	15	100	$ 0.5 - 1.5	57	$ 0.0 - 1.0
	Intermediate	3	21	100	$ 0.6 - 1.0	100	$ 0.1 - 0.2
Multi-village/ town network	Small	6	13	67	$ 0.1 - 1.1	17	$ 0.0 - 0.0
	Medium	11	8	91	$ 0.4 - 1.7	36	$ 0.0 - 0.6
	Intermediate	1	13	100	$ 1.8 - 1.8	0	$ 0.0 - 0.0
Mixed piped supply	Small	8	10	88	$ 0.3 - 1.4	38	$ 0.0 - 0.8
	Medium	66	7	94	$ 0.7 - 2.1	59	$ 0.0 - 0.5
	Intermediate	6	6	100	$ 0.2 - 0.6	50	$ 0.0- 0.1

Across all the piped networks, operational expenditure values were quite modest at between US$ 0.2 and US$ 2.1 per person. Operational expenditure on piped systems represents 1-6% of the initial capital outlay.

Only 3 of the 22 service areas which have only boreholes with handpumps reported operational expenditure, and none reported any capital maintenance expenditure. However, past expenditure on repairs or rehabilitation to some of the older assets is likely to have occurred without the data being recorded. As capital maintenance tends to occur at irregular intervals, variations in expenditure between different service models is much more pronounced than for OpEx, with higher capital maintenance expenditure reported in older systems. This is illustrated by the fact that small single-village/town networks, which are the oldest systems with an average age of more than 26 years, incurred the highest levels of capital maintenance expenditure at US$ 5.6 per person per year. However, this correlation between age of infrastructure and CapManEx expenditure is not evident for all service delivery models and it can be affected by a multitude of other influential factors. Across all delivery systems the typical annual capital maintenance expenditure per person is low, between US$ 0.3 and US$ 2.0. For many newer systems no expenditure at all has been recorded. It should be kept in mind that service interruptions and breakdowns are relatively common and that the actual expenditure on capital maintenance is not an indication of the most cost-effective level of expenditure.

Figure 5: Mean annual maintenance expenditure per person with approximate age of water delivery system



Household expenditure on operation and maintenance of private sources was very low in all service areas sampled with a typical expenditure of under US$ 0.1 per person per year. No information was collected on capital maintenance expenditure at household level.

3.3 Comparing expenditure and service levels in Andhra Pradesh

In Andhra Pradesh, household surveys were conducted in 103 of the 187 communities where research took place. A comparison of costs with service levels can be made based on this restricted number of communities[22].

3.3.1 Use of water sources in Andhra Pradesh

In many service areas with piped water networks, more than half of residents do not use the networked source for their drinking water and instead use boreholes and handpumps, community wells or other informal sources (Table 11). Their reasons for not using the piped water supply vary from community to community but include issues related directly to functionality, including the size and hydraulic capacity of the piped network (water pressure), the reliability of the electricity supply, security of the source and water quality as measured scientifically. There are also community-related issues such as the social status of the user[23], perceived (rather than actual) water quality and the availability of alternative sources or private water vendors (Fanaian and Ramachandrudu, 2011).

In larger single- and multi-village networks serving more than 500 people, use of the piped network for drinking water is greater, between 60% and 63%. The most common alternatives to piped sources were boreholes with handpumps. Across all piped service delivery models it was typical for 20-35% of families to use an alternative source as their main supply. Indeed, in a few cases the proportion of families not using the piped services was much higher – with up to 85% relying on boreholes with handpumps. Informal, unprotected sources and bought-in water also play an important role in rural water supplies, and are the primary source for around 15% of families in areas served by a piped scheme. Even the existence of multiple formal sources does not necessarily win the support of a majority of potential users; this partial rejection of the safe formal supply has consequences for the level of services delivered.

22 No cost versus service level information is available for small and intermediate-sized single-town schemes, as well as for small mixed piped supply scheme.

23 In some of the communities visited, certain groups were prohibited by social convention from using certain water points.

Table 11: An overview of primary drinking water sources accessed per type of supply

Service delivery model	Service area size	% of people using a piped source	% of people using a handpump or community well	% of people using an informal source/ buying water
Handpump		0%	98%	2%
Mechanised borehole	Small	44%	9%	46%
	Medium	32%	45%	23%
Single-village/town network	Medium	38%	33%	29%
Multi-village/town network	Small	15%	85%	0%
	Medium	61%	20%	19%
	Intermediate	60%	22%	18%
Mixed piped supply	Medium	63%	18%	19%
	Intermediate	61%	35%	3%

3.3.2 Water quantity, quality and reliability

The availability of multiple supply sources means that more than 98% of all sampled households received the basic water quantity standard of 20 litres per person per day from formal sources, with some households receiving considerably more. The sheer number of water points and infrastructure available in these communities means that access to formal sources was not a significant problem, either in terms of crowding or time for collection. In Andhra Pradesh, researchers measured the total time taken to complete a round trip to collection water, as the marker for access, and across all systems the average time to fetch water was just six minutes; corresponding to higher service level[24].

The two biggest factors precluding the delivery of water services that achieve basic satisfactory levels in Andhra Pradesh are water quality and service reliability. As stated, approximately a fifth of all residents access informal sources or buy water and are thus at risk of having low water quality, corresponding to "no improved service" on the WASHCost ladder.

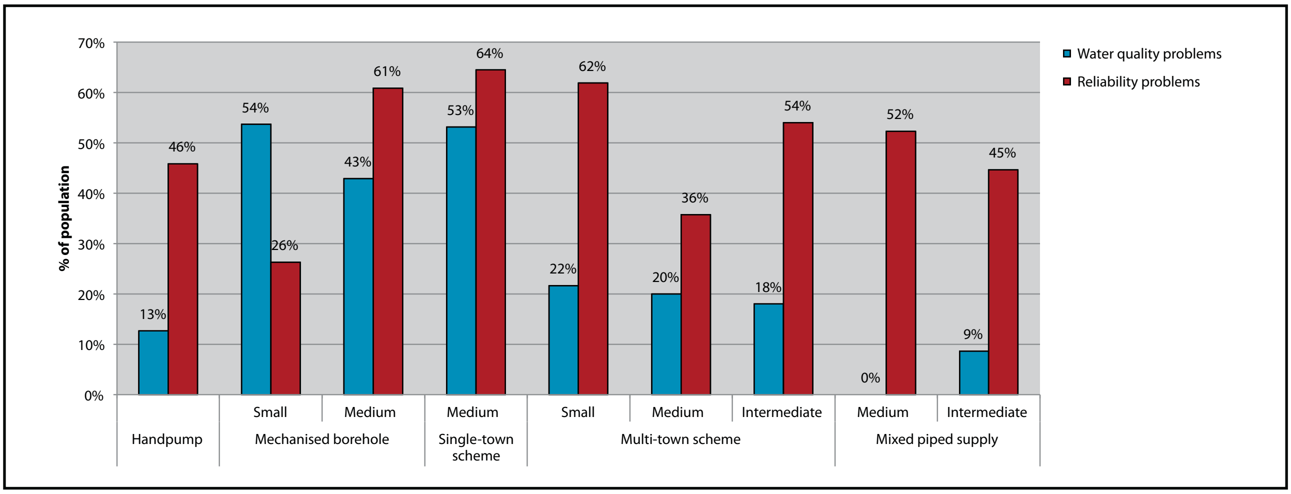
Data about water quality testing was not available for formal sources and water quality was determined through community perceptions, derived from focus group discussions. These responses were scored into five levels corresponding to the service ladder. As shown in Figure 6, water quality was found to be a particular problem for mechanised borehole networks and the medium-sized single-village/town networks, where 43-54% of residents reported high dissatisfaction with water quality.

Reliability was determined by the time that the primary drinking water source was non-functional; more than 12 days a year corresponds to a "sub-standard service" and more than 20 days to "no improved service". Under five of the nine service delivery models sampled, the primary drinking water supply for more than half of sampled residents suffered regular and/ or prolonged breakdowns of more than 12 days per year. Indeed under each service delivery model, at least 25% users did not achieve the criteria for basic service reliability, emphasising a serious obstacle to satisfactory service delivery throughout the state.

24 Only households fetching water from streams and canals spent more than 10 minutes per trip (16 minutes).

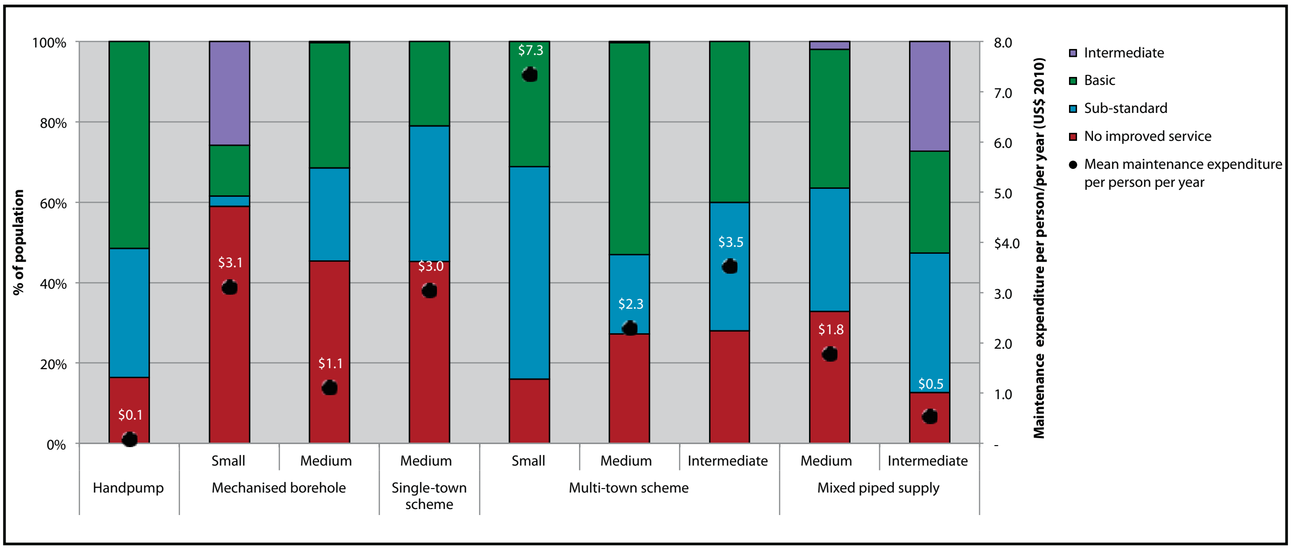
Despite these high levels of unreliability, the fact that households continue to access sufficient quantities of water highlights the resilience built into service due to the multiple point source supply options at the community and household level. This means that when one system breaks down there is usually an alternative still working. This sets service delivery in Andhra Pradesh apart from service levels in the African countries discussed in this paper.

Figure 6: Percentage of households receiving a sub-standard water service in terms of water quantity and service reliability



The majority of households do not receive a basic level of service in any of the service areas sampled in Andhra Pradesh (Figure 7). At this aggregated level it is apparent that no single water service delivery model is providing a significantly better or worse level of service than any other. No clear correlation can be drawn between expenditure on maintenance and improved service delivery, probably because expenditure on maintenance is extremely low.

Figure 7: Combined service level per service area - with total maintenance expenditure (US$ 2010)



3.4 Analysis per user per service delivery model

The previous section looked at the service levels in a service area; this section investigates the number of people using different service delivery models and the service levels they receive. This provides an understanding of what is being spent for users of formal sources under each service delivery model, as well as determining the level of service each model provides to users.

This analysis covers the 103 communities where detailed household surveys were carried out, and the costs and service levels delivered by different technologies correspond to the data from this smaller sample.

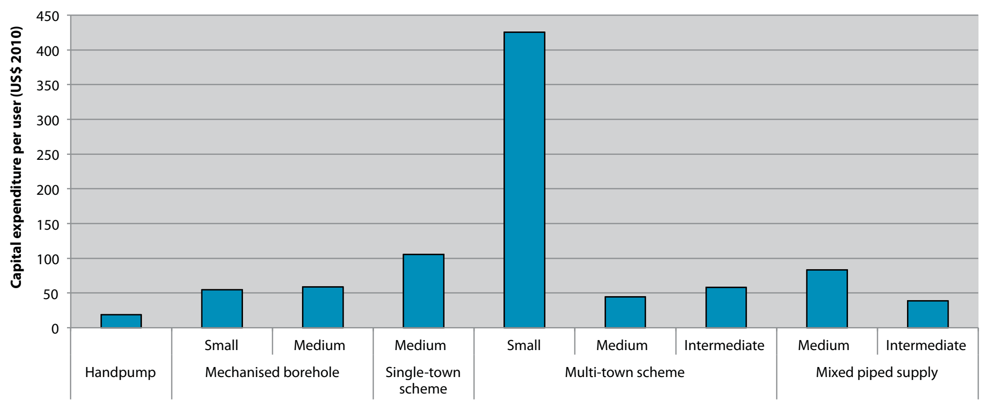
Table 12: Sample used for expenditure per service delivery model

Service delivery model	Service area size	Nº of service areas	Nº of users per system
Handpumps only		11	698
Mechanised borehole	Small	4	109
	Medium	8	489
Single-village/town network	Medium	14	523
Multi-village/town network	Small	5	44
	Medium	8	1,040
	Intermediate	1	3,140
Mixed piped supply	Medium	47	884
	Intermediate	3	4,217

As noted earlier, community residents use a number of sources, both piped and pumped and formal and informal for drinking purposes. Figure 8 demonstrates the capital costs of constructing each system relative to the number of people who actually use it.

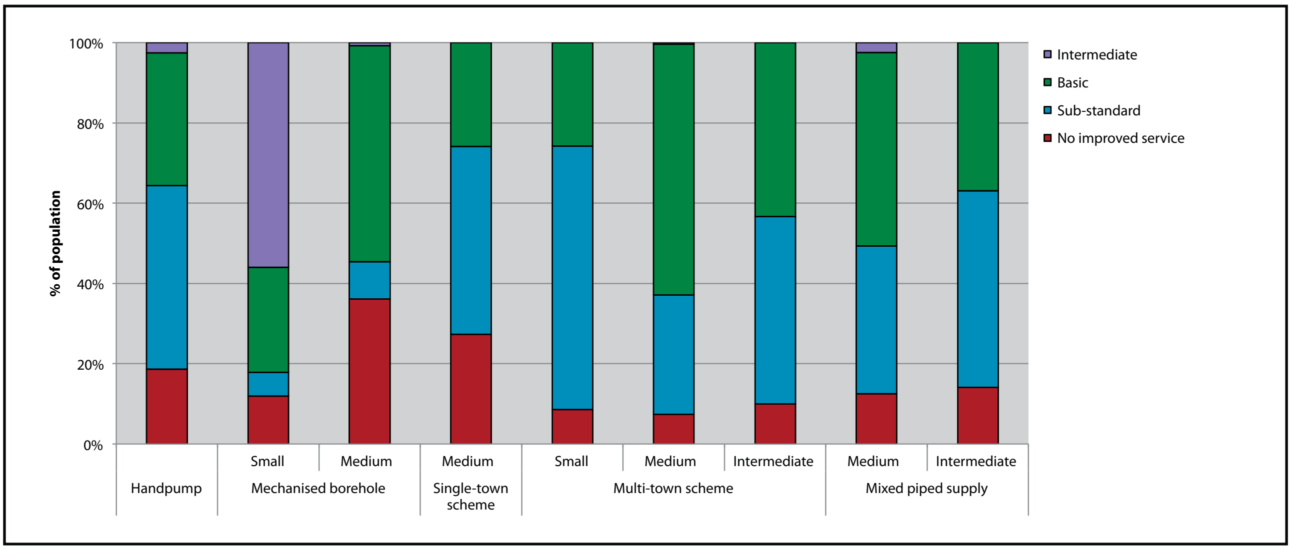
Low usage levels for some systems leads to very high per user expenditure. This is most notable in the case of small multi-village/town networks where just 15% of residents use the piped network sources leading to a per user expenditure of US$ 425. Other values range from a minimum of US$ 21 per user for borehole and handpump to US$ 106 per user for residents in single-village/town networks.

Figure 8: Capital expenditure per user (US$ 2010)



Although services levels do increase when the analysis is done per user (rather than per person), in only three cases do more than 50% of users receive a basic service: those using small and medium-sized mechanised borehole networks and those using medium-sized, multi-village/town network. The most effective model is that of small mechanised boreholes, which have high levels of reliability and are used by residents who tend to be satisfied with the water quality; with the result that 82% of their users receive a basic service. This serves to emphasise that a proliferation of water points does not necessarily correspond to high levels of service, especially when these water points break down on a regular basis. One conclusion that could be drawn from this analysis is that maintaining the functionality of key sources through effective source protection, an improved maintenance regime or rationalisation of existing infrastructure to retain only the most viable sources, is a critical factor to increase service levels. Sustaining a few well-maintained sources is more effective than providing many systems, all of which break down regularly.

Figure 9: Combined service levels per user



4 Burkina Faso

4.1 Water service delivery in Burkina Faso and study sample

There are two key service delivery models for rural water supply in Burkina Faso: boreholes fitted with handpumps and small piped mechanised borehole systems. Burkina Faso national norms state that each borehole with handpump should serve 300 people with 20 litres of water per day at a distance on no more than one kilometre (km) from the point source. Each public tap stand should serve 500 people with 20 litres of water per day at a distance of no more than one km. The reality of service delivery in rural communities is, however, more complex with residents using a mix of formal sources, alongside informal wells and surface water sources, to access water for different purposes at different times of the day.

In Burkina Faso, data was collected in nine rural and peri-urban[25] service areas spanning three regions: Centre, Haute-Bassins and Nord. Across the three regions, both rural water supply service models were costed. More than 2,500 household surveys were conducted across all nine service areas allowing for a comparison of expenditure and service levels (Table 13). The sample size and distribution were designed to illustrate the Burkina Faso context, but do not represent a statistically significant sample of the regional or national reality (Pezon and Bassono, 2012).

25 In WASHCost, peri-urban areas are defined as locations on the periphery or very close to urban areas, but are not directly served by (conventional) urban utilities.

Table 13: Study sample from Burkina Faso

Region	Nº of service areas	Nº schemes visited		Nº of household surveys
		Borehole and handpumps with valid expenditure data	Mechanised borehole networks with valid expenditure data	
Centre	3	21 (14)	1 (1)	487
Hauts-Bassins	3	16 (12)	2 (1)	1,579
Nord	3	22 (12)	2 (0)	980

4.2 Analysis of capital expenditure per user per service delivery model

4.2.1 Borehole and handpumps

Capital expenditure was collected for a total of 38 boreholes with handpumps. As shown in Figure 9, the mean capital expenditure ranged from a minimum of US$ 10,677 in Hauts-Bassins region to a maximum of US$ 13,588 in Nord region. The mean capital expenditure per borehole across all regions was US$ 12,507 with an interquartile range of US$ 10,717 to US$ 14,282. The mean borehole depth across all regions was found to be 60m giving an average borehole and handpump expenditure per metre of US$ 209.

Variations in expenditure between regions are not fully explained by the depth of the borehole, as the shallowest bore wells found in the Centre region are approximately a third more expensive than those in Hauts-Bassins. Within Hauts-Bassins the relationship between depth and expenditure can be clearly seen in Figure 10, although this correlation is not found elsewhere. This suggests that regionally specific factors other than depth play a factor in driving the cost of boreholes and handpumps. This chimes with similar findings from wide ranging studies by Carter and Rwamwanja (2006) that demonstrated that the cost of every borehole is unique, driven by: variations in the physical environment (e.g., [hydro]geology, climate); variations due to different actors involved in the process; ease of access and proximity to local manufacturers and practitioners; and variations in the materials used for construction.

Figure 10: Capital expenditure on boreholes with handpumps, with interquartile ranges (US$ 2010)

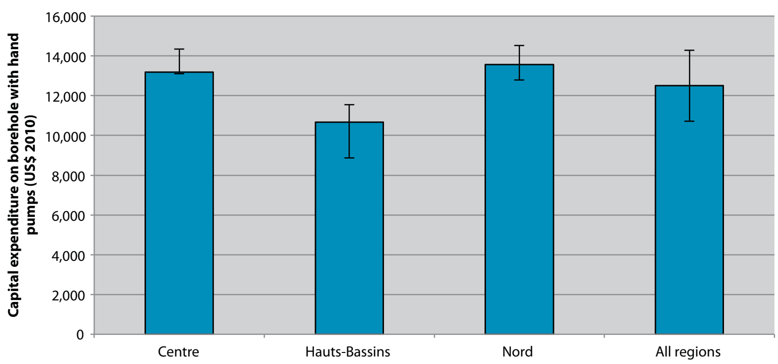
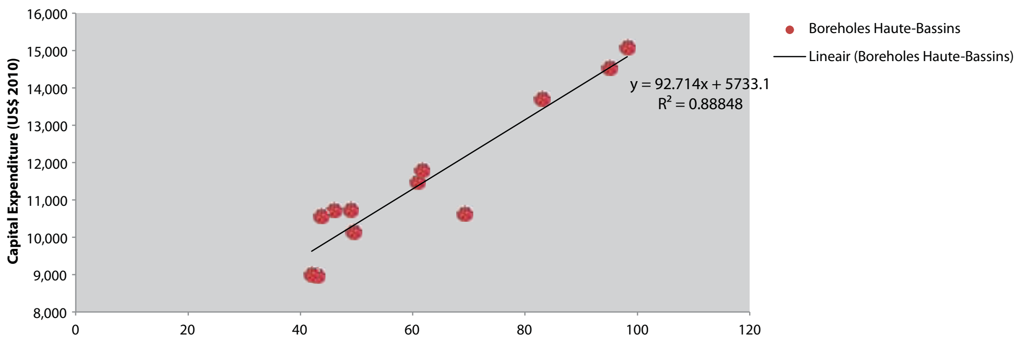


Figure 11: Scatter graph of borehole depth versus capital expenditure in Hauts-Bassins



The number of users per system varies between regions, with more than 300 users using each source in the Hauts-Bassins region, and fewer than 100 users in the Nord Region. As a consequence CapEx per user values rise sharply from US$ 31 in Hauts-Bassins to US$ 142 in Nord (Table 14).

Table 14: Capital expenditure per user of borehole with handpumps (US$ 2010)

Region	Nº of water points sampled	Average borehole depth	Nº of people served per borehole	Mean capital expenditure (US$ 2010)	Capital expenditure per user (US$ 2010)
Centre	14	53	152	$ 13,183	$ 87
Hauts-Bassins	12	62	342	$ 10,667	$ 31
Nord	12	64	95	$ 13,558	$ 142
All Regions	38	60	194	$ 12,507	$ 64

4.2.2 Small mechanised boreholes networks

Five small mechanised boreholes were visited during the sampling but only two—Dossi and Komsilga—had sufficient expenditure data for analysis. An overview of the characteristics of these two networks is displayed in Table 15. The Komsilga scheme was constructed in 2009 and has an extensive piped network of more than three kilometres connected to four public standposts (PSPs). In comparison, the Dossi network which is much older (constructed in 1997) has just two public standposts and ten private connections.

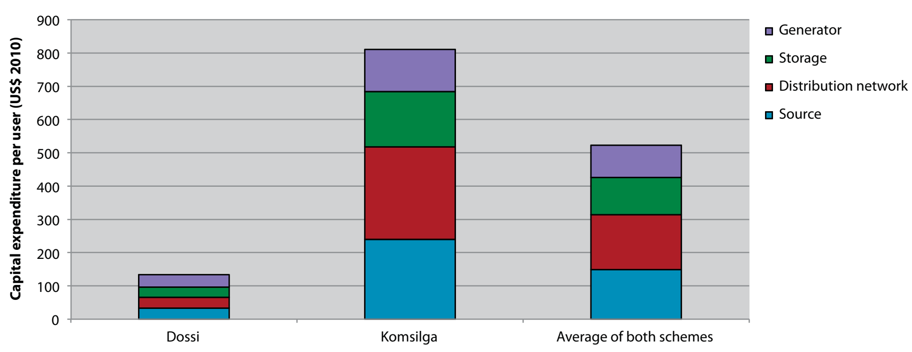
Both networks are serving significantly fewer people than their design capacity of 500 people per public standpost. Despite having a larger network and more point sources, just 216 people were found to be using the Komsilga network, equating to 54 users per public standpost. That compares with 255 total users in Dossi, or 127 users per public standpost.

Table 15: Details of small piped networks sampled in Burkina Faso

Details of the network	Dossi	Komsilga
Date of construction	1997	2009
Depth of borehole	49	70
Length of piped network (m)	212	3,523
Material of network	PVC	PVC
Storage capacity (m^3)	10	20
Nº of public standposts	2 (10 private connections)	4
Nº of users of the network	255	216

This underuse of formal sources has a significant impact on expenditure per user; capital expenditure per user is very high for Komsilga at US$ 810 per user, compared to US$ 134 per user in Dossi. This means that in this very small sample of two networks the combined per user expenditure is over US$ 500 per user. Although each system has different characteristics, roughly 25% of capital expenditure is spent on each of the following: developing the source, providing water storage, providing a generator and constructing the distribution network.

Figure 12: Disaggregated capital expenditure on small mechanised borehole networks (US$ 2010)



Expenditure per user on the small mechanised borehole systems is approximately nine times higher than the per user costs of boreholes with handpumps. The small sample size of the mechanised borehole networks means that this comparative difference may not hold true for the whole country.

Table 16: Comparison of capital expenditure per user per service delivery model (US$ 2010)

Service delivery model	Service area size	Capital expenditure per user US$ 2010
Borehole with handpump		$ 64
Mechanised borehole	Small	$ 513

4.3 Analysis of recurrent expenditure per user per service delivery model

4.3.1 Borehole with handpump

For most boreholes with handpumps, a 10-year record of operational expenditure was available. The typical expenditure for an individual borehole with handpump per year ranged from almost nothing to US$ 92, with annual expenditure on three-quarters (76%) of boreholes ranging from nothing to US$ 25. This translates into a per user annual expenditure of less than US$ 0.2 in the Centre and Nord regions, and an average across all networks of just US$ 0.1.

Table 17: Recurrent maintenance expenditure for boreholes with handpumps (US$ 2010)

Region	Operational expenditure		Capital maintenance expenditure	
	Nº with valid data	Mean expenditure per user per year	Nº with valid data	Mean expenditure per user per year
Centre	14	$ 0.2	3	$ 0.1
Hauts – Bassins	12	$ 0.0	7	$ 0.1
Nord	12	$ 0.2	0	-
All Regions	38	$ 0.1	10	$ 0.1

Information about capital maintenance expenditure was found for only 10 of the 33 boreholes sampled, all of which were constructed before the year 2000. The average age of those with data was 15 years, two of which had been rehabilitated on more than one occasion, some years apart. Each CapManEx episode cost between US$ 260 and US$ 2,205, with a mean of US$ 1,024. In some cases this rehabilitation covered the replacement of a handpump unit, and in other cases represented the replacement of handpump components, such as the foot valve. Although these figures vary considerably, the mean CapManEx of US$ 1,024 is just 8% of the mean construction cost of US$ 12,507.

Taking these CapManEx values over the age of the different service delivery models and the number of users they serve, the mean per person per year CapManEx for all of them combined is US$ 0.1 per person. In the sample area there were also eight systems constructed after 2008 that were not functioning at the time of data collection (2010) suggesting a potentially high attrition rate of handpump components or failure of the source. Either way, if these networks remain non-functional, they represent a high level of wasted investment in relatively new infrastructure, and threatens the delivery of basic services. This has implications for policy makers determining how to allocate money towards system rehabilitation (at a mean expenditure of US$ 1,024) or new construction (at a mean expenditure of US$ 12,507). It would require 12 episodes of average cost rehabilitation before expenditure reached the level of replacing the whole system, suggesting that rehabilitation is the more cost-effective option.

4.3.2 Small mechanised borehole networks

Operational expenditure for the two mechanised borehole networks was available for a single year and was calculated at US$ 24 per user in Dossi and US$ 45 per user in Komsilga, with a mean of US$ 33 for both systems combined. The purpose of the expenditure was not documented, but it is clear that the cost of operating these networks runs to many thousands of dollars per year; significantly more than the running costs of boreholes with handpumps. No capital maintenance expenditure had been recorded for either system.

Table 18: Recurrent maintenance expenditure for small mechanised borehole network (US$ 2010)

System	Operating expenditure	Capital maintenance expenditure
Dossi	$ 24	$ 0
Komsilga	$ 45	$ 0
Dossi and Komsilga combined	$ 33	$ 0

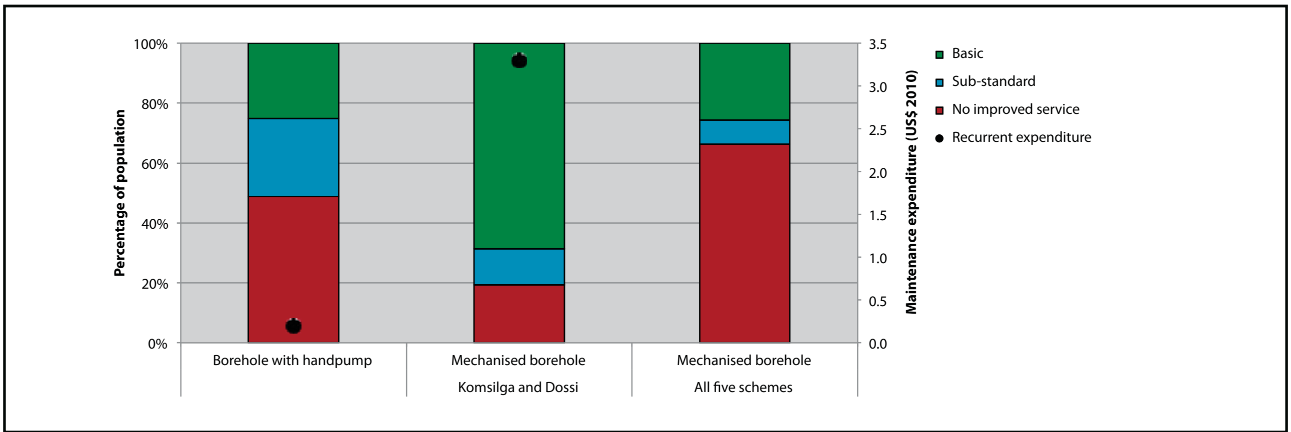
4.4 Comparing recurrent expenditure and service levels per service delivery model

This section compares the level of water services delivered by boreholes with handpumps and mechanised borehole networks with the recurrent expenditure for each system[26]. For comparison purposes, the service levels of all the mechanised borehole networks are also provided, although no expenditure data is available for these.

Mechanised borehole systems in Dossi and Komsilga deliver a basic service to 69% of their users compared to just 24% who receive a basic service under the borehole with handpump model. There are two main reasons for this difference. Firstly, the mechanised borehole systems deliver more water to users, an average of 48 litres per person per day (lpcd), so that 87% of users receive at least the basic amount of 20 lpcd. Boreholes with handpumps provide an average of 32 lpcd, and only 65% of users achieve the basic water quantity standard. Secondly, users in Dossi and Komsilga are typically 150m closer to water points and these tend to be less crowded.

However, the service level achieved by the two mechanised borehole systems is partly a consequence of them being underused, and may not be representative of the typical service levels delivered by such systems. Indeed, if all five sampled mechanised borehole systems are considered, including those where usage rates are higher, service levels are considerably lower[27]. An underused mechanised borehole network has a much higher percentage of users receiving a basic service, but far fewer users overall and therefore fewer satisfied customers, and recurrent expenditure that is more than 160 times higher (US$ 33.0 versus US$0.2) (Figure 13). The impact of this low use on overall service levels per person (rather than per user) is shown in section 4.5.

Figure 13: Combined service level with recurrent expenditure per person per year (US$ 2010)



4.5 Comparing recurrent expenditure and service levels per service area

This section compares expenditure and service levels for three communities: Yagma, which is served entirely by boreholes with handpumps, and Dossi and Komsilga where their respective piped networks do not extend beyond the higher density areas of each community, and the majority of residents rely on handpumps and unprotected wells. The formal service delivery model is therefore a blend of boreholes with handpumps and mechanised boreholes.

The capital expenditure and recurrent expenditure (OpEx and CapManEx) to deliver a service in these areas and a comparison of recurrent expenditure with service levels is shown in Table 19. This analysis shows that for this sample,

26 Recurrent costs here cover OpEx and CapManEx. Direct and indirect support costs are discussed in chapter 8.

27 WASHCost collected service level data on five mechanised borehole systems but was only able to find enough cost data for analysis on two of them, which is why the other three systems do not appear in most figures and discussions.

the CapEx on the mixed borehole and piped service delivery model is US$ 56 per person, roughly a third less than for services based exclusively on boreholes with handpumps (Yagma). In contrast, the annual burden of operational expenditure is much higher at US$ 3.3 per person for the piped network than for any sampled boreholes with handpumps supply.

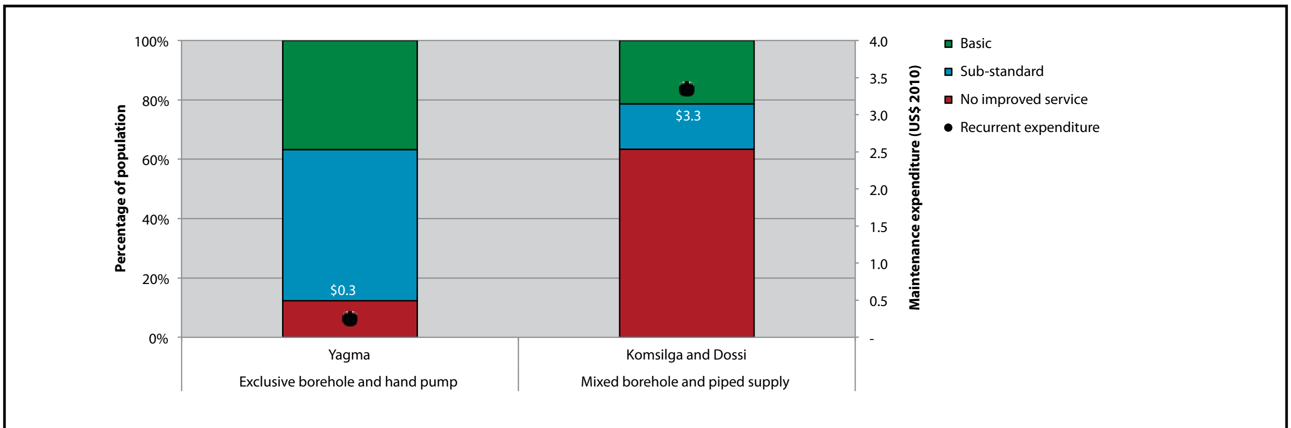
Table 19: **Capital and recurrent expenditure per service area (US$ 2010)**

Service Delivery Model	CapEx per person			OpEx per person per year			CapManEx per person per year		
	BH w/ HP*	Mech BH	Total	BH w/ HP	Mech BH	Total	BH w/ HP	Mech BH	Total
Mixed borehole and piped systems	$ 25.0	$ 31.0	$ 56.0	-	$ 3.3	$ 3.3	$ 0.1	-	$ 0.1
Exclusively boreholes with handpumps	$ 78.0	-	$ 78.0	$ 0.2	-	$ 0.2	-	-	-

*BH w/ HP – Boreholes with handpumps; Mech BH – Mechanised borehole

The combined service levels show that in each service area fewer than 40% of residents achieve a basic service level. Overall service levels are worse in Komsilga and Dossi where 46% of community members do not use a formal supply infrastructure at all, with just 9% using the piped sources and 44% using a borehole with handpump. This is the consequence of low-service use: the mechanised boreholes satisfy a relatively high percentage of their users, but a very low percentage of all those living in the area.

Figure 14: **Combined service level per service area, with recurrent maintenance expenditure per person per year (US$ 2010)**



5 Ghana

5.1 Water service delivery in Ghana and study sample

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 ongoing 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.

In Ghana, the sampling strategy focused on in-depth studies of rural point sources and small town community systems in three regions, encompassing three different hydro-geological zones. In total, 31 rural communities and four small towns were visited, and 1,273 household surveys were conducted (Table 20). Capital expenditure data was also gathered from the CWSA, specifically contract data on 1,591 boreholes with handpumps and financial records from a further 63 small town systems[28]. In each of the small towns, the number of users of formal sources was established, but not the number of people accessing informal sources. Therefore, for small town systems in this study all residents in the service area are assumed to use the formal piped service.

Table 20: Study sample in Ghana

Region	District	Nº of service areas visited		Nº of HH surveys	
		Rural villages	Small towns	Rural villages	Small towns
Ashanti	Bosomtwe	10	1	488	132
Northern	East Gonja	15	2	153	30
Volta	Ketu South	6	1	391	79
Other data sources	Contract data on 122 construction contracts for boreholes with handpumps and financial records from a further 63 small town systems.				

5.2 Capital expenditure per user per service delivery model

This section presents expenditure and service levels for boreholes with handpump, and for single and multi-town networks[29]. Expenditure data has been collated from field investigation and contract sources. Only a small number

28 Additional data was sought as it became evident that it would be difficult to collect by other means. As these water points and small towns were not part of the original sampling areas, service level data is not available for the areas covered by these systems.

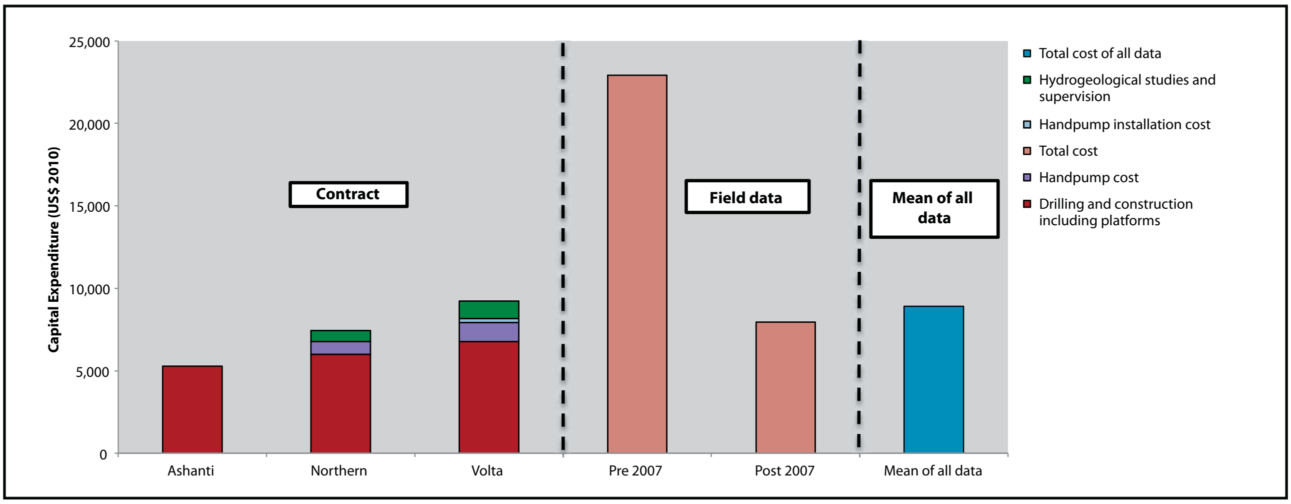
29 Household surveys did not capture residents' use of alternative sources for water. Therefore the comparisons of expenditure and services only covers the formal systems.

of small town areas have both expenditure and service level data and the expenditure versus service level analysis is restricted to this smaller sample.

5.2.1 Boreholes with handpumps

The primary source for capital expenditure was construction contracts from three regions: Ashanti, Volta and Northern. CapEx data was also collected for 15 boreholes with handpumps as part of field collection and these have been triangulated with the contract data. The comparison of these two data sets is shown in Figure 15. The analysis of cost data collected by the WASHCost team (field data) shows a significant distinction between those systems constructed before and after 2007. These periods have been presented separately.

Figure 15: Average capital expenditure on borehole and handpump (US$ 2010)



The mean capital expenditure on borehole and handpumps in the Volta region (VR) was US$ 9,222, some US$ 1,771 higher than those in the Northern region (NR) and more than US$ 1,200 higher than the average from field data collected on all boreholes and handpumps systems constructed after 2007. The main driver of CapEx was borehole drilling and development, accounting for 73% of expenditure in the Volta region and 80% in the Northern region[30] with expenditure on the handpump and supervision of the project each representing approximately 10% of the total per borehole.

In the Ashanti region, the mean capital expenditure on borehole drilling and platform construction was US$ 5,727, and is some US$ 300-1,000 lower than the equivalent expenditure in the other regions[31]. From the field data sample, there is evidence of a significant fall in the cost of boreholes with handpumps, with those constructed before 2007 costing approximately three times more than those constructed later. Taking the comparable values across all the data sets, the mean capital expenditure for a borehole and handpump is US$ 8,922.

Information on borehole depth was available for just over half the borehole contracts in the Ashanti region. The depth of these boreholes ranged between 31 and 74 metres, with a mean of 51 metres. Expenditure per metre of depth (excluding the handpump) is presented in Figure 16. From this sample, it is observed that the total expenditure on

30 Information concerning handpump installation is not specified in the northern region and it is likely that this was merged into the construction costs.

31 For further analysis on CapEx cost drivers in Ghana, refer to: Nkrumah, E. et al., 2011. *Drivers of capital expenditure of rural piped water systems in Ghana : the Volta , Ashanti and Northern regions. [ppt] In:* Rural Water Supply Network, 6th International Rural Water Supply Network Forum. Kampala, Uganda. Available at: <http://rwsnforum.files.wordpress.com/2011/11/presentation-16-3-bismark-dwumfour-asare.pdf> [Accessed 5 January 2013].

drilling and developing a borehole was US$ 102 per metre and that borehole drilling and lining the well constituted 54% of total capital expenditure (excluding the cost of the handpump).

Figure 16: Average disaggregated borehole drilling expenditure per metre depth (US$ 2010)

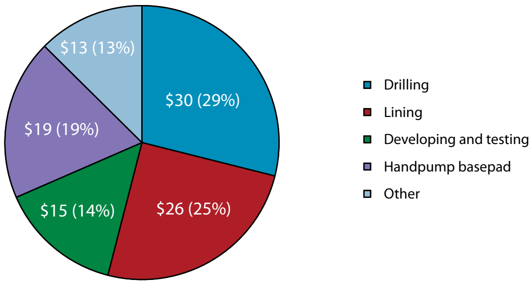


Table 21 shows that the average capital expenditure on all boreholes with handpumps found in the field data is more than twice as high as the costs indicated by the contracts. As we have seen, most of this difference is due to the much higher costs that were incurred on boreholes pre 2007. Table 21 also shows that the impact of overcrowding at water points is to reduce expenditure per user. Boreholes with handpumps in Ghana are designed to serve 300 people, at which theoretically, level of use expenditure per user would average US$ 30 per person. Since data reveals that each borehole with handpump is used by an average of 450 people, expenditure per user is reduced by more than a third, amounting to US$ 19 per user. However, overcrowding itself leads to a reduction in service levels, and lower expenditure per capita comes at a price.

Table 21: Capital Expenditure per user (per design and observed) for boreholes with handpumps (US$ 2010)

Area of study	Data type	Mean capital expenditure	Expenditure per user (design)	Expenditure per user (observed)
Ashanti region	Contract	$ 5,272	$ 18	$ 12
Northern region	Contract	$ 7,451	$ 25	$ 16
Volta region	Contract	$ 9,223	$ 31	$ 20
Field data	Field	$ 16,936	$ 56	$ 37
Mean of all data sets	Combined	$ 8,922	$ 30	$ 19

5.2.2 Single and multi-village/town networks

Capital expenditure data was collected and analysed for water systems serving 48 villages and towns. The most common systems are medium sized (serving between 500 and 5,000 people), but there are also large networks serving nearly 20,000 people. All sampled networks were constructed relatively recently and the mean ages ranged between four years for medium single-village/town networks to seven years for intermediate multi-village/town networks (Table 22).

Table 22: Piped water networks with capital expenditure data

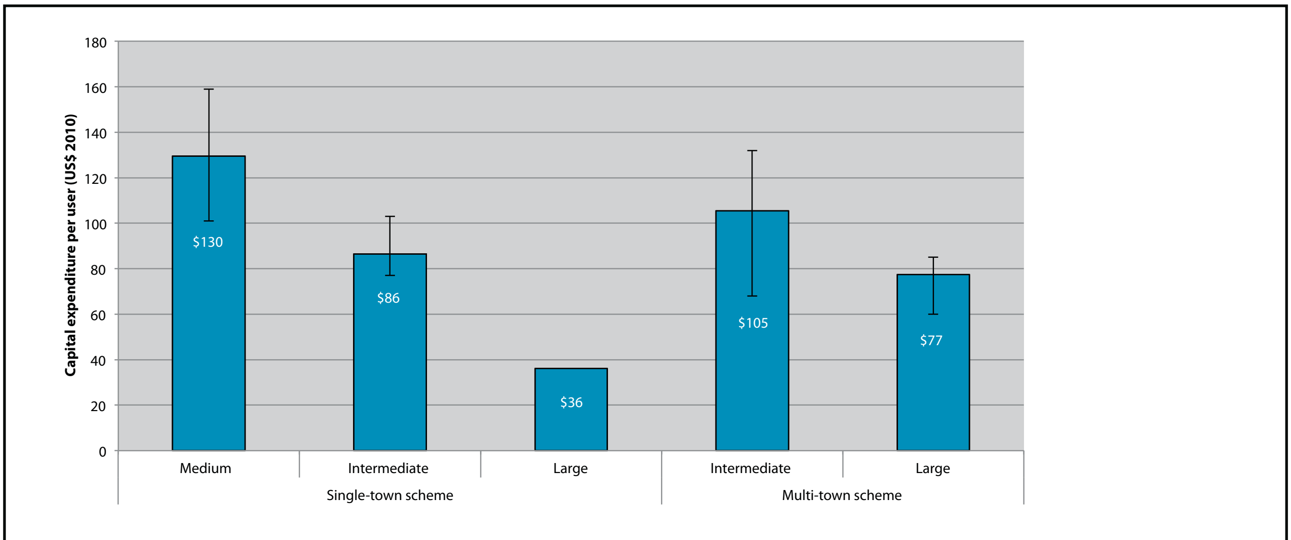
Service delivery model	Service area size	Nº of networks	Mean network age	Mean service area size
Single-town network	Medium	22	4	$ 3,204
	Intermediate	14	5	$ 7,243
	Large	1	4	$ 19,477
Multi-town network	Intermediate	9	7	$ 7,511
	Large	2	5	$ 19,820

Evidence of economies of scale can be seen in Figure 17. Capital expenditure per user decreases for single-village/town and multi-village/town networks as the size of the networks increase. The medium-sized, single-village/town systems were, on average, the most expensive to construct at US$ 130 per user (interquartile range US$ 101-159); a third more expensive than the US$ 86 (interquartile range US$ 77–103) spent on intermediate single-village/town systems.

The mean expenditure on the intermediate multi-village/town systems was US$ 105 (interquartile range US$ 68-132), 18% higher than the equivalent single-village/town system. Moreover, the large multi-village/town system at US$ 77 (interquartile range US$ 60-85) was more than twice the cost of the equivalent single-village/town system.

Although the sample size for large single-village/town systems and multi-village/town systems is small, indicative findings show that contrary to the situation in Andhra Pradesh, multi-village/town networks can be considerably more expensive to construct than single-village/town networks.

Figure 17: Capital expenditure per user on small-village/town piped networks, with interquartile ranges (US$ 2010)



5.2.3 Comparison of capital expenditure

Per user capital expenditure for boreholes with handpumps is shown to be well below expenditure per user for any of the piped supplies, in most cases four to five times less (Table 23). This suggests that transitioning from a handpump based service delivery model to a piped supply model[32] requires a five-fold increase in capital investment costs, from US$ 19 to US$ 97 per user.

Table 23: Comparison of the capital expenditure per user of different supply systems (US$ 2010)

Service delivery model	Service area size	Mean capital expenditure per user
Borehole and handpump		$ 19[33]
Single-village/town network	Medium	$ 130
	Intermediate	$ 86
	Large	$ 36
Multi-village/town network	Intermediate	$ 105
	Large	$ 77

5.3 Analysis of recurrent expenditure per user per service delivery model[34]

5.3.1 Boreholes with handpumps

Operational expenditure was gathered from field surveys and was only available for 47 boreholes with handpumps with 11 (23%) of these not incurring any annual expense. The maximum annual operating expenditure encountered for a single borehole was very high, at US$ 421. However, typical values were much lower with a mean expenditure of US$ 45 translating to just US$ 0.1 per user per year.

Capital maintenance had been carried out in 14 out of the 75 boreholes visited, but information on expenditure was only available for two. Both instances were related to the replacement of the handpump at a cost of US$ 800 each in 2005; a current 2010 value of US$ 1,649. The remaining 12 systems had also undergone handpump rehabilitation/replacement at different points in their service life, but expenditure data was not found. The age of these systems at the time of data collection ranged from 2 to 23 years, with a mean age of 11 years. If handpump replacement costs are typical (US$ 1,649), then using an estimated lifespan of 11 years, annual CapManEx can be estimated at roughly US$ 0.5 per user.

5.3.2 Single and multi-village/town networks

Recurrent expenditure on single and multi-village/town networks was only available for 8 of the 48 locations visited during primary data collection. This data was therefore augmented with information from 16 networks collected through specific research. The intermediate sized single-village/town systems incurred the highest annual operating expenditure, with an average of US$ 4.1 per user, more than twice the total for other single-village/town systems. For the four intermediate multi-village/town systems, operational expenditure per year varied considerably between a minimum of US$ 5,668 and a maximum of US$ 73,001, translating to a per user expenditure ranging between US$ 0.6 and US$ 11.1, and with a mean of US$ 3.8.

In none of the 24 networks did operating and minor maintenance expenditure fall below US$ 0.5 per user. The majority of systems incurred an annual operating expenditure of US$ 1-4, significantly higher than the expenditure found for boreholes with handpumps.

32 This refers to a piped supply predominantly through standpipes, with some household connections.

33 This is based on the capital expenditure per person according to the design population of each borehole. The data reflects the average value of all the contract and field data.

34 In this context, recurrent expenditure includes only operating and minor maintenance expenditure (OpEx) and capital maintenance (CapManEx). Expenditure on direct and indirect support is discussed in Chapter 8 of this paper.

Table 24: Operational expenditure on small-village/town networks (US$ 2010)

Service delivery model	Size of network	Nº	Annual OpEx				Annual OpEx per user			
			min	max	median	mean	min	max	median	mean
Single-village/ town network	Medium	4	$ 2,060	$ 14,788	$ 3,078	$ 5,760	$ 0.5	$ 3.9	$ 1.3	$ 1.8
	Intermediate	12	$ 4,625	$ 97,705	$ 26,312	$ 31,095	$ 0.6	$ 12.2	$ 3.7	$ 4.1
	Large	4	$ 12,315	$ 44,074	$ 21,919	$ 25,057	$ 0.7	$ 2.4	$ 1.2	$ 1.4
Multi-village/ town network	Intermediate	4	$ 5,668	$ 73,001	$ 32,768	$ 36,051	$ 0.6	$ 11.1	$ 2.7	$ 3.8

Mean capital maintenance expenditure on small-village/town networks is lower than operational expenditure, with the range over all systems falling between US$ 0.4 and US$ 1.5 per user per year. The mean age of each of system is under ten years. It is therefore reasonable to assume that the majority do not yet require significant capital maintenance. Nevertheless occurrences of some high expenditure—such as capital maintenance reaching US$ 8.4 per user for the five medium size small-village/town networks—suggest that premature breakdowns do happen, and when they do, the costs can be significant.

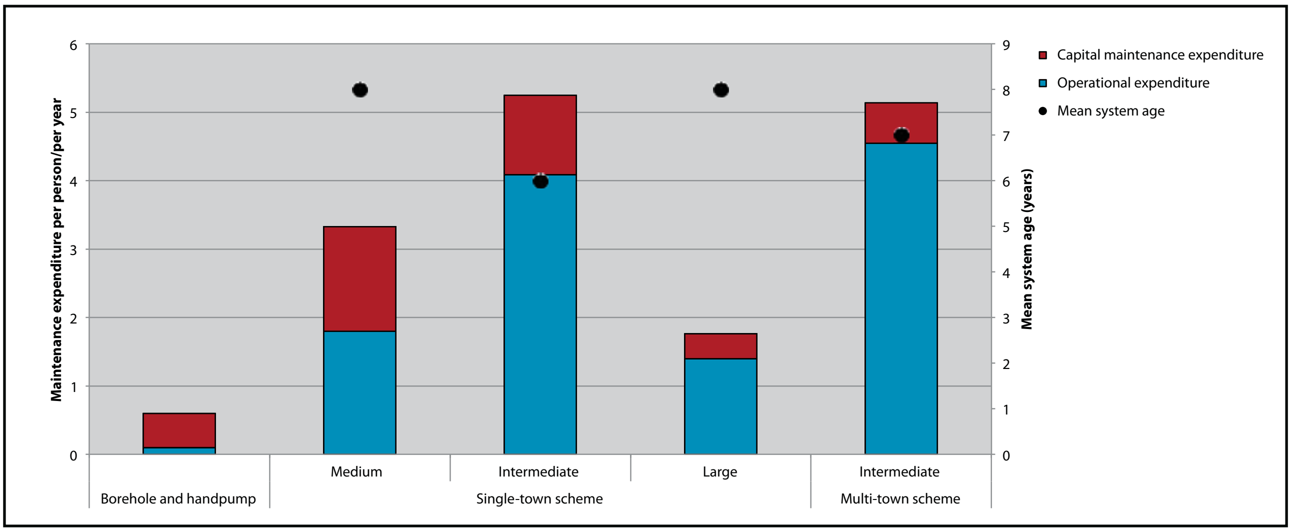
Table 25: Capital maintenance expenditure on small-village/town networks (US$ 2010)

Service delivery model	Size of network	Nº	Average annual CapManEx				Annual CapManEx per user			
			min	max	median	average	min	max	median	average
Single-village/ town network	Medium	5	$ 871	$ 16,381	$ 2,717	$ 5,070	$ 0.2	$ 8.4	$ 0.6	$ 1.5
	Intermediate	13	$ 78	$ 35,038	$ 9,079	$ 9,056	$ 0.0	$ 4.4	$ 1.1	$ 1.2
	Large	4	$ 2,562	$ 11,318	$ 5,917	$ 6,428	$ 0.2	$ 0.6	$ 0.3	$ 0.4
Multi-village/ town network	Intermediate	3	$ 333	$ 13,789	$ 3,354	$ 5,992	$ 0.0	$ 2.1	$ 0.3	$ 0.7

5.3.3 Comparison of recurrent expenditure

Both regular and occasional maintenance expenditure per user is found to be significantly higher in piped networks compared to a traditional borehole and handpump supply.

Figure 18: Comparison of operational and capital maintenance expenditure per user per year (US$ 2010)



5.4 Comparing capital and recurrent expenditure with service levels

Service level data was collected in five communities served by small-village/town systems and 31 rural communities served by boreholes with handpumps[35]. Table 26 illustrates some of the characteristics of the service delivered by these service models.

The majority of users receive a basic quantity of water from both these service models. Piped networks generally provide more water per user per day (36 lpcd), than boreholes with handpumps (24 lpcd), and larger networks provide a greater quantity than smaller ones. Water points are, on average, provided at an acceptable distance from users (i.e., less than 300m) under both service models. In small-village/town systems, water quality is tested annually and was found to be of acceptable quality in all cases. However, testing was not carried out in one fifth of the boreholes with handpumps, and as a result these systems were automatically classified as delivering a sub-standard service according to the WASHCost water service ladder[36].

The principal barrier to achieving a basic level of service is in the lack of sufficient functional water points to meet the service level norm of one source per 300 users. Indeed, for three out of the four service delivery models, more than 50% of users access an overcrowded source. Not only does this mean that users are much more likely to spend an unreasonable amount of time accessing water, but it may also make water points more susceptible to breakdown due to constant use. The only delivery model that does not experience overcrowded sources is the intermediate single-village/town network, and as a consequence, it achieves the highest service levels with 73% of the users attaining at least a basic level of service for all indicators. In contrast, more than two thirds of users in the rest of the sample receive either a "sub-standard" or a "no improved service" score (Figure 19).

35 This sample does not cover communities served by multi-town networks and a comparison of expenditure and service level cannot be done for this service delivery model.

36 Since 2010, IRC Ghana and IRC's Sustainable Services at Scale Project (Triple-S) have been working with district authorities on functionality testing and service level improvements under which water quality testing and functionality checks are given a higher priority and are included in budgets.

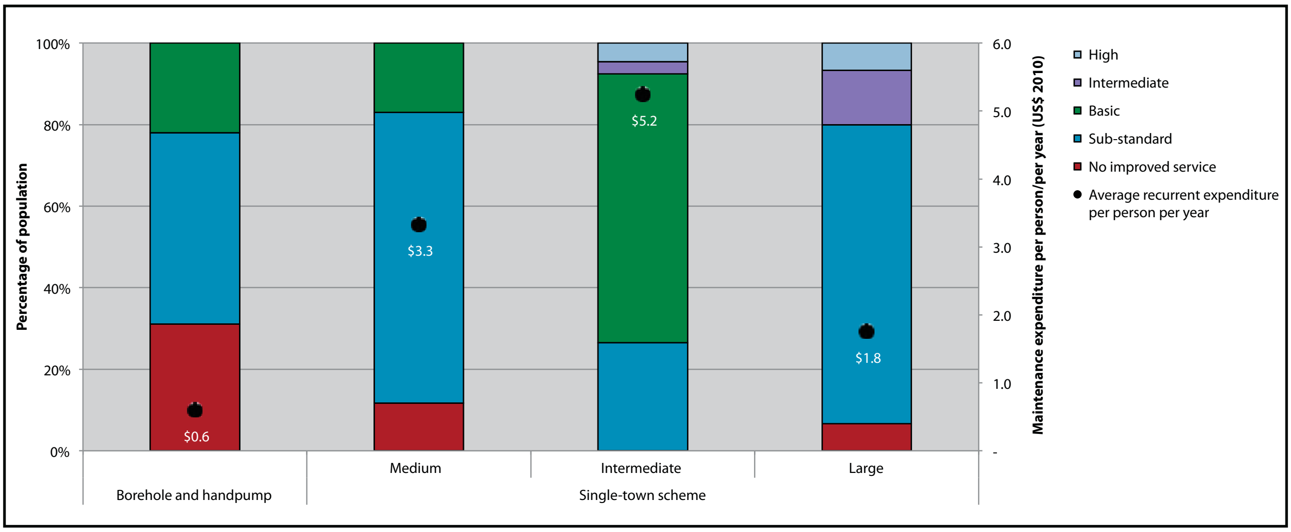
Table 26: Characteristics of a water service in sampled areas in Ghana

Service delivery model	Service area size	Nº service areas sampled	Mean water consumption (lpcd)	Mean distance to water point (m)	% of users receiving a basic water quality	% of users with a reliable source	% of users with a crowded source
Borehole and handpump		31	24	224	79%	92%	56%
Single-village/town systems	Medium	3	32	252	100%	100%	57%
	Intermediate	1	37	90	100%	100%	0%
	Large	1	39	286	100%	100%	80%
	All single-village/ town systems	5	35	166	100%	100%	27%

In contrast to what may be expected, piped networks do not necessarily provide a better overall service to users than the boreholes with handpumps. However, it is telling that while many piped systems primarily face problems with source crowding, boreholes with handpumps face additional problems of inadequate water quality testing, greater unreliability of supply with fewer users receiving an adequate quantity of water. As a consequence, the extra investment required, both in terms of capital and recurrent expenditure, to achieve a basic level of service for communities served by borehole and handpumps is likely to be greater than for small piped networks.

In summary, data from Ghana shows that it may be reasonably assumed that a five-fold increase in capital investment expenditure (from US$19 to US$97 per user) to transition from boreholes with handpumps to a piped supply is likely to result in doubling the number of consumers receiving a basic service.

Figure 19: Combined service level per service area, with total maintenance expenditure per person per year (US$ 2010)



5.5 Relationship between direct support and service levels

In Ghana, expenditure on direct support was collected from District Water and Sanitation Teams (DWST) tasked with monitoring the functionality of water services, as well as from the Community Water and Sanitation Agency (CWSA), in charge of supporting both district and community service delivery.

Expenditure by CWSA to support service delivery was determined as a single figure for all rural and small town areas at US$ 0.37 per person per year. Expenditure by water and sanitation teams did vary from district to district from a minimum of US$ 0.07 per person per year in East Gonja district (Volta region) to a maximum of US$ 0.24 in Bosomtwe district (Northern region). When added together, the combined average of the CWSA and water and sanitation team values is US$ 0.47 per person per year. A general comparison of service levels achieved per district and the expenditure on direct support suggests a link between higher expenditure and higher service levels (Table 27). However at this level of aggregation it is not possible to explain these interactions further.

Table 27: Expenditure on direct support in Ghana (US$ 2010)[37]

Region	District	% of users achieving a basic service	Expenditure on direct support		
			CWSA	DWST	Total
Ashanti	Bosomtwe	41%	$ 0.37	$ 0.24	$ 0.61
Northern	East Gonja	10%	$ 0.37	$ 0.07	$ 0.44
Volta	Ketu South	14%	$ 0.37	$ 0.15	$ 0.52

6 Mozambique

6.1 Water service delivery in Mozambique and study sample

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 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. 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 tariffs.

Data on water points and households was collected in six out of the ten regions of Mozambique. The sampling methodology[38] 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.

In addition, through close collaboration with DNA, more than 300 governmental contracts on the construction and rehabilitation of boreholes with handpumps were sourced from the National Information System for Water and Sanitation (SINAS) database. Specific enquiries outside the six main study regions provided additional expenditure data for single-village/town networks. A summary of the data sample for this study is shown in Table 28.

37 Further details on expenditure for direct support in Ghana and other countries are explained in: Smits, S., et al., 2011. *Arrangements and cost of providing support to rural water service.* (WASHCost Working Paper 5) [online] The Hague: IRC International Water and Sanitation Centre. Available at: <http://www.washcost.info/page/1567> [Accessed 15 December 2012]. Also see: Smits, S., 2012. *Direct support post-construction to rural water service providers.* (Triple-S Briefing Note 6) [online] The Hague: IRC International Water and Sanitation Centre. Available at: <http://www.waterservicesthatlast.org/Media/Files/Direct-support-post-construction> [Accessed 10 January 2013].

38 A detailed overview of this methodology can be found in: WASHCost Mozambique, 2010. *Sampling methodology Mozambique: using the MICS as base for WASHCost.* [online] Maputo: WASHCost Mozambique. Available at: <http://www.washcost.info/media/files/washcost_moz_sampling_methodology> [Accessed 20 November 2012].

Table 28: Study sample in Mozambique

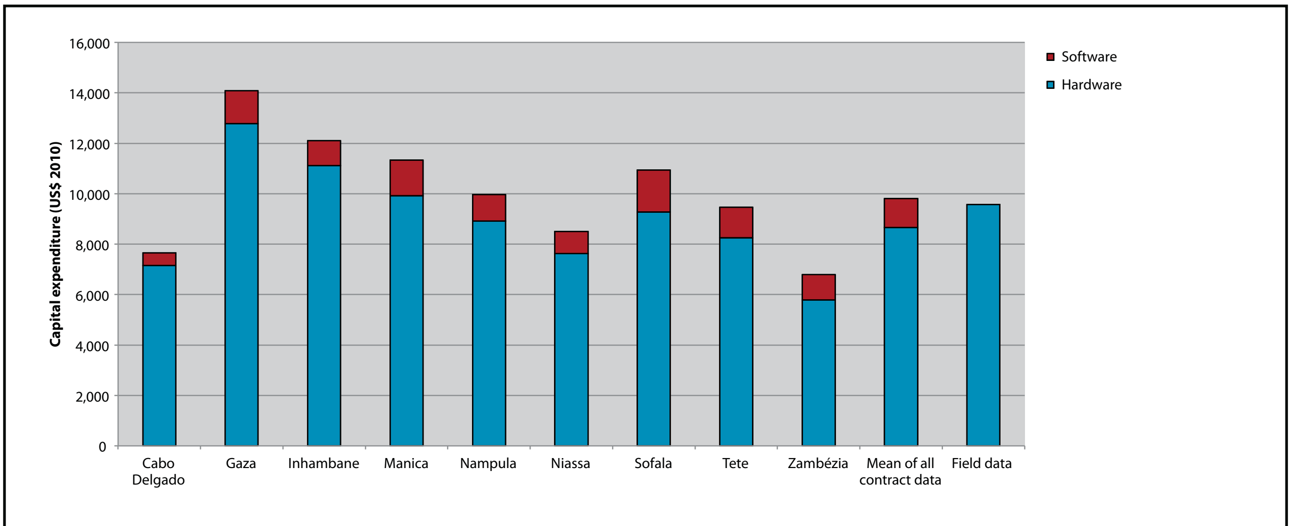
Region	Nº of water points visited (with valid expenditure data)		Nº of household surveys
	Boreholes with handpumps	Single-village/town networks	
Cabo Delgado	17 (4)	4 (3)	230
Inhambane	22 (10)	4 (1)	180
Manica	15 (9)		210
Maputo	1 (1)	4 (3)	
Nampula	25 (19)	5 (4)	192
Tete	11 (9)	2 (2)	198
Other data sources	352 contracts from across the country for boreholes with handpumps (154 relating to capital expenditure hardware, 82 for capital maintenance, and 116 for capital expenditure software).		
	Expenditure data from three single-village/town networks collected outside the primary study area in the Gaza and Sofala regions.		

6.2 Capital expenditure per service area

6.2.1 Boreholes with handpumps

The primary source of capital expenditure data is based on the analysis of national contract records sourced from SINAS. The SINAS database details both hardware and software expenditure for more than 4,000 boreholes, taken from 270 contracts. The WASHCost field sample yielded only four valid capital expenditure data points for boreholes with handpumps. An overview of the regional breakdown of capital expenditure is shown in Figure 20.

Figure 20: Mean capital expenditure on borehole and handpumps (US$ 2010)



The hardware costs of installing a borehole with a handpump vary across the regions of Mozambique from a minimum of US$ 5,788 in Zambézia to a maximum of more than twice that sum at US 12,779 in Gaza, although the majority (65%) of values fall between US$ 7,000 and US$ 10,500 per borehole. Mean CapEx across all the contracts was US$ 8,660, slightly lower than the US$ 9,575 recorded from boreholes sampled in the field.

Capital software expenditure varied from a minimum of US$ 500 in Cabo Delgado region to a maximum of US$ 1,664 in Sofala, constituting between 7% and 17% of the hardware expenditure, with a mean for all systems of US$ 1,145. The combined capital expenditure on hardware and software is US$ 9,805 for a borehole with handpump. Assuming each borehole serves an average of 300 people, this gives a per user cost of US$ 33.

An analysis of figures from a 2006 assessment of the average depth of boreholes per region (WSP/ DNA 2006) shows an indicative link between borehole depths and capital hardware expenditure (Table 29). The most expensive boreholes with handpumps were in the Gaza region, which also has the deepest boreholes in the country at 55m. Conversely, the cheapest boreholes in the Zambézia region are also the shallowest at 31m. Across all regions the expenditure per metre depth of borehole ranges from US$ 187 to a maximum of US$ 266; the mean value for all regions is US$ 211. These findings are based on regional average depth figures and are not directly related to the boreholes in the contracts and field data. Therefore, they can only be considered indicative findings.

Table 29: **Mean capital expenditure hardware compared with average borehole depths (US$ 2010)**

Region	Mean CapEx hardware per borehole	Mean borehole depth (metres)	Expenditure per metre depth
Cabo Delgado	$ 7,155	37	$ 193
Gaza	$ 12,779	55	$ 232
Inhambane	$ 11,119	54	$ 206
Manica	$ 9,927	41	$ 242
Nampula	$ 8,913	40	$ 223
Niassa	$ 7,624	38	$ 201
Sofala	$ 9,272	43	$ 216
Tete	$ 8,252	31	$ 266
Zambézia	$ 5,788	31	$ 187
All together	$ 8,660	41	$ 211

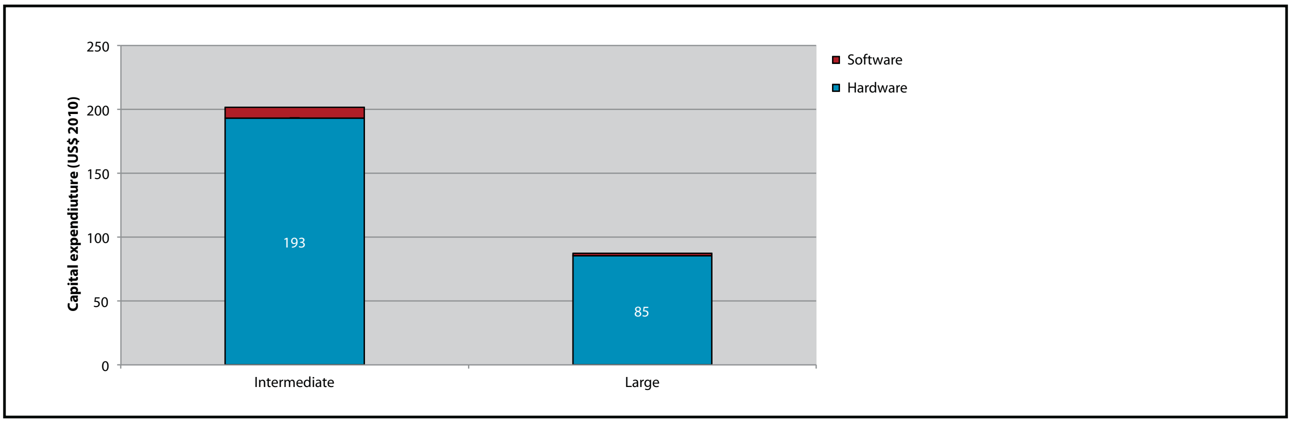
6.2.2 Single-village/town networks

From the ten valid capital expenditure values collected for single-village/town systems, nine relate to intermediate networks serving between 5,000 and 15,000 people, and the other to a large network serving just over 17,000 people. The capital hardware and software expenditure on these networks is shown in Figure 21.

The mean capital expenditure on intermediate networks is US$ 193 per person, more than double the per person cost of the single large network with a CapEx of US$ 85 per person. It is noteworthy, however, that the CapEx values from the nine intermediate networks varied sharply from a minimum of US$ 30 per person to a maximum of US$ 380 per person, meaning that intermediate networks are not always more costly than larger equivalents.

Mean capital expenditure for software was US$ 8 per user for intermediate networks (4% of the hardware expenditure) compared to US$ 2 per user for the larger network (2% of hardware expenditure).

Figure 21: Mean capital expenditure per person in small-village/town piped networks, with interquartile ranges (US$ 2010)



6.2.3 Comparison of capital expenditure on boreholes with handpumps and single-village/town systems

The average CapEx for borehole and handpump systems is one sixth of that for intermediate piped networks, and approximately a third of that for the large piped network. This emphasises the significant expenditure that would be required to make the transition to more technically advanced piped networks.

Table 30: Comparison of the capital expenditure per user of different supply systems (US$ 2010)

Service delivery systems	Service area size	Hardware per user	Software per user	Total per person
Borehole and Handpump		$ 29	$ 4	$ 33
Single-village/town network	Intermediate	$ 193	$ 8	$ 202
	Large	$ 85	$ 2	$ 87

6.3 Recurrent expenditure[39] per service area

6.3.1 Boreholes with handpumps

Operational expenditure data was collected from the WASHCost sample for 50 boreholes with handpumps across the five regions. At current costs, the annual OpEx for individual systems had an interquartile range of US$ 11 to US$ 47 with a mean of US$ 35. Only two systems had not incurred any annual operational expenditure. These figures translate to a mean OpEx for each system of US$ 0.1 per person per year, with only very minor regional variations. This suggests that minor OpEx is systematically undertaken in rural regions of Mozambique.

Field teams were unable to collect capital maintenance expenditure for many boreholes with handpumps. This data was therefore gathered from a total of 58 capital maintenance contracts detailing the rehabilitation expenditure on 765 individual boreholes and handpumps across the country between 2006 and 2011. The mean expenditure per rehabilitation was US$ 1,885, although values varied widely from a minimum of US$ 478 to a maximum of US$ 9,871. Regional variations were also notable with the highest expenditure in the coastal regional of Inhambane, Sofala and Zambézia, and the lowest in the inland areas of Tete and Niassa.

39 Recurrent expenditure includes only operating and minor maintenance expenditure (OpEx) and capital maintenance (CapManEx). Expenditure on direct and indirect support is discussed in chapter 8 of this paper.

Table 31: Capital maintenance expenditure per region (US$ 2010)

Region	Nº of contracts	Mean capital maintenance expenditure
Cabo Delgado	3	$ 1,413
Gaza	17	$ 1,700
Inhambane	7	$ 2,992
Manica	9	$ 1,368
Nampula	4	$ 1,908
Niassa	1	$ 989
Sofala	6	$ 2,473
Tete	4	$ 606
Zambézia	7	$ 2,440

Evidence from a compilation of contract sources suggests that approximately 3.6% of boreholes nationwide undergo significant rehabilitation every year. In this sample the average age of each borehole at the point of rehabilitation was seven years[40]. This provides an indicative annual CapManEx value of US$ 9.6 per year or a seemingly insignificant US$ 0.03 per person per year.

6.3.2 Single-village/town systems

Operational expenditure on piped systems was available for just three systems – two intermediate sized and one large. The annual expenditure on the two intermediate sized systems was US$ 2.6 per person and US$ 5.4 per person (mean US$ 3.6). The most significant OpEx components were the fixed expenditure on salaries, rents and associated taxes representing between 64% and 77% of total annual operational expenditure with only a small percentage (<4%) being spent on replacement materials (Table 32). Annual operational expenditure on the larger network was of a similar magnitude at US$ 4.8 per person and, contrary to the findings from other countries, there was no evidence of any economies of scale. This suggests that the fixed costs and certain variable costs such as electricity bills are the only costs that are being met to maintain a bare minimum of services. Spending such a small proportion of operational expenditure on materials for repairs suggests that system leakages are not being adequately prioritised.

Table 32: Operating expenditure on small-village/town piped networks (US$ 2010)

Size of system	System name	People served	Annual OpEx per person	Salary	Electricity	Materials	Admin	Transport	Treatment	Tax, rent etc.
Intermediate	Quissico	5,830	$ 5.4	41%	27%	4%	4%	1%	0%	23%
	Nametil	10,275	$ 2.6	67%	12%	0%	4%	6%	Neg.	11%
Large	Vilanculos	39,458	$ 4.8	NA	NA	NA	NA	NA	NA	NA

No valid capital maintenance was available for any of the single-village/town networks, and the values remain unknown.

40 This does not imply that each borehole suffers a major breakdown every seven years, these can happen much sooner; the figures relate to the frequency of rehabilitation work actually undertaken.

6.4 Comparing expenditure and service levels in Mozambique

6.4.1 Service level and expenditure per area

Of the 1010 surveys undertaken, 816 households were in service areas served by boreholes and handpumps, and 196 households were served by medium and intermediate sized single-village/town systems[41]. From these surveys it is clear that, despite the existence of formal sources, in many areas they are not being used by residents to access drinking water (Table 33).

Table 33: Number of users of different water sources

Service delivery systems	Service area size	% of population using boreholes with handpumps	% of population using single-village/town networks	% of population using informal sources
Borehole and handpump		61%	0%	39%
Single-village/town network	Medium	17%	41%	42%
	Intermediate	0%	82%	18%
	Unknown size	0%	100%	0%

Those using informal sources tend to access less water than those using formal sources. This contributes to over 70% of residents not receiving a basic 20 lpcd quantity of water from either boreholes with handpumps, or from medium and intermediate piped systems (Table 34).

Table 34: Quantity of water received (litres per person, per day)

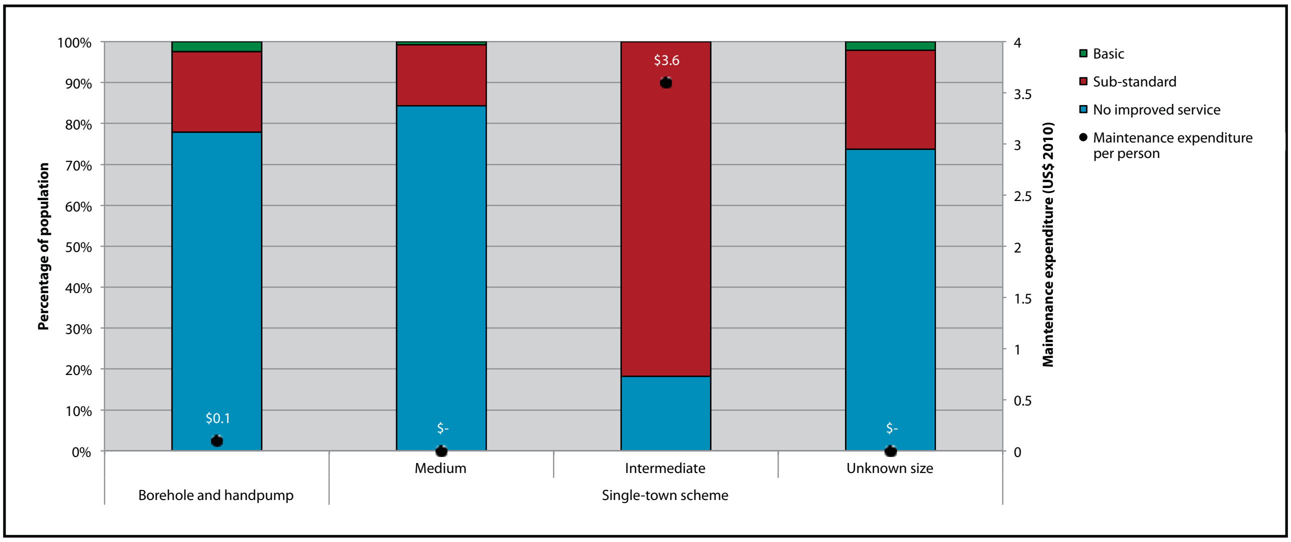
Service delivery systems	Service area size	Water quantity (lpcd)	% of population receiving a water quantity of 20 lpcd
Boreholes with handpumps		12	22%
Single-village/town network	Medium	12	23%
	Intermediate	18	32%
	Unknown size	38	88%

The use of alternative sources clearly has a major impact on the service levels achieved in a particular service area. The combined service level—incorporating indicators on water quantity, quality, accessibility and reliability—reflects this, showing that only 2% of those drawing their water from boreholes with handpumps or from single-village/town piped service models (Figure 22) receive a basic water service.

Because the majority of sources in the sample have not had their water tested for quality, in the absence of evidence, the water sources are classified as having a sub-standard quality. This is explored further in the following section. For a service area analysis, it is not surprising that the almost non-existent expenditure on maintenance per person appears to bear no relation to service levels achieved (Figure 23).

41 Service level data is not available for large single-town systems.

Figure 22: Combined service level per person with total maintenance expenditure per person per year (US$ 2010)

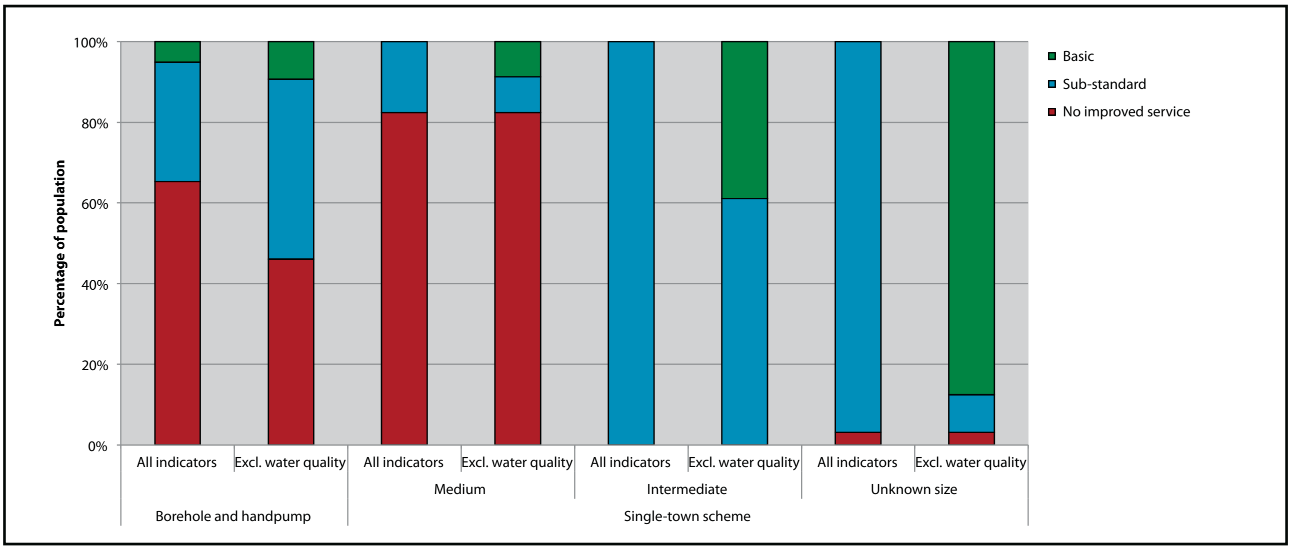


6.4.2 Service level per user per service delivery model

In order to understand the service delivery effectiveness of different delivery models, it is useful to focus on the services received by those using formal sources only. This section collates service level data collected for 664 households using boreholes with handpumps for drinking water, and 107 households using single-village/town networks.

This analysis focuses primarily on the service delivery model, and the overall service level achieved in this sample is still very low, primarily due to the lack of water quality testing. When this indicator is discounted, service levels for some of the small piped networks improve dramatically to as high as 87% of users having a basic service. Taking all the small-village/town models together the percentage of users receiving a basic service from this delivery model rises to 37%. The service level increase for the boreholes with handpumps systems is less pronounced in an analysis per delivery model, as users of these systems have difficulty in accessing sufficient water and the resulting average amount received is still below the basic 20 litres at 18 lpcd (Figure 23).

Figure 23: Combined service level per user both including and excluding the water quality indicator



For small-village/town systems, no direct relationship can be drawn between recurrent expenditure and service levels because the data required for this analysis was only available for the intermediate sized systems. However, for boreholes with handpumps, comparisons can be made between operational expenditure and system reliability. According to the WASHCost service ladder, a basic level of reliability is determined by the supply infrastructure being functional for at least 95% of the year and, as shown in Table 35, the most reliable boreholes were found to be those where between US$ 5 and US$ 100 is spent maintaining the boreholes every year. Poor reliability was found to be most problematic for systems where expenditure is very low (<US$ 5) or very high (>US$ 100). This suggests that basic maintenance of these systems is important and has a positive effect on infrastructure reliability. The link between very high expenditure and unreliability suggests that some boreholes are problematic and demand high levels of expenditure and yet still fail regularly.

Table 35: **Boreholes with handpumps: annual operational expenditure compared with reliability (US$ 2010)**

Annual OpEx per borehole with handpump	Reliability service level (percentage of users)	
	Basic service	No service improvement
Less than $5	65%	35%
Between $5 and $20	92%	8%
Between $20 and $50	98%	2%
Between $50 and $100	100%	0%
Greater than $100	73%	27%

7 Water supply expenditure and service levels across the four countries

This chapter highlights some of the findings which can be made across the four countries. It brings together the capital and recurrent expenditure for the most comparable data in Andhra Pradesh, Burkina Faso, Ghana and Mozambique. Although sample sizes are very different for each of the countries as described previously in chapter 2, and findings are context-specific as described in the country sections, we can compare some of the expenditure data and service levels for boreholes with handpumps and for service areas with piped schemes (small/ medium and intermediate/ high population).

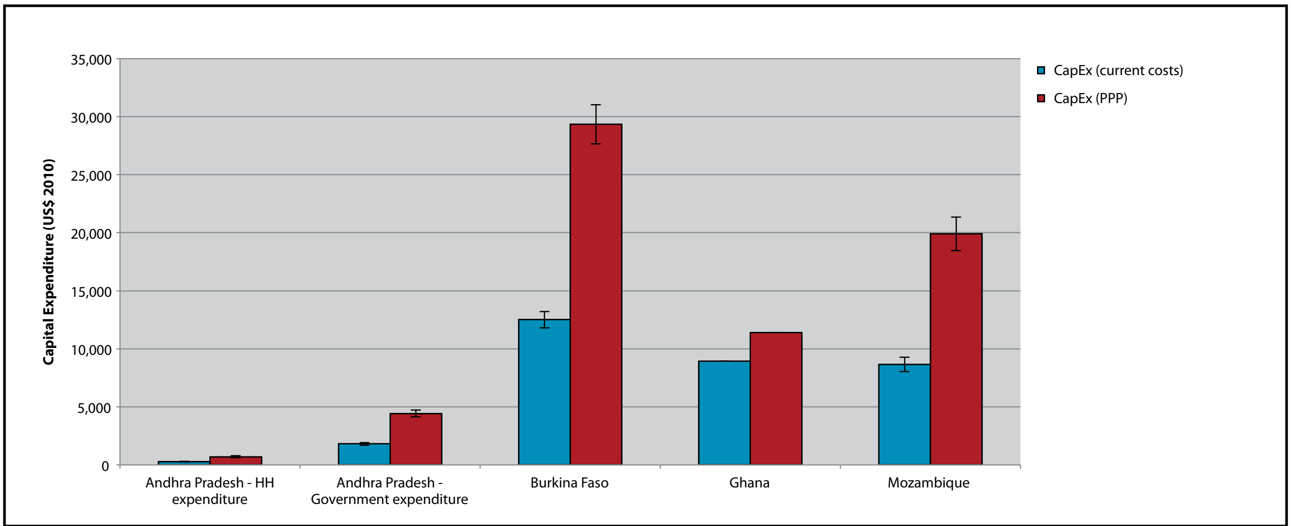
7.1 Boreholes with handpumps: expenditure and service levels

7.1.1 Capital expenditure per scheme

Across the sample areas of the three African countries, the mean expenditure for a borehole with a handpump was highest in Burkina Faso at US$ 12,507. This is 45% higher than the US$ 8,922 spent in Ghana, and 25% higher than the US$ 8,660 spent in Mozambique. Andhra Pradesh shows a completely different picture with costs of some four or five times lower, at a mean of US$ 1,820. Private boreholes are lower still, at just US$ 290. The WASHCost team could not isolate a specific reason for this difference between public and private sector expenditure but believes it to be connected to high private sector capacity driven by agricultural borehole development that has relentlessly brought down costs over past years. As well as the competitive market for borehole drilling in Andhra Pradesh, other factors may include a tendency for government contracts to demand a higher quality of construction, and for contractors to charge more when tendering for government contracts.

An analysis taking into account the relative purchasing power parity (PPP)[42] of each country (illustrated by the red bars in Figure 24 exacerbates the significant (95% level of confidence) differences between countries: boreholes with handpumps in Burkina Faso are one and half times more expensive (PPP) than in Mozambique, and two and half times more expensive than in Ghana. In turn, Ghana is more than two and half times more expensive than Andhra Pradesh.

Figure 24: Mean construction expenditure per borehole and hand pump scheme with 95% confidence intervals (US$ 2010)



The conversion factors used to convert these values to purchasing power parity (Table 36) show that the purchasing power of a single US dollar is 1.3 times greater in Ghana than in the United States, and in Andhra Pradesh, Burkina Faso and Mozambique the purchasing power of the US dollar is around 2.3 times greater. Using these PPP calculations, the mean expenditure for a borehole with a handpump therefore increases to US$ 29,328 in Burkina Faso, to US$ 11,383 in Ghana, to US$ 19,905 in Mozambique, and to US$ 4,267 in Andhra Pradesh, with the private borehole costs rising to US$ 706.

Table 36: Comparison of capital expenditure on boreholes with handpumps, at US$ 2010 (PPP)

Study area	Capital expenditure on boreholes with handpumps	Purchasing power parity conversion factor	Capital expenditure on boreholes with handpumps at purchasing power parity
Andhra Pradesh - household expenditure	$ 290	2.4	$ 706
Andhra Pradesh - government expenditure	$ 1,820	2.4	$ 4,267
Burkina Faso	$ 12,507	2.3	$ 29,328
Ghana	$ 8,922	1.3	$ 11,383
Mozambique	$ 8,660	2.3	$ 19,905

42 See section 2.2.2 of this paper for an explanation of purchasing power parity (PPP). The conversion factor for purchasing power parity is fixed according to values of the World Bank data repository. As the values for Andhra Pradesh, Burkina Faso and Mozambique are roughly the same, the relationship between costs in these countries remains relatively unchanged. The exception is Ghana where the conversion factor is well below that of the other countries, as the dollar has comparatively less purchasing power. Expenditure values in Ghana are therefore diminished in comparison to the other countries studied when PPP values are expressed.

These comparisons do not take into account the necessary software components of borehole construction such as the cost of supervising the work of the contractor and providing initial training for local mechanics and service providers. This data was not readily or systematically available across the four focus countries. However, indicative estimates from 112 contracts in Mozambique suggest that they are significant; the average cost of employing a supervisor was US$ 1,145 per borehole ranging from a minimum of US$ 182 to a maximum US$ 4,073.

Table 37: Capital expenditure for boreholes with handpumps (US$ 2010)

Data category	Capital expenditure				
	Andhra Pradesh schemes built by households	Andhra Pradesh schemes built by service provider	Burkina Faso	Ghana	Mozambique
Nº of data points	90	1,129	38	40 contracts + 82 individual boreholes	152 contracts (representing 4051 boreholes)
Mean	$ 290	$ 1,820	$ 12,507	$ 8,922	$ 8,660
Min	$ 42	$ 132	$ 8,366	NA[43]	$ 2,428
Max	$ 1,082	$ 36,990	$ 15,397	NA	$ 31,266
25th percentile	$ 184	$ 1,004	$ 10,717	NA	$ 7,027
Median	$ 253	$ 1,351	$ 13,369	NA	$ 8,127
75th percentile	$ 338	$ 2,053	$ 14,282	NA	$ 9,796
Standard Deviation	186	1,988	2,252	NA	3,972
95% Confidence	38	121	716	NA	631
Mean Value at PPP	$ 706	$ 4,267	$ 29,328	$ 11,383	$ 19,905

7.1.2 Capital expenditure per user

The sample size of capital expenditure varied considerably from country to country, as did the sources of data available. Table 38 highlights the sample size used to make these comparisons as well as the number of people found to be using each source (or, in the case of contract figures, assumed to be using).

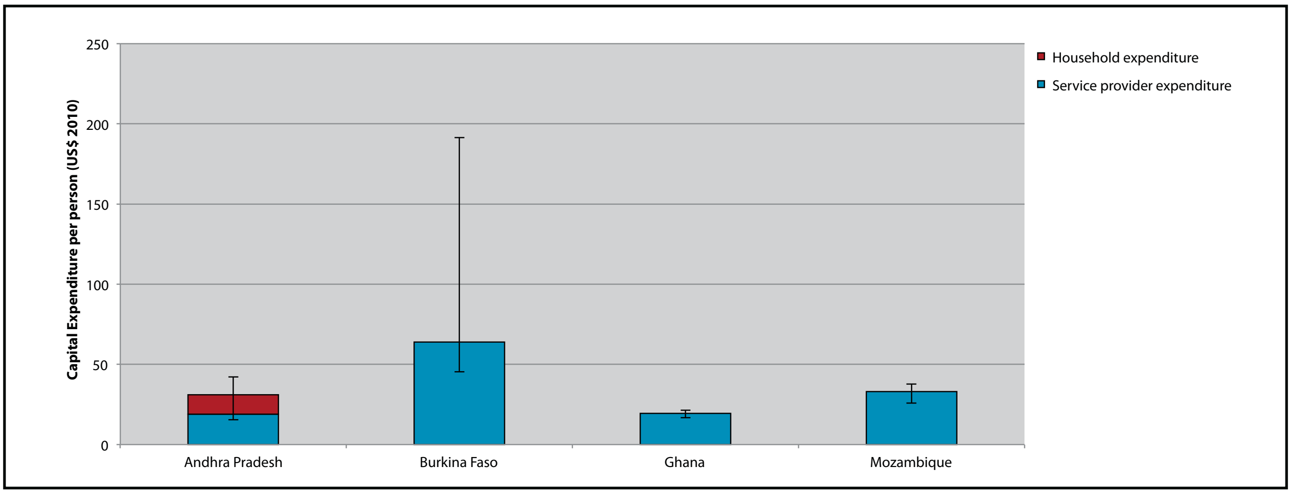
Table 38: Sample size of borehole with handpump capital expenditure

Country	Nº of data points	Mean or assumed population per water point
Andhra Pradesh	1,129	94
Burkina Faso	38	194
Ghana	40 contracts (representing 1,587 boreholes) and 82 individual borehole	458
Mozambique	152 contracts (representing 4051 boreholes)	300

43 Average borehole costs in Ghana were generated from a combination of contracts covering various borehole components. The average cost for each component was used to derive an average total cost.

The mean capital expenditure per person (Figure 25) ranges from a minimum of US$ 19 in Ghana to a maximum of US$ 64 in Burkina Faso. The interquartile range of values in each country shows that the costs incurred by the service provider per user are not substantially different in Andhra Pradesh, Mozambique and Ghana, despite the fact that total capital costs are very different in each country. This reflects the fact that the number of users per borehole varies between countries. In Andhra Pradesh for example, the mean capital cost of a borehole was almost five times lower than any other country, but the service provider expenditure person was the same as for Ghana. When household expenditure was also taken into account, the overall cost per person in Andhra Pradesh was higher than for Ghana and the same as in Mozambique.

Figure 25: Capital expenditure for borehole and handpump per user with interquartile ranges (per person in US$ 2010)



7.1.3 Recurrent expenditure for boreholes with handpumps

Operational and minor maintenance

Across the areas supplied through boreholes with handpumps, annual operational expenditure by the service provider ranged from US$ 0.05 to US$ 0.40 per user per year, although values did vary considerably. In Andhra Pradesh, only 5% of boreholes were reported incurring any operating expenses at all in 2009, these values ranged between US$ 30 to US$ 574. In Ghana, annual operational expenditure ranged from nothing at all to US$ 421 – with typical values being around US$ 45.

Burkina Faso and Mozambique showed more consistent expenditure patterns. Over 85% of sampled boreholes in Burkina Faso had incurred operating expenditure at a typical amount of US$ 19 per borehole, per year; almost half the mean expenditure of US$35 in Mozambique. However, in both countries, the annual cost worked out at US$ 0.1 per user.

Capital maintenance expenditure

Capital maintenance expenditure, by definition, occurs less frequently than OpEx, and correspondingly is more difficult to collect. Newer systems may not have incurred any CapManEx, while in older systems it may have been incurred some years before but—particularly in the remote rural areas investigated by WASHCost—historical maintenance expenditure records were not available.

In the Andhra Pradesh sample, CapManEx seems to have been undertaken sporadically leading to negligible amounts being spent per user per year. Similarly, in Ghana, only two cases of CapManEx were recorded. In Burkina Faso, capital maintenance expenditure was found for 30% of handpumps and when these values are spread across all handpumps in the Burkina sample, this equated to a mean of US$ 0.1 per user per year.

In Mozambique, 58 contracts on rehabilitation were used for analysis. Typically 3.6% of all existing boreholes get rehabilitated nationwide in a year, at an average expenditure of US$ 1,885 per borehole. This represents an average CapManEx expenditure of US$ 9.6 per existing borehole per year[44], or a seemingly negligible US$ 0.03 per user per year.

The fact that that about one in three boreholes in Africa are out of action at any one time suggests that this reported capital maintenance expenditure is significantly below the expenditure necessary to ensure sustainable services.

Expenditure on direct and indirect support

Expenditure on direct and indirect support was collected in three countries, with no data currently available for Burkina Faso. In India, estimates were based on budgetary allocations by the Andhra Pradesh State Government: apportioning these costs to the rural population gives a direct support expenditure of US$ 0.30 per person per year.

In Ghana, expenditure on direct support was collected from District Water and Sanitation Teams (DWST) tasked with monitoring the functionality of water schemes, as well as from the Community Water and Sanitation Agency (CWSA), in charge of supporting both district and community service delivery.

The expenditure by the CWSA in supporting service delivery was determined as a single figure for all rural and small town areas at US$ 0.37 per person per year. Expenditure by water and sanitation teams varied from district to district from a minimum of US$ 0.07 per person per year in East Gonja district (Volta region) to a maximum of US$ 0.24 in Bosomtwe district (Northern region). The combined average of both the DWST and CWSA totals US$ 0.47 per person per year.

In Mozambique, expenditure on directly supporting service delivery is the responsibility of local government; although financial data was only available at national level and therefore does not incorporate specific local expenses. The annual national level expenditure allocated to supporting service delivery equates to a negligible per person expenditure of US$ 0.0012 (just over one tenth of one cent). Since 2008, responsibility for direct support across 38 of the 128 districts in Mozambique has been contracted out to NGOs and private firms as part of what is termed PEC Zonal support. The annual per person expenditure on PEC zonal varied from US$ 0.2 – US$ 4.7 across a sample of 94 contracts in support of water and sanitation services. The average expenditure for those districts receiving PEC Zonal support was US$ 1.1 per person, half of which (i.e., US$0.55) can be attributed to the direct support costs for water (Zita and Naafs, 2011a). In non-PEC zonal areas, expenditure was almost zero (i.e., just 0.0012 per person). Across all the research areas, direct support expenditure averaged at US$ 0.17 per person. However, this figure is not representative of what will happen if and when PEC is delivered to more districts around the country.

In each country study, expenditure on direct and indirect support was given as lump sum figures at district, regional or national level. As a consequence analysis could not be differentiated between different models of water supply, and values are therefore the same for handpump and piped supplies[45].

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44 The average age of boreholes in Mozambique before repair is 7 years; the figures are thus divided by 7.

45 For an analysis of expenditure on direct and indirect support, see: http://www.washcost.info/page/1567 (Smits et al., 2011) and <http://www.waterservicesthatlast.org/Media/Files/Direct-support-post-construction> [Accessed 10 January 2013].

Cost of capital

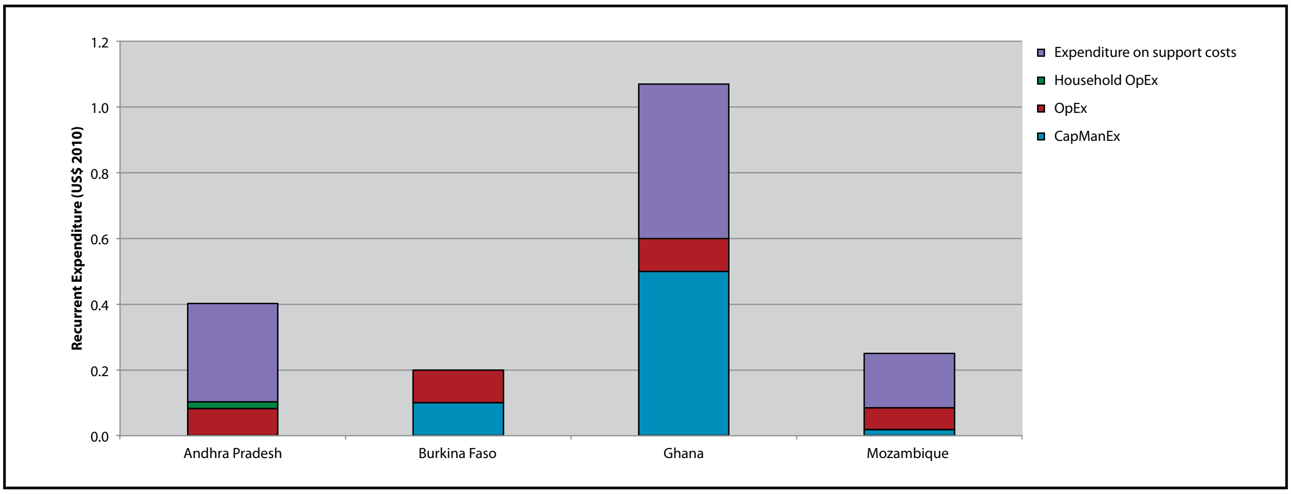
No cost of capital—in the form of interest payments or other returns to providers of capital—was found for any rural water scheme. The cost of capital is explored in chapter 8.

Total recurrent expenditure for boreholes with handpumps

The total recurrent expenditure per user per year can be calculated by adding the operational expenditure, the capital maintenance expenditure, the direct and indirect support costs, and the cost of capital. Summing up all expenditure leads to a range of existing total recurrent expenditure between US$ 0.3-1.1 (Figure 26) per user per year:

- US$ 1.1 (PPP US$ 1.4) in Ghana
- US$ 0.4 (PPP US$ 0.8) in Andhra Pradesh
- US$ 0.3 (PPP US$ 0.6) in Mozambique
- US$ 0.2 (PPP US$ 0.5) in Burkina Faso

Figure 26: Recurrent expenditure on boreholes and handpump schemes per user per year (US$ 2010)



7.1.4 Analysis of recurrent expenditure and corresponding service levels delivered by boreholes and handpumps

The combined service level represents aggregated household information on the four criteria defined in the WASHCost service levels ladder: water quantity received per user per day; the quality of drinking water; the accessibility of the water source; and its reliability. Since all four criteria need to be met to achieve a certain level of service, the indicator with the lowest score determines the overall household service level.

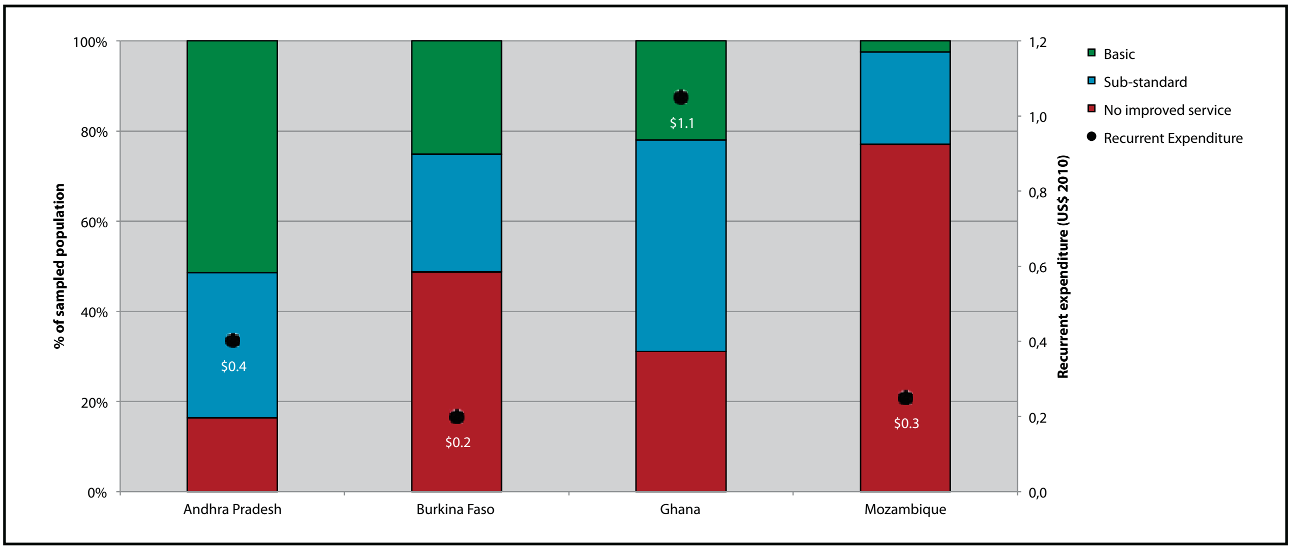
The majority of households using a borehole with handpump in all of the study areas reported they receive a water service below a "basic" level (Figure 27). There were a number of reasons for this: water quality was tested only sporadically in most cases, and mainly at the time of construction, while there were also problems with water quantity and the accessibility of water points.

The WASHCost service ladder defines a basic quantity as a minimum of 20 lpcd. However, in Mozambique, average water consumption in the households surveyed was 18 litres per person per day, 70% below the basic standard. The average consumption is higher in Ghana at 24 litres per person per day—but it is inequitably distributed—leading to 50% of users falling below the "basic" standard.

In Burkina Faso, almost all residents received an acceptable quantity of water. However, many were considered to have inadequate access as sources were located more than 1,000m from households leading to unacceptable amounts of time being spent each day on collecting water. This highlights the difficulty faced by many African countries in providing sufficient formal water points within a reasonable distance of the household in sparsely populated rural areas.

In Andhra Pradesh, users of boreholes with handpumps do not encounter problems of access, but rather with reliability; 16% of users reported that their supply was non-functional for more than 18 days per year, with a further 32% reporting annual downtime of 12-18 days per year. In communities where the borehole with handpump is the only formal source, households regularly need to resort to informal sources.

Figure 27: Combined service levels for borehole and handpump schemes compared with total recurrent expenditure per use (US$ 2010)



Given the level of aggregation and the low levels of recurrent expenditure across all the sampled areas in the four countries, it is not surprising that we cannot see a clear relationship between the levels of expenditure and the service levels delivered. It is likely that the relationship between expenditure and service levels is not a gradual linear increase at low levels and that a minimum threshold of recurrent expenditure is needed before the majority of the population receives a basic level of service. This is further explored in chapter 8.

7.2 Small and medium service areas with piped systems: expenditure and service levels

It was mentioned in chapter 2 that one reason for selecting these four countries for action research was that they represented a diversity of WASH services. This allowed for data collection across numerous systems, the services they provide and associated expenditure. However, given the spread of findings, not all data is comparable.

For the analysis presented in this section, a small service area is defined as one with less than 500 residents, and a medium service area is one with a range between 500 and 5,000 residents – the size of the sample is detailed in Table 39. For some piped systems, only expenditure data was captured meaning comparisons with service levels could not be done in all service areas. The majority of data is from Andhra Pradesh and this is not always comparable with expenditure in the African countries.

Table 39: **Small and medium service areas sampled for piped schemes**

Size of service area	Location of service area	Service delivery model	Mean population per service area	Nº of schemes with data	
				Expenditure data	Service level data
Small service area (<500 people)	Andhra Pradesh	Mechanised borehole	262	17	4
		Single-town scheme	441	2	0
		Multi-town scheme	308	6	5
		Mixed piped schemes	351	8	7
Medium service area (500-5,000 people)	Andhra Pradesh	Mechanised borehole	1,128	17	8
		Single-town scheme	1,559	28	15
		Multi-town scheme	1,591	11	8
		Mixed piped schemes	1,510	66	42
	Burkina Faso	Mechanised borehole	2,696	2	2
	Ghana	Single-town scheme	3,174	22	1

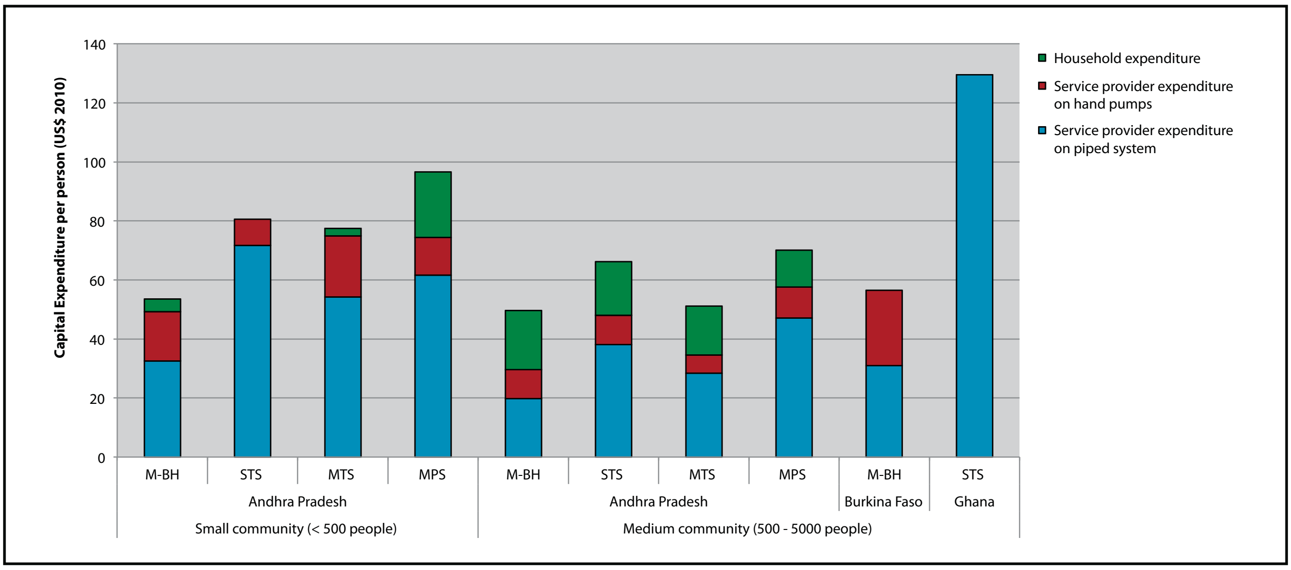
7.2.1 Capital expenditure per person within a service area

In each of these service areas, piped and point sources (predominantly boreholes and handpumps) co-exist. In Andhra Pradesh and Burkina Faso expenditure on these different supply options is recorded separately, but expenditure could not be disaggregated in Ghana.

Small service areas (<500 people) with piped supply services were found only in Andhra Pradesh. The mean per person capital expenditure by the service provider ranged between US$ 33 for a mechanised borehole supply and US$ 72 for a single-town scheme. In each of these small service areas a further 15-50% of total expenditure has been made towards providing boreholes and handpumps, either through household self-supply or through additional governmental expenditure.

Data from medium-sized service areas was available from Andhra Pradesh and Ghana and from a small sample in Burkina Faso (Figure 28). The highest capital expenditure per person for single-town schemes was found in Ghana with a mean of US$ 130, ranging from US$ 33 to US$ 278. In Andhra Pradesh, total expenditure on a combination of piped and point sources ranged between US$ 50 and US$ 70 per person, quite close to the US$ 56 per person spent in the two schemes in Burkina Faso.

Figure 28: Mean capital expenditure per person of piped schemes for small and medium service areas (US$ 2010)



7.2.2 Recurrent expenditure for piped schemes for small and medium service areas

Operational and minor maintenance expenditure

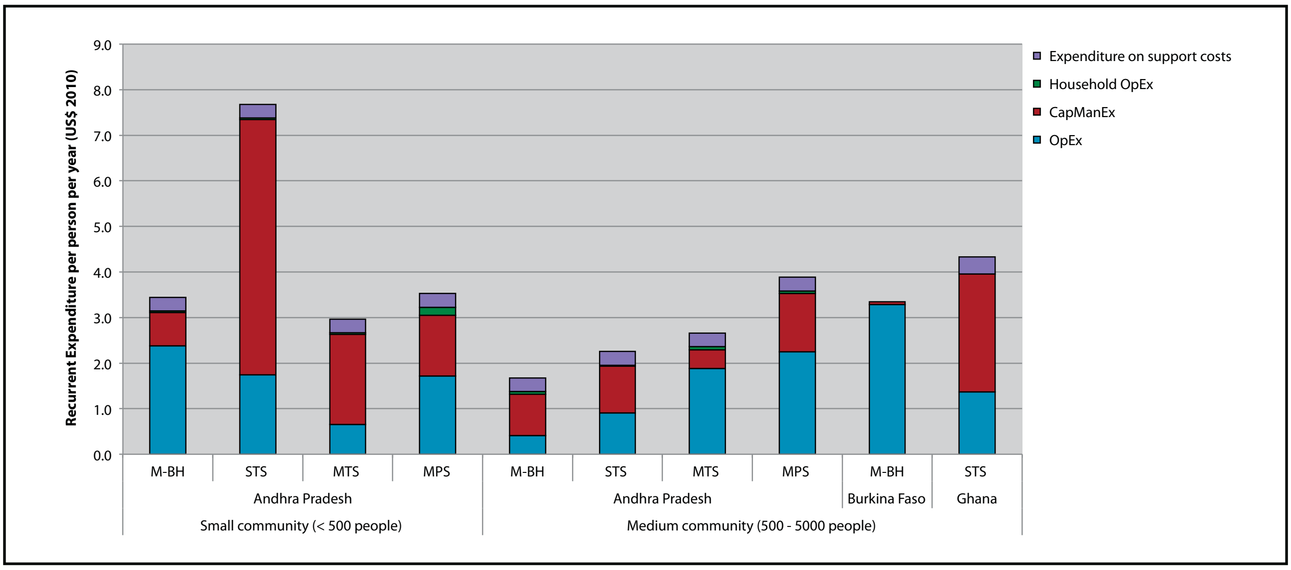
The mean annual operating expenditure in these service areas falls between a minimum of US$ 0.4 per person per year for small mechanised borehole schemes in Andhra Pradesh, and a maximum of US$ 3.3 for the combination of mechanised boreholes and boreholes with handpumps in two service areas in Burkina Faso. The mean expenditure in Ghana is US$ 1.4.

Capital maintenance expenditure

Capital maintenance expenditure varied more markedly from US$ 0.1 per person per year for the mechanised borehole schemes in Burkina Faso to US$ 1.5 in Ghana and $ 5.6 for the small single-town schemes in Andhra Pradesh.

Given that capital maintenance is typically an irregular expenditure, dependent on the age of infrastructure and deterioration of different infrastructure components, a large variation in per person expenditure is not surprising, especially in small systems of various ages.

Figure 29: Recurrent expenditure on piped schemes for small and medium-sized service areas (US$ 2010)



Total recurrent expenditure for piped schemes for small and medium service areas

The total recurrent expenditure per person per year can be calculated by adding operational expenditure, capital maintenance expenditure, expenditure on direct and indirect support and the cost of capital. Summing these expenditures leads to a broad range of US$ 1.7- 7.6 per person per year, as shown in Table 40.

Table 40: Range of total recurrent expenditure for small and medium piped schemes (US$ 2010)

Size of service area	Andhra Pradesh	Burkina Faso	Ghana
Small	$ 3.0-7.6	$ 3.4	-
Medium	$ 1.7-3.9	-	$ 3.8

7.2.3 The use of small and medium piped sources as primary supply

It is common in many WASHCost study areas for more than half of service area residents not to utilise the piped water scheme as their primary supply. Reasons for non–use vary from community to community but include issues related to scheme functionality: such as the size and hydraulic capacity of the piped network, the reliability of the electricity supply, the security of the source and the water quality as measured; as well community-related issues such as the social status of the user, perceived water quality, and availability of alternative sources or private water vendors.

In the two service areas sampled in Burkina Faso for example, the piped network did not extend beyond the higher density areas of the community, leaving households found in the fringes of the service area reliant on handpumps and unprotected wells. Furthermore, even households that were close to a formal piped source, were found to be using alternative formal and informal sources. This left an average of just 100 people using these improved sources, which have a design capacity of 500.

A similar situation was found across small and medium-sized piped service schemes in Andhra Pradesh. Indeed, in only two of the seven piped service delivery models sampled did more than half of residents receive drinking water from the piped network (Table 41). In the majority of models this was much less with as many as 85% of users not accessing the scheme. Inevitably, therefore, there is a reliance on boreholes with handpumps in a number of communities even though the state government policy is that handpumps are no longer promoted as comprehensive solutions for rural drinking water schemes.

At this level of aggregation there is no clear link between the types of service delivery model or system size with the percentage of residents using the piped scheme.

Table 41: Percentage of residents using drinking water sources per service delivery model

Size of service area	Location of service area	Service delivery model	Nº of schemes	% of people using piped sources	% of people using handpump/ protected wells	% using other sources
Small service area (<500 people)	Andhra Pradesh	Mechanised borehole	4	44%	9%	46%
		Multi-village scheme	8	32%	45%	23%
		Mixed piped schemes	15	38%	33%	29%
Medium service area (500-5,000 people)	Andhra Pradesh	Mechanised borehole	5	15%	85%	0%
		Single-town scheme	8	61%	20%	19%
		Multi-village scheme	7	41%	44%	15%
		Mixed piped schemes	42	63%	18%	19%
	Burkina Faso	Mechanised borehole	2	9%	47%	44%
	Ghana	Single-town scheme	1	NA	NA	NA

The underuse of formal sources in service delivery areas has significant impact on the service levels achieved in a community and, ultimately, on per user costs of different service delivery models. These issues are further explored in section 7.6.

7.2.4 Recurrent expenditure and service levels[46] delivered per service area

In Andhra Pradesh, most households receive more than the basic threshold figure of 20 lpcd of water from a nearby source. Nevertheless, many households are classified as receiving “no service improvement” because they are using an unprotected source, or more commonly the drinking water source is out of use for more than 12 days per year. This means that most households do not receive a basic water service according to either the criteria used in the WASHCost service ladder, or indeed the more demanding national norms of India. Despite significant investment, in some villages only 21% of the population obtains basic services.

What sets the Andhra Pradesh context apart from the other study areas is that despite the high levels of unreliability and breakdown, the sheer quantity of supply infrastructure available means that households continue to access sufficient quantities of water, highlighting the resilience, if not the economic efficiency that is built into a service that has multi-source supplies. This approach leaves significant scope for improvements to be made in service delivery, with specific attention required on the rationalisation of viable sources, improved maintenance regimes and the progressive realisation of continuous piped supply to reduce the risk of foul water infiltration into the piped network.

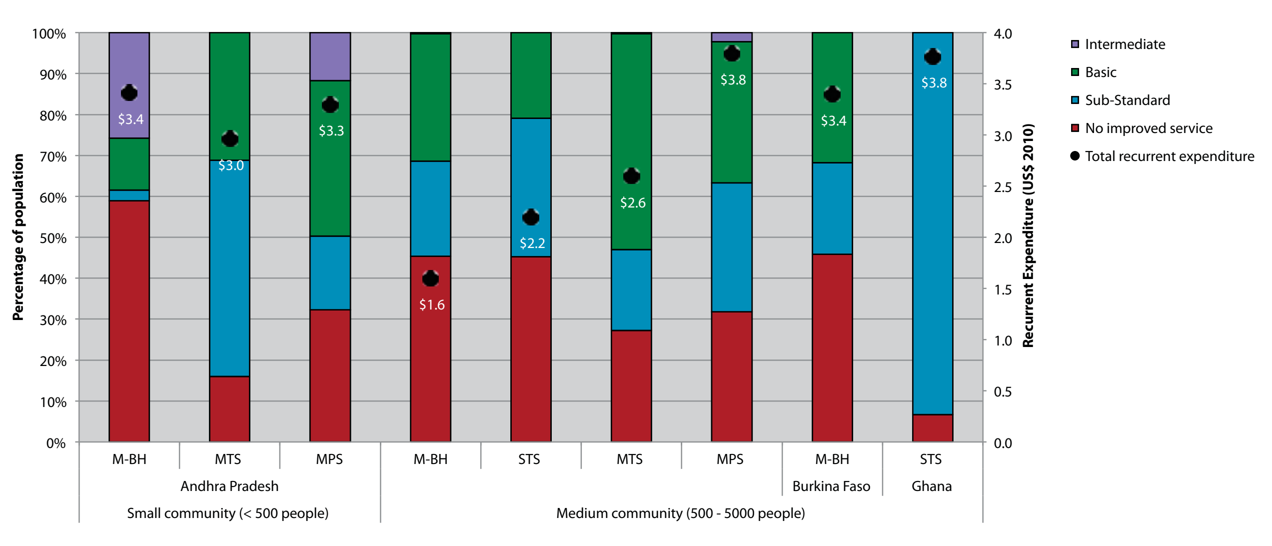
In the single-town system sampled in Ghana, the biggest constraint to service delivery was overcrowded public tap stands, with largely acceptable results achieved for other indicators. In Burkina Faso only nine per cent of users utilised

46 As service level data was not collected in all areas where expenditure data was collected, service levels are not generated for all schemes.

the small piped network and relied on a combination of more crowded handpump supplies as well as other informal sources, with the main barrier being the higher price of accessing the piped source.

At this aggregated level it is apparent that no particular piped service delivery model is providing a significantly better or worse level of service than any other when all the criteria used in the service levels are put together.

Figure 30: Combined service level for small and medium-sized service areas with total recurrent expenditure per person per year (US$ 2010)



7.3 Piped schemes for intermediate and large service areas: comparing expenditure and service levels

7.3.1 Capital expenditure per person within a service area

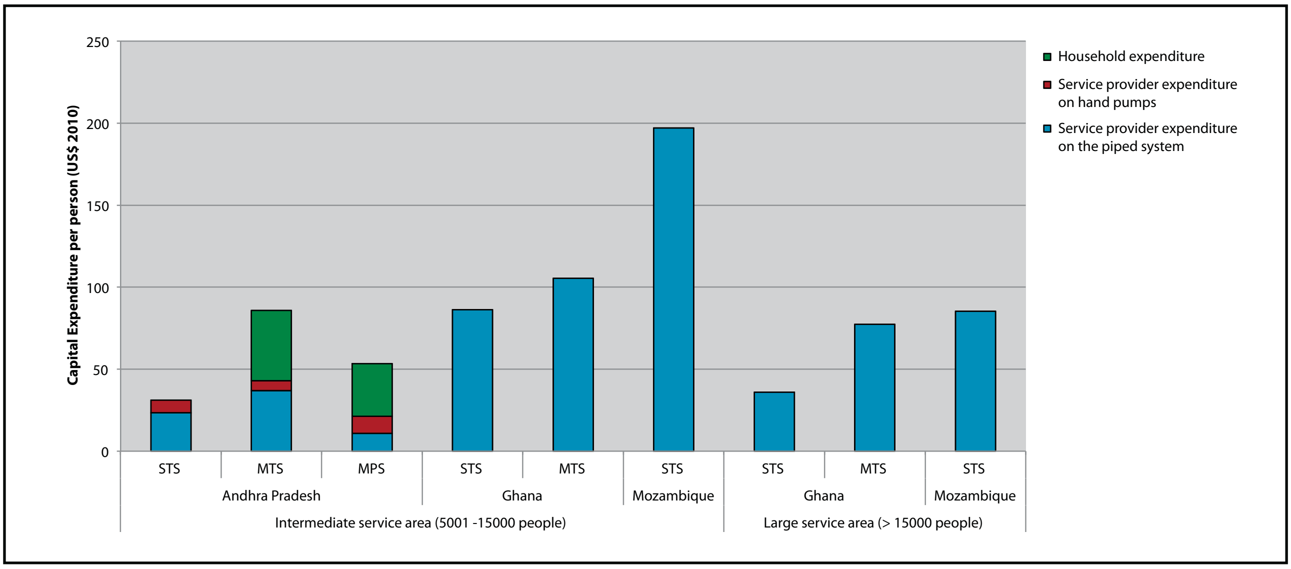
In this study, an intermediate service area is defined as one with between 5,000 and 15,000 residents, and a large service area as one with over 15,000 residents – the size of the sample is detailed in Table 42 and identifies available data in Andhra Pradesh, Ghana and Mozambique.

Table 42: Intermediate and large service areas sampled for piped schemes

Size of service area	Location of service area	Service delivery model	Average population served per scheme	Nº of schemes with data	
				Expenditure data	Service level data
Intermediate service area (5001 -15,000 people)	Andhra Pradesh	Single-town scheme	9,771	9	0
		Multi-town scheme	5,234	2	1
		Mixed piped scheme	6,929	6	2
	Ghana	Single-town scheme	7,403	14	1
		Multi-town scheme	8,274	9	0
	Mozambique	Single-town scheme	9,115	9	1
Large service area (> 15,000 people)	Ghana	Multi-town scheme	19,820	2	0
		Single-town scheme	19,477	1	2

The nine medium-sized single-town schemes in Andhra Pradesh[47] had the lowest mean per person capital expenditure at US$ 31 per person compared with US$ 86 for the 14 schemes in Ghana, and US$ 197 for the eight schemes in Mozambique. Mean expenditure for the multi-village systems in Andhra Pradesh at US$ 43 was less than half the US$ 105 per person spent in Ghana.

Figure 31: Mean capital expenditure per person on piped schemes serving intermediate and large service areas (US$ 2010)



7.3.2 Recurrent expenditure for piped schemes in intermediate and large service areas

In Ghana, data on recurrent expenditure was only available for 6 out of 23 intermediate piped systems where capital expenditure data was collected. In Mozambique recurrent expenditure was not available for most systems sampled[48]. The majority of data collected relates to operational expenditure.

In Andhra Pradesh, annual operational expenditure values ranged from US$ 0.5 per person for the mixed piped supply delivery model to a maximum of US$ 1.8 per person for the multi-town system. In Ghana current expenditure on the intermediate single-town system was US$ 4.1 per person per year, nearly three times as much as the US$ 1.4 spent on the multi-town scheme. OpEx from the intermediate single-town system in Ghana was US$ 4.1, slightly higher than comparable schemes in Mozambique and much higher than those in Andhra Pradesh. OpEx for multi-town systems was also higher in Ghana—at US$ 3.8—than what was spent in Andhra Pradesh.

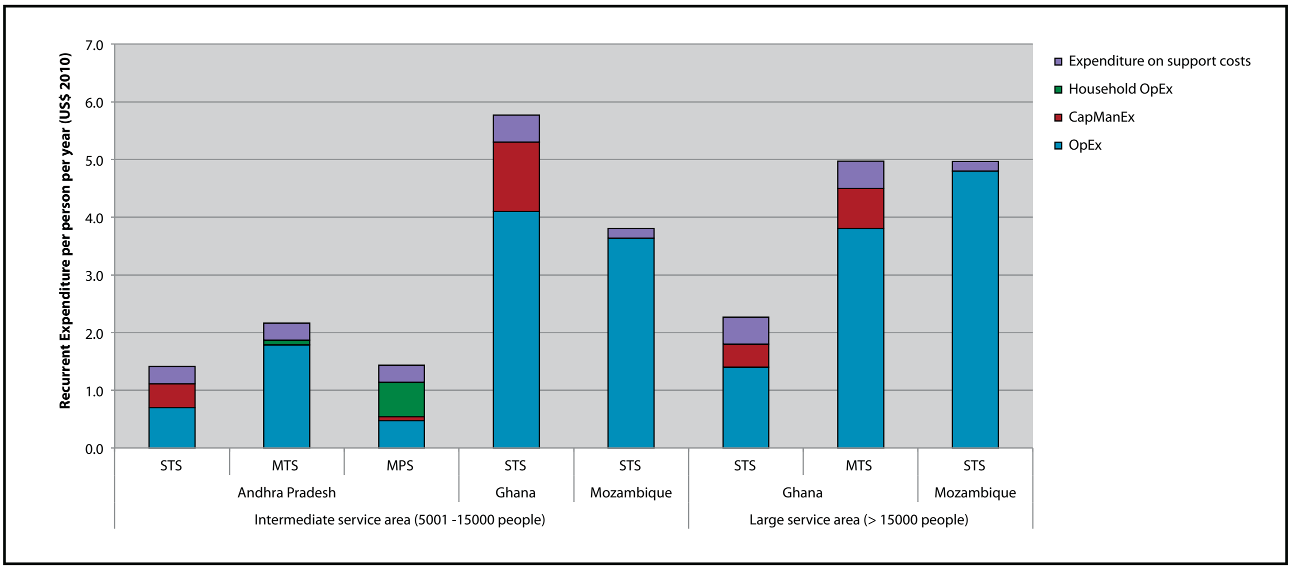
Across all service delivery models, capital maintenance expenditure was lowest in Andhra Pradesh where the value for all systems was US$ 0.5; and highest for intermediate single-town scheme in Ghana at US$ 1.2; followed by large multi-town schemes at US$ 0.7. No values were available in Mozambique and these were given a zero.

The mean total recurrent expenditure for the three approaches in Andhra Pradesh was between US$ 1.2 and US$ 2.2 per person per year; for the most part, less than what was spent in comparable schemes in other countries. The highest values were for multi-town schemes sampled in Ghana at US$ 6.5. For all of these delivery models, expenditure on operation and minor maintenance dominates, with expenditure of less than US$ 1 per person per year on capital maintenance.

47 Includes expenditure on the piped systems, as well as boreholes and manual handpumps.

48 The challenge in Mozambique has been that cost data was available for some areas, and service level data for other areas. Cost data is sufficient to distinguish between the various types of systems, but service level data can only be grouped as "piped systems". The main reason is the clustered sampling approach (WASHCost Mozambique, 2010) that was used to arrive at representativeness at provincial and national level, was not representative for system or community level. Service levels can only be analysed as piped systems, not for sub-categories of a piped system.

Figure 32: **Mean recurrent expenditure per person on piped schemes for intermediate and large service areas (US$ 2010)**



Total recurrent expenditure for piped schemes in intermediate and large service areas

Total recurrent expenditure per person per year can be calculated by adding operational expenditure, capital maintenance expenditure, direct and indirect support and the cost of capital. Summing these expenditures leads to a range between US$ 1.4 and US$ 5.8 per person per year, slightly lower than piped schemes in small and medium service areas. The range of total recurrent expenditure for intermediate and large schemes is shown in Table 43.

Table 43: **Range of total recurrent expenditure for intermediate and large piped schemes (US$ 2010)**

Size of service area	Andhra Pradesh	Ghana	Mozambique
Intermediate (5,001-15,000)	$ 1.4-2.2	$ 5.8	$ 3.8
Large (>15,000)	-	$ 2.3-5.0	$ 5.0

7.3.3 The use of intermediate and large piped source

In intermediate-sized service areas, between 60% and 91% of residents use piped sources; higher usage values than those generally found in smaller service areas with piped systems.

Table 44: **Percentage of users of drinking water sources per service delivery model**

Size of service area	Location of service area	Service delivery model	Nº of schemes	% piped source	% handpump/ protected wells	Other sources
Intermediate (5,001-15,000)	Andhra Pradesh	Multi-town scheme	1	60%	22%	18%
		Mixed piped schemes	2	91%	8%	1%
	Ghana	Single-town scheme	1	NA	NA	NA
	Mozambique	Single-town scheme	1	82%	0%	18%
Large (>15,000)	Ghana	Single-town scheme	2	NA	NA	NA

7.3.4 Recurrent expenditure per service area and service levels delivered

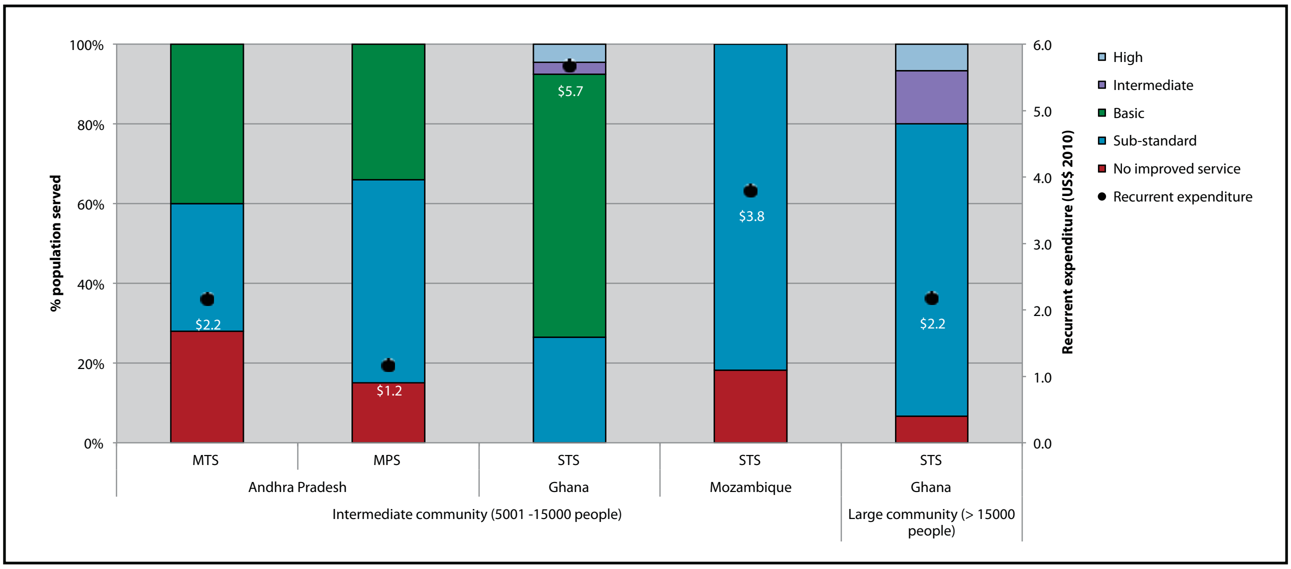
The comparison of service levels for these larger systems highlights mixed service level outcomes within and between countries.

In Ghana for example, the crowding of sources is the primary barrier to basic services. In areas where there are sufficient sources (e.g., the intermediate service area in our sample), service outcomes are better than elsewhere with some 75% of residents receiving a basic, intermediate or high level of service. Yet as can be seen in the large single-town system in Ghana, some 80% of residents do not receive a basic service due to source crowding.

The intermediate piped systems in Andhra Pradesh deliver a similar standard of service with approximately two thirds of residents failing to reach the basic service standard. As with small piped systems, the reliability of the primary source accessed is the main barrier to basic services.

Intermediate piped systems in Mozambique fail to deliver basic quantities of water to residents: on average, individuals receive 18 lpcd, in comparison to the basic standard of 20 lpcd. This issue is of course connected with system performance, which is not adequately addressed by existing levels of expenditure.

Figure 33: Combined service levels for intermediate and large service areas with total recurrent expenditure per person per year (US$ 2010)



7.4 Summary of expenditure for all piped systems

For all piped schemes across the four countries, the mean recurrent operational and minor maintenance expenditure was between US$ 1.4 and US$ 5.8 per person per year. This is roughly 5-8 times higher than what is spent on boreholes with handpumps, and constitutes between 1% and 8% (average 4%) of the initial capital expenditure for all piped approaches. Operational expenditure—along with capital maintenance and support expenditure—make up the total annual recurrent expenditure collected, and for the numerous piped schemes sampled mean, values ranged between US$ 1.4 and US$ 5.0 per person.

7.5 Findings on cost drivers

Many cost drivers for capital expenditure were analysed in the four countries. However, country reports indicate that there are so many varied components (materials used in construction, contract bundling arrangements, depth of boreholes, distance from main roads or cities, etc.) that they are difficult to isolate, and they fail to provide a consistent explanation.

Carter and Rwamwanja (2006) explain that the cost of every borehole is unique, driven by variations in the physical environment (e.g., [hydro-] geology, climate); variations due to different actors; ease of access and proximity to local manufacturers and practitioners; and variations in the materials used for construction. An analysis by the WASHCost team in Mozambique found an effect from packaging different numbers of boreholes in drilling and construction contracts; larger packages of 100 boreholes or more were found to be 17% cheaper than smaller packages of 10 boreholes (Zita and Naafs, 2011b).

In Ghana, an analysis of 39 piped systems constructed between 1998 and 2010 in the Volta, Ashanti and Northern regions showed that the major cost drivers for capital expenditure were the nature of the system, the contract packaging and the hydrogeology of the area. The major capital expenditure components were comprised of piped works and overhead tanks. The type of reservoir also had an influence on the cost, as steel tanks are more expensive than concrete tanks. Water systems using a solar energy source have higher capital expenditure per capita than those using the national grid. Generally, capital expenditure on water systems with internationally competitive bidding contracts is higher than in schemes with national competitive bidding contracts (Nkrumah et al., 2011).

In India, a broader perspective was taken and the WASHCost team conducted multiple regression analysis to understand the cost drivers of capital expenditure and service levels. Analysis suggests that the level of education in the community, demographic and economic factors, technology, and governance-related factors appear to influence levels of expenditure and service levels. Agro-climatic conditions and economies of scale also seem to be factors, although there is limited information on hydrogeology (Reddy et al., 2011).

Capital expenditure cannot be extrapolated from one country to another or sometimes from one region to another within the same country given the context-specific characteristics that define the costs of each component.

Monitoring the factors that influence capital expenditure can help to reduce costs over time. For instance, improving the bundling and packaging of tenders can reduce the overall average cost. A relatively simple and flexible methodology can be used to collect expenditure and service levels systematically and regularly.

7.6 Expenditure and service levels per user across the four countries

We have tried to understand relationships between different service delivery models, the levels of service delivered, and capital and recurrent expenditure. This section compares the percentage of the service users receiving a basic level of service with the per user expenditure for each service delivery model.

7.6.1 Capital expenditure and service levels

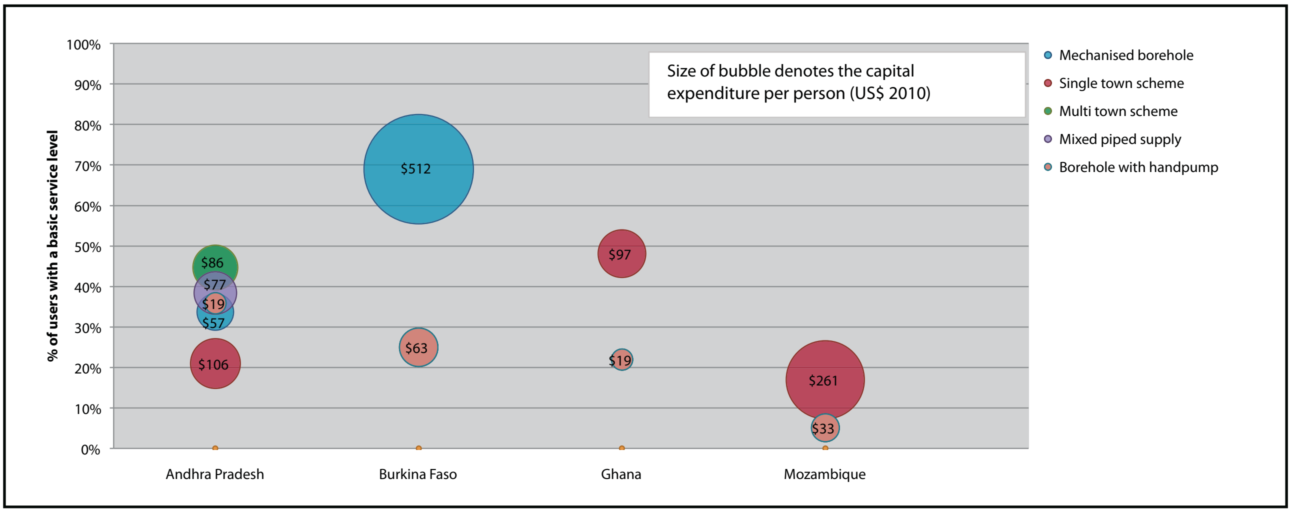
Figure 34 focuses on capital expenditure for each service delivery model, without differentiating by the size of the system. This analysis shows the following:

- Capital expenditure per user of mechanised borehole supplies in Burkina Faso is very high at US$ 512 per person. This is because just 9% of residents use these systems in the two areas where such systems were sampled; only one fifth of the number of people for which they were designed. 69% of users of these systems in rural Burkina Faso receive a basic service compared with only 25% of borehole and handpump users, which however, are a lot cheaper at US$ 65 per user.
- Similarly, the more expensive option can be seen to deliver a higher standard of service to its users when comparing a single-town piped service in Ghana with a borehole and handpump. Although both schemes can suffer from overcrowding at the access point, users of the piped schemes tend to receive higher quantities of water and a

more reliable service: 48% of users receive a basic service at US$ 97 per user compared to 22% receiving a basic service from boreholes with handpumps at US$ 19 per user.

- In Andhra Pradesh there are four piped supply approaches, in addition to boreholes with handpumps. The piped services all have similar average costs of between US$ 57 and US$ 106 per user, compared to a per user cost of US$ 19 for boreholes with handpumps.

Figure 34: Percentage of users receiving a basic service level and capital expenditure per user of different systems (US$ 2010)



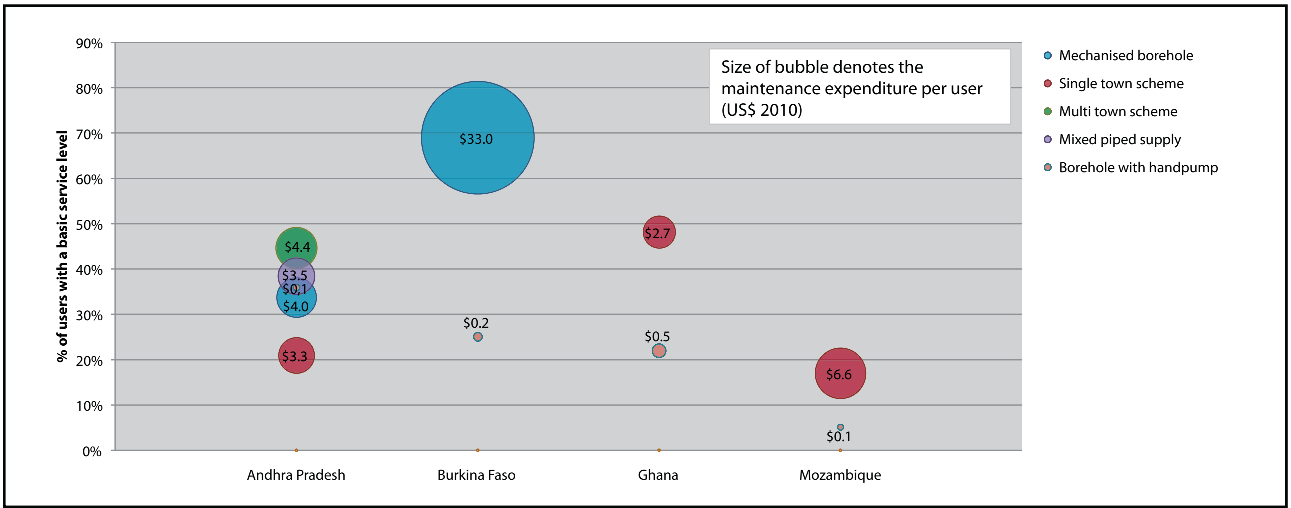
As the majority of systems do not deliver even half of users with a basic service, the main conclusion from this analysis is that low levels of service were found to be very costly. Independent of the water scheme, many towns and regions across the four countries found themselves with high percentages of the population with no service improvements after interventions while at the same time, the expenditure per person per year spent on capital expenditure was observed to be as high as US$ 512 in Burkina Faso and US$ 261 in Mozambique. Service levels in Mozambique were, in general, the lowest, reflecting low overall coverage levels and highly dispersed rural population.

7.6.2 Recurrent expenditure and service levels

There are also conclusions to be drawn from comparing recurrent expenditure per person with service levels delivered by different service models. Figure 35 shows:

- The overall picture is that piped schemes tend to provide better services than boreholes with handpumps but they do so at a higher capital cost, and sometimes with a significantly higher recurrent cost
- More complex schemes, with higher recurrent minor and major maintenance, do not necessarily provide better levels of service. For instance, in Andhra Pradesh, a lower percentage of users are provided with a basic service by single-town systems with US$ 3.3 per person annual recurrent expenditure, than by borehole with handpumps with annual recurrent expenditure of US$ 0.1 per person.
- In each country, the recurrent expenditure per person on handpump systems is very low, between US$ 0.1 and US$ 0.5 per user. Recurrent expenditure per user on all varieties of piped systems is considerably higher, ranging between US$ 2.7 and US$ 6.6 for most systems. The exception is Burkina Faso where the underuse of the two mechanised borehole systems results in a very high per user expenditure of US$ 33.0.

Figure 35: Comparison of the percentage of users receiving a basic service level with maintenance expenditure[49] per user of different schemes (US$ 2010)



The most striking finding from the analysis is that none of the schemes provide a basic service to even half their populations, primarily due to the unreliability of services. Most piped systems are non-functional for an average of more than ten days per year, while boreholes with handpumps are on average, non-functional for 12-14 days a year. This gives strong support to the hypothesis that current levels of expenditure on minor maintenance and appropriate capital maintenance to keep infrastructure in good condition are insufficient to maintain a basic water service to consumers.

Although the quantity of water accessed in Andhra Pradesh is generally high, extended periods of down time result in households turning to unprotected sources for drinking water. Results from the African countries indicate that piped schemes do provide a higher level of service than boreholes with handpumps alone, but require considerably higher capital and recurrent expenditure. However, an underexplored aspect of this study for all countries is the effect of intermittent water supply on the water quality of piped networks. Water quality testing was done in some countries, but presented inconclusive results.

8 Water cost benchmarks

It is impossible to avoid the conclusion that money is currently being spent on providing services that do not meet national or international norms. The tentative hypothesis drawn by the authors is that recurrent expenditure for services have a necessary threshold below which it is essentially impossible to provide an adequate level of service. Above the necessary threshold, other factors come into play which affect the quality of the service (such as strength of management, efficacy of regulation, etc.). In this chapter we bring together data collected in WASHCost, and data collected from other studies to offer cost benchmarks for capital costs and recurrent costs sufficient to finance a basic level of service.

We believe these benchmarks to be the best available, providing reliable guidance for planning, implementing and monitoring WASH services. However, they cannot be regarded as precise for every setting, as local factors must be taken into account. For example, the lower cost ranges were generally, but not always found in India, while cost data from Latin America tends to be higher than the maximum ranges, but usually relates to higher service levels.

49 Maintenance expenditure includes both operational and capital maintenance expenditure.

WASHCost research shows that the local context is highly significant in determining costs in developing countries. Many social, institutional and political aspects influence the level of services and value for money. However, we can say with some confidence that if expenditure is much lower than the benchmarks presented here, then the services being planned or delivered have a high probability of being unsustainable. Costs are one of the key factors to ensure sustainability.

If expenditure is lower than the minimum range, there is higher risk of reduced service levels whereby one or more of the service criteria will not be met, or of long-term failure. If expenditure is higher than the maximum range, an affordability check may be required, for users and providers to ensure long-term sustainability. In a situation where a basic level of service is being delivered and expenditure levels are outside the cost benchmark ranges, there may be context-specific reasons for this.

For water supply services, a basic level of service is achieved when all the following criteria have been realised by the majority of the population in the service area: people access a minimum of 20 litres per person, per day; water is of acceptable quality (judged by user perception and country standards); water is drawn from an improved source, which functions at least 350 days a year without any serious breakdowns; and no more than 30 minutes per day, per round trip (including waiting time) is spent collecting water.

8.1 Benchmark thresholds for recurrent expenditure: operational, capital maintenance and direct support

Expenditure on direct support, operational expenditure and capital maintenance, which includes renewal and rehabilitation, was found to be extremely low in all cases: less than US$ 0.50 per person per year for boreholes and handpump schemes, and US$ 3-4 per person per year for piped schemes. There was no correlation found between the level of recurrent expenditure and service levels. It can be said that in all the areas researched by the WASHCost teams, inadequate investments in services delivery, and particularly in direct support and capital maintenance, has contributed to inadequate services. These low levels of recurrent expenditure are assumed to be behind the observed high levels of non-functionality and poor service delivery.

A simple back of the envelope calculation serves to illustrate the point. If we take 20 years as a conservative estimate for the life of a borehole, and use a simple linear depreciation rate for the capital expenditure ranges found in the African countries for boreholes with handpumps (US$ 8,660-12,507), this implies that roughly: a maximum of US$ 400-600 should be spent on maintenance and rehabilitation for each borehole system each year; bearing in mind that this is the cost of developing an entirely new borehole. Looked at another way, and taking the replacement cost of a handpump as US$ 2,000 (the relatively high value found in Mozambique) and assuming an (again conservative) life span of five years, we arrive at a similar annual figure of US$ 400. Spread over a typical design community of 300 people, these figures suggest a conservative upper estimate for capital-maintenance of some US$ 1.50 to US$ 2.00 per person per year for boreholes with handpumps – three to four times the current levels of spending on capital maintenance and direct support combined.

Looking at piped systems and taking a capital expenditure range of between US$ 30 and US$ 130 per person (as found for most systems sampled) and assuming a 20-year life span for the components of the system, an application of the same linear depreciation results in a conservative capital maintenance allocation of between US$ 1.5-7 per person per year.

An analysis done by IRC looking at successful cases of organising direct support in (lower-) middle income countries in Latin America and Southern Africa found that an expenditure of US$ 3 per person per year seems to be effective in those countries (Smits et al., 2011). Other countries, particularly in Africa, were found to have levels of expenditure on direct support of less than US$ 1 per person per year. This was considered too low to deliver sustainable services.

Finally, the operational expenditure benchmarks for piped systems are given at US$ 0.5-5 per person per year, based on the interquartile values for the large range of schemes analysed during the WASHCost study. For boreholes with handpumps on the other hand, the WASHCost analysis showed that only a small percentage of these systems had recorded any operational expenditure values, and therefore on average, current levels of expenditure are likely to be below required levels. Consequently, the tentative benchmark given of US$ 0.5-1 per person per year is two to four times the amount of current recorded expenditure.

It can be argued that many boreholes with handpumps continue to function effectively with levels of expenditure well below this benchmark. This is more likely to happen when there is an effective water committee at community level which pays close attention to functionality. This time and attention is not paid for in financial terms, and therefore shows as a nil cost. However, even well-run water committees can be fragile organisations dependent on continuous input from key community members. A strong system of direct support is therefore highly desirable to ensure that well-functioning organisations can be sustained.

Summing up the findings above and adding the figures together (Table 45) gives a best-guess estimate of an annual recurrent figure for rural point source sustainability in the region of US$ 3-6 per person per year; some 8-10 times the actual reported figures. For piped systems, the likely figure is somewhat higher at US$ 3-15 per person per year.

Table 45: Breakdown of recurrent expenditure benchmarks for water (US$ 2011)

Breakdown of recurrent expenditure*	**Cost ranges** [min-max] in US$ 2011 per person, per year	
	Borehole and handpump	All piped schemes
Operational and minor maintenance expenditure	0.5-1	0.5-5
Capital maintenance expenditure	1.5-2	1.5-7
Expenditure on direct support	1-3	1-3
Total recurrent expenditure	**3-6**	**3-15**

Source: WASHCost, 2012, p. 2.

The cost of capital and expenditure on indirect support are not included in Table 45, owing to insufficient and unreliable sources of information. No extrapolations can be made concerning indirect support given the overall lack of data in the sector. Section 8.3 discusses how the cost of capital can be calculated.

8.2 Threshold for capital expenditure benchmarks

The interquartile ranges for capital investment suggest that the capital costs of preparing and installing a borehole with handpump (at 2011 prices) range from US$ 20 per person to just over US$ 60 per person. For small schemes, including mechanised boreholes and piped supplies, the costs range from US$ 30 to just over US$ 130 per person. For intermediate and larger schemes, benchmark capital costs vary widely from US$ 20 to US$ 152 per person (Table 46).

Table 46: Capital expenditure benchmarks for water services (US$ 2011)

Cost component	Primary formal water source in area of intervention	Cost ranges* [min-max] in US$ 2011
Total capital expenditure (per person)	Borehole and handpump	20-61
	Small schemes (serving less than 500 people) or medium schemes (serving 500-5,000 people) including mechanised boreholes, single-town schemes, multi-town schemes and mixed piped supply	30-131
	Intermediate (5,001-15,000) or larger (more than 15,000 people)	20-152

Source: WASHCost, 2012, p. 2.

8.3 Financing services through loans comes at a cost

Where grants have been used to support rural water supply, whether from taxes or international transfers, the direct cost of capital is zero. However, the cost of capital is incurred in two situations: where the capital to invest in water supply infrastructure is borrowed; or government or donors subsidise capital expenditure as grants or below the market rates for government borrowing (Franceys et al., 2011).

The 'real' costs of government and commercial borrowing found for each of the countries show that finance to scale up services could be accessed at relatively modest cost (Table 47). But, it is still a cost and one that is not currently being counted.

In Andhra Pradesh, the World Bank supported the Andhra Pradesh Rural Water Supply and Sanitation programme which incurred zero debt servicing interest payment costs as it was an IDA 'soft loan' with only repayment of principal required. Nominal government borrowing rates in India (2012) were reported at 8.9%. Removing the effect of inflation on borrowing, presently at 9%, indicates that the real rates of borrowing are as low as -0.1%, meaning that in real terms there may be small financial gain in taking these loans. This is an untypically low borrowing rate and is the result of the current global financial situation. A more typical government borrowing rate was found to be between 3% and 5% in real terms. HUDCO, a government housing and urban development finance body that supports water projects, lends at a nominal rate of 13%, which translates to 4% real rates once inflation is taken into account. Commercial banks that might support small scale providers are currently lending at 6% real rate of interest.

Table 47: Cost of capital – real and nominal rates per country, per type of borrower

Countries/ States	Borrowing from development banks or 'IDA' type soft loan	Government borrowing rates		Commercial borrowing to private providers real rates
		Nominal rates	Real rates (removing effect of inflation)	
Andhra Pradesh	Zero debt servicing – only repayment of principal required	8.9% (2012) 13% (HUDCO)	-0.1% (2012) 4% (HUDCO)	6%
Burkina Faso		4.2% (2012)	1.7% (2012)	10%
Mozambique		13.8% (2012)	5.1% (2012)	10.9%
Ghana		13.5% (2012)	4.9% (2012)	12.4% (Braimah, 2010)

Source: Franceys.R (Personal communication)

9 Conclusions and recommendations

This document reports findings from the application of a life-cycle costs approach developed by the WASHCost project in four countries. While the findings are specific to the countries and contexts in which this work was carried out, the framework for the categorisation of water supply technologies, service levels and cost components has been designed to have wider applicability; and a life-cycle costs approach can be applied in many countries.

However, linking expenditure to service delivery is not easy given the challenges of accessing and determining actual expenditure and levels of service, as well as the difficulties in precisely defining service areas, and thus the served and un-served populations within an unregulated domain. This should not be seen as simply a problem for researchers. Poor definition of service areas, poor specification of services and service levels and poor record keeping of actual expenditure all contribute to weak planning and management that is characteristic of the sector. The majority of service authorities and service providers in WASHCost countries and other developing countries have little or no idea of what service they are providing, to whom, or how much it costs.

9.1 Key findings from the country studies

According to the "improved/ unimproved" classification adopted by the UNICEF/ WHO Joint Monitoring Programme (JMP), villages and districts sampled by WASHCost in the four countries were considered to have 100% improved sources and therefore, "covered" by water services. However, when service levels were analysed in these areas using country norms and the four criteria of quantity, quality, accessibility and reliability, less than 50% of the population had access to a basic service. In fact, from all the data collected across all the countries, the vast majority were receiving inadequate water supply services; services that did not meet country standards and norms.

Low levels of service were found to be very costly. Independent of the water supply system, a high percentage of the population in many communities and regions across the four countries had no service improvements despite interventions that were aimed at improving water supply services. At the same time, annual capital expenditure was as high as US$ 512 per user for small mechanised borehole schemes in Burkina Faso, and US$ 425 per user in India for small multi-town schemes.

A key factor for these high values is the relative underuse of many piped sources. It was found that even when piped schemes are available, boreholes fitted with handpumps still play an important role in communities: both as a main source and as an alternative source when the piped scheme suffers from seasonal (and therefore predictable) source failure, poor (perceived) water quality, or regular and prolonged mechanical breakdown. Under various service delivery models in Andhra Pradesh, between 9% and 85% of residents do not use the piped scheme as their main supply. The unreliability of much of the formal infrastructure, and the effect on services and costs of the underuse of expensive systems are not generally recognised by most governments.

In Ghana, WASHCost findings suggest that in order to change from a borehole delivery model to a piped supply, a five-fold increase in initial capital expenditure is required (from a mean of US$ 19 to US$ 97 per user). This would double the number of users receiving a basic service, but they would still make up less than half of the population in the area. In Burkina Faso, indicative results also suggest that the users of small piped systems receive a much higher level of service than those using boreholes with handpumps; but this comes at a much higher per user cost (US$ 512 compared to US$ 63) as the piped systems sampled by WASHCost were more costly to construct, and were underused.

Additionally, it was found that more complex schemes with higher maintenance costs, do not necessarily provide better levels of service. For instance, in Andhra Pradesh, single-town schemes with a recurrent annual expenditure cost of US$ 3 per person provide a basic level of service to a lower percentage of users than what is achieved for users served by boreholes with handpumps which have a recurrent expenditure of US$ 0.1 per person per year.

Andhra Pradesh is unique in this study due to the co-existence of multiple piped systems and public and private water points in most of the communities analysed. To capture this aspect, expenditure and service levels were also analysed by service area, accounting for the combined contribution of all water sources. The primary finding from this study shows that although the vast majority of residents and households easily secure the minimum quantity of 20 litres per person per day, the poor performance and reliability of much of infrastructure means that many significant past investments in water supply assets have not been translated into improved water services for residents.

In Mozambique, a similar analysis per service area highlights some chronic problems with rural service delivery. Despite the existence of point sources and piped supplies, it is often the case that less than 5% of the population receive a basic service, reflecting low overall coverage levels and a highly dispersed rural population. Even when focusing on the services received by users of boreholes with handpumps or piped networks, service levels are still lower than in any other country sampled.

One problem identified in rural Mozambique was the poor reliability of boreholes and handpumps. There was some evidence from examination of operational expenditure for 50 such schemes to suggest that a minimum level of OpEx of around US$ 5-100 per year can be sufficient to deal with minor mechanical breakdowns and repairs. Although, there is also evidence that some schemes are simply problematic and still fail regularly despite high levels of OpEx.

Various cost drivers for capital expenditure were analysed in the four countries. As outlined in section 7.5, findings from country reports indicate that many factors influence capital expenditure but they are hard to isolate and fail to provide a consistent explanation. There is no single strong cost driver for capital expenditure or for recurrent expenditure, and some cost drivers cannot be extrapolated from one country to another or even between regions within the same country.

9.1.1 Findings for users of boreholes and handpump schemes

Andhra Pradesh has, in all comparisons, the lowest cost of building and maintaining water infrastructure. The capital expenditure for a borehole with a handpump built with government funds was found to be US$ 1,820. Across the sample area of the three African countries the mean cost of a borehole with handpump was highest in Burkina Faso at US$ 12,507. This is 40% higher than the US$ 8,922 spent in Ghana, and 44% higher than the US$ 8,660 spent in Mozambique.

Variation in the number of users means that capital expenditure per user for boreholes with handpumps ranges from the lowest values in Ghana (interquartile range US$ 17-21) and Andhra Pradesh (interquartile range US$ 11-22), to the highest values in Burkina Faso (interquartile range US$ 45-192). Comparing across countries, the lowest mean capital expenditure was US$ 19 per user for borehole and handpump schemes in Ghana and Andhra Pradesh, which may be regarded as the absolute minimum for any planning purposes. Mean recurrent operations and minor maintenance expenditure for borehole and handpump schemes are of a similar order of magnitude in all countries, ranging between US$ 0.1-1.0 per user per year; but for the majority of schemes expenditure is well below US$ 0.5 per user per year.

Boreholes and handpumps fail to supply a basic level of service to more than 51% of users in any of countries measured. In the African countries in particular, boreholes tend to be inaccessible to users and often fail to deliver the basic quantity of 20 litres per person, per day. In the state of Andhra Pradesh, the main barrier to service from boreholes with handpumps is not the quantity of water received by users, but frequent source failures, mechanical breakdowns and slow repair times.

9.1.2 Findings for users of piped schemes

Across the four country samples, mean capital expenditure on small and medium-sized piped schemes ranged from US$ 30 to US$ 130 per person (US$ 44 to US$ 512 per user). For intermediate and large systems, mean expenditure ranged from US$ 21 to US$ 193 per person (US$ 39 to US$ 333 per user).

Most piped schemes fail to provide a basic service supply to more than 50% of the population of users. The two exceptions are found in the intermediate single-town schemes in Ghana and the small single-town schemes in Burkina Faso. However, it has been shown that the Burkina piped schemes sampled are underused and that its higher service level comes at a high price of US$ 512 per user.

Across all sampled countries, users tend to receive a better service from piped schemes in comparison to borehole and handpumps. This however comes at a cost of higher initial capital expenditure, as well as a higher recurrent expenditure to maintain service delivery. Moreover, although there is wide variation of expenditure on different systems, it is apparent that due to economies of scale, larger systems tend to be 25-50% cheaper to construct than equivalent systems of a smaller size.

The mean recurrent operational and minor maintenance expenditure for all piped schemes was found to be between US$ 0.4 and US$ 4.8 per person per year (expenditure divided by the number of people in the area). Operational expenditure per user (expenditure divided by the number of people actually using the service) ranged between US$ 0.8 and US$ 6.6 per year for all schemes, except the underused small mechanised borehole systems in Burkina Faso where expenditure was much higher at US$ 33.0 per user. This annual OpEx constitutes between 1% and 8% of the initial capital expenditure for all piped approaches – the average percentage for all schemes was 4%. OpEx on piped schemes was found to be roughly 5-8 times higher than what is spent on boreholes and handpumps.

These operational costs, along with expenditure on capital maintenance and direct support make up total annual recurrent expenditure. For the numerous piped schemes sampled, values ranged between a mean of US$ 1.4 to US$ 5.8 per person, and between US$ 1.8 to US$ 6.7 per user (excluding the exceptionally high value from Burkina Faso).

A further element—most prominent in Andhra Pradesh—is household expenditure. Field data shows that in many communities, household expenditure can represent a significant proportion of total capital investment for water supply infrastructure. In some larger communities, more than half the sampled households had a private source. Extrapolating this level of private expenditure across other communities, expenditure by private individuals ranged from 20% to over 150% of what the government itself has spent. In small communities (<500 residents) with a piped system, there was much less investment in private sources, correlating with lower levels of household income.

9.2 Overall conclusions and recommendations

A “business as usual” approach in the WASH sector is expensive and provides very low value for money. Based on country sector reports and non-functionality data, it seems that at any one time, 40% of systems are not functioning; at any one time, 40% of investments are being wasted.

This situation can be corrected if, after new works and systems are built, people, systems and finances are put in place in the districts to monitor post-construction, and allocate funds for asset maintenance. Existing recurrent expenditure on operations and on capital maintenance are remarkably low and appear to have resulted in limited serviceability of assets and reduced service levels for consumers.

The data presents a mixed message in that it highlights the existing problems but also points to a solution. On the one hand, recurrent costs for rural water services are chronically underfunded, and this is associated with high observed levels of breakdown and low service delivery. On the other hand, by spending a relatively small amount of additional money in absolute per person terms, sustainability could be achieved. The problem is that this relatively small amount already represents 8-10 times the amount of current spending: rising for rural handpump based services from the current per capita expenditure of about US$ 0.50 per person per year to US$ 3-6 per person per year. For piped systems, ongoing finance requirements are greater at roughly US $ 3-15 per person per year; although this very much depends on the size of systems being sampled.

The figures mentioned above represent the threshold funds that need to be allocated per person per year as a necessary condition for sustainability. While in absolute terms these amounts do not seem much for a year-round supply of good quality and reliable drinking water, for many countries the suggested amount is still "too much" for available budgets and levels of economic development. An important message from the work emerging from WASHCost is therefore that without a clear commitment from government and donors to subsidise part of the recurrent costs over the long term, sustainable water services for the rural poor in developing countries will remain unachievable.

What is needed to continue the work that WASHCost has started?

The strength of a life-cycle costs approach developed by the WASHCost team is that it recognises the complexities of water delivery in each context, and seeks to compare the amount spent in supplying a service from all formal sources with the corresponding service levels. By bringing costs and service levels together it is possible to calculate the following:

- How much does it cost, on a yearly basis, to provide a specific level of service?
- Who is paying – or should be paying – for each of the cost components?
- What modalities will be used to fund recurrent expenditure every year?
- Is it affordable for all the stakeholders involved?
- Do service delivery models need to be revisited to ensure that they last?
- Can we get more value for money from existing capital investments?
- Can we provide a basic level of service to everyone?

The methodology has enabled the comparison of costs against service levels in each of the regions, but it has also demonstrated that a life-cycle costs approach is flexible enough to be adapted in different contexts. The approach may also be adapted (selectively or in its entirety) by organisations that wish to understand better the sustainability of their respective service delivery models. The most complex aspect of applying the methodology is in making costs explicit for a specific geographic area where many stakeholders operate.

Data was readily available at household and community level, and provided good quality and relevant data on service levels. However, real expenditure data at national, regional and district level was not readily available. In general, getting hold of good quality completed project reports is difficult. Most NGOs that installed water points no longer exist, taking cost knowledge along with them. Gathering cost data older than three years continues to be a problem for projects implemented by governments, NGOs and/ or the private sector. Even when expenditure information is available, it primarily exists in the form of lump sum amounts rather than disaggregated costs, especially for water point sources. Often, the only information found is a headline figure (e.g., 400 boreholes with handpumps in three districts).

In some countries, Bills of Quantities or Schedule of Rates guide budgets and contract arrangements, and are taken very seriously as arbiters of costs. These documents refer only to capital expenditure and "official costs" in WASHCost research were often underestimated, except in Burkina Faso[50]. Problems arise when reconciling data collected at village level with official government figures since there is a tendency for stakeholders not to validate cost data collected from villages.

Adopting a life-cycle costs approach can trigger the necessary mindset change and increase the pace of improvements towards sustainable services. But many challenges remain, and work needs to continue to overcome them.

- The only way to have relevant, up to date costs which relate with the service levels really provided is if reporting systems begin including indicators of sustainability (or serviceability over time), and expenditure per person per year. There is no cost data available in the WASH sector because no one asks; governments, donors and NGOs need to ask the right questions, and set up systems to deliver the answers.
- The challenge of financing post-construction in areas with very low income levels is very real and pressing. Direct support and capital maintenance are costly but they are not budgeted for and not happening. The question of how the sector can finance these needs costs to be addressed.
- Defining accountability mechanisms towards recurrent expenditure to ensure (financial) sustainability is complex. Contracts between donors and service providers are, in practice, limited to a maximum of five years. In many instances, monitoring systems at national level are weak, and no one monitors what happens after implementation. Monitoring processes usually ceases three to five years after the contract has been signed.

However, while limited, incomplete cost data is better than no cost data at all. Once gaps in data sets have been identified, realistic costs can be calculated. For recurrent expenditure, sector professionals experienced in running water services can be brought together to develop realistic budgets for post-construction support.

Using the WASHCost life-cycle costs approach and shifting from delivering technologies to delivering services have significant programmatic implications. They require changes in the design, scale and timing of contractual arrangements by all those involved, including service authorities, service providers and external support agencies.

50 In Andhra Pradesh, Standard Scheduled Rates are used to arrive at unit costs. These are revised regularly but are often found to be lower when compared with market prices. In Mozambique and Ghana, engineer estimates are made to complete project-specific Bills of Quantities, which are usually lower than the real expenditure. Real expenditure is found in completion reports. In Burkina Faso, the opposite takes place: boreholes with handpumps cost less than the guiding official rates for capital investment and rehabilitation. For small network schemes, investment costs can sometimes be higher or lower than the guiding rates.

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Annexes

Annex 1 Capital expenditure per person and per user at purchasing power parity

Service area size	Service delivery model	Mean capital expenditure per person in a service area (per user) at purchasing power parity (US$ 2010)						
		Andhra Pradesh gov't	Andhra Pradesh HH	Burkina Faso	Ghana	Mozambique	Range of expenditure per person	Range of expenditure per user
-	Borehole and handpump	63 (46)	29	178 (148)	24 (24)	71 (71)	24-178	24-148
Small	Mechanised borehole	119 (134)	10	131 (1201)			119-131	134-1201
	Single-town schemes	197 (-)					197	
	Multi-town schemes	180 (1035)	7				180	1035
	Mixed piped supply	180 (-)	5				180	
Medium	Mechanised borehole	73 (144)	49				73	144
	Single-town schemes	117 (258)	44		166 (166)		117-166	166-258
	Multi-town schemes	83 (107)	41				83	107
	Mixed piped supply	139 (205)	32				139	205
Range for small and medium piped schemes							**73-197**	**107-1201**
Intermediate	Single-town schemes	76 (-)			110 (110)	444 (765)	76-444	110-765
	Multi-town schemes	105 (141)	105		134 (134)		105-134	134-141
	Mixed piped supply	51 (95)	78				51	95
Large	Single-town schemes				46 (46)	195 (239)	46-195	46-239
	Multi-town schemes				98 (98)		98	98
Range for intermediate and large piped schemes							**51-444**	**46-765**

Annex 2 Recurrent expenditure per person and per user at purchasing power parity

Service area size	Service delivery model	Mean recurrent expenditure per person in a service area (per user) at purchasing power parity (US$ 2010)					
		Andhra Pradesh gov't	Burkina Faso	Ghana	Mozambique	Range of expenditure per person	Range of expenditure per user
-	Borehole and handpump	1.0 (1.0)	0.5 (0.5)	1.4 (1.4)	0.7 (0.7)	0.5-1.4	0.5-1.4
Small	Mechanised borehole	8.3 (12.4)	8.0 (77.4)			8.0-8.3	12.3-77.4
	Single-town schemes	18.5 (-)				18.5	
	Multi-town schemes	7.3 (19.0)				7.3	19.9
	Mixed piped supply	8.0 (-)				8.0	
Medium	Mechanised borehole	4.1 (6.8)				4.1	6.8
	Single-town schemes	5.4 (7.6)		4.8 (4.8)		4.8-5.4	4.8-7.6
	Multi-town schemes	6.6 (8.0)				6.6	8.0
	Mixed piped supply	9.5 (12.4)				9.5	12.4
Range for small and medium piped schemes						**0.5-18.5**	**0.5-77.4**
Intermediate	Single-town schemes	3.4 (-)		7.4 (7.4)	8.7 (14.9)	3.4-8.7	7.4-14.9
	Multi-town schemes	5.4 (8.3)				5.4	8.3
	Mixed piped supply	3.7 (4.4)				3.7	4.4
Large	Single-town schemes			2.9 (2.9)	11.5 (15.6)	2.9-11.5	2.9-15.6
	Multi-town schemes			6.4 (6.4)		6.4	6.4
Range for intermediate and large piped schemes						**2.9-11.5**	**2.9-15.6**