WASHCost

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Burkina Faso

Household expenditure on water service

Financial and economic expenditures of rural and peri-urban households across socio-economic classes and seasons in Burkina Faso

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COVER PHOTO
Women fetching water at the village of Dossi, west of Burkina Faso (by Pascal Dabou).

LAYOUT
Cristina Martinez, IRC

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WASHCost was a five-year action research programme, led by IRC, running from 2008 to 2012 with partner organisations in Burkina Faso, Ghana, Andhra Pradesh (India) and Mozambique. WASHCost collected and analysed cost and service level information for water, sanitation, and hygiene in rural and peri-urban areas, applying a life-cycle costs approach. A life-cycle costs approach examines the complex relationships between expenditure, service delivery, poverty, effectiveness and sustainability (see www.washcost.info)

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Abbreviations

CapEx	Capital Expenditure
CapManEx	Capital Maintenance Expenditure
CFA	*Communauté Financière d'Afrique franc* (West African franc, monetary code XOF, Burkina Faso)
DGRE	*Direction Générale des Ressources en Eau* (National Department for Water Resources. Burkina Faso)
GDP	Gross domestic product
GIS	Geographic information system
HH Dry	Household surveys conducted during the dry season
HH Wet	Household surveys conducted during the wet season
JMP	Joint Monitoring Programme
lpcd	Litres per capita per day
NP	Non-Poor household
ONEA	*Office National de l'Eau et de l'Assainissement* (National Office for Water and Sanitation, Burkina Faso)
OpEx	Operation Expenditure
$OpEx_{ECON}$	Economic Operation Expenditure
P	Poor household
VP	Very Poor household
WASH	Water, sanitation, and hygiene
Wtpt1	Preferred water point (Wtpt2, second preferred water point, etc.)

Variables

Summary of select variables used in this research[1]:

Variable	Units	Definition
Variables normalised per person		
CapEx	US$/ person	Capital expenditure (includes money, labour and materials)
CapManEx		Capital maintenance expenditure (includes money, labour and materials)
OpEx1		Annual financial operating expenditure (yearly estimates) per person
OpEx2* (aka OpEx$_{FIN}$)		Annual financial operating expenditure (daily estimates) per person
Financial_EX		Total financial expenditure on water per person per year
OpExeconA	US$/ person/ year	Economic expenditure (opportunity costs) calculated using empirical data to determine transportation mode carrying capacity
OpExeconB* (aka OpEx$_{ECON}$)		Economic expenditure (opportunity cost) calculated using field observations to determine transportation mode carrying capacity
Cumm_Ex		Cumulative expenditure (financial and economic) on water per person per year using dry season (eight months) and wet season (four months)
Rev_Ex		Total household income normalised per person per year
Exp_Ex		Total expenditure on all goods and services per person per year
water_use	litres/ person/ day	Per person daily water consumption
Variables normalised by household		
OpExfin_TOT*		Annual financial operating expenditure (daily estimates) per household
Financial_TOT		Total financial expenditure on water per household per year
OpExecon_TOT*		Household annual economic expenditure (opportunity cost) calculated using field observations to determine transportation mode carrying capacity
Cumm_TOT	US$/ household/ year	Cumulative expenditure (financial and economic) on water per household per year
Rev_TOT		Total annual household revenue
Exp_TOT		Total annual household expenditure
HH_size	# people/ household	Number of members in each household
HH_water_use	litres/ household/ day	Total household daily water consumption
INV-4	US$/ household/ day	Daily amount paid for filling all receptacles (all sources)
INV-8	US$/ household	Value of investment in implementation of infrastructure (all sources)
INV-10	US$/ household/ source	Value of investment on repairs (per source)
INV-13	US$/ household/ year	Estimated yearly expenditure on water (all sources)
Miscellaneous variables		
Collxn_time	minutes/ day	Minutes per day dedicated to collecting water for each household
INV-11	US$	Current cost of containers used to transport water
INV-12	US$	Current cost of storage containers
Wtpt1_dist	metres	Distance to first preferred water point (wtpt2 is second point, etc.)
Wtpt1_trips	# trips	Number of trips from the water point to the household for transporting containers
Financial_%_income	%	Financial expenditures as a percentage of household income (OpEx$_{FIN}$, OpEx$_{ECON}$, and Cumulative expenditures are also similarly normalised)
Financial_%_expenes		Financial expenditures as a percentage of household expenses (OpEx$_{FIN}$, OpEx$_{ECON}$, and Cumulative expenditures are also similarly normalised)

[1] Exchange rate used: US$ 1 = 502.271 CFA (December 2011).

Executive summary

Capturing how much time and money households are spending on water, sanitation and hygiene is notoriously underreported in census and other national surveys. Most research into the subject is limited to analysing tariffs paid to water vendors or is based on proxy indicators of income.

Financial expenditures refer to the financial transactions (e.g., tariffs, user fees) incurred by households, while economic expenditures refer, in this paper, to the time spend on fetching water. Economic expenditure is particularly relevant in the context of gender roles and the unfair burden set on women and girls, resulting in a reduction of time available for other household, educational or productive activities. This tends to exacerbate gender differences in school attendance, with negative results for the families and the overall economy.

The research presented in this paper analyses household expenditure (financial and economic) on formal water sources, in rural and peri-urban areas, and across socio-economic groups and season (wet/ dry). It also defines and compares the level of water service received by different socio-economic groups using quantity, water quality monitoring, distance and crowding as the criteria.

Methodology

Data was collected in nine sites in the North, Center, and Hauts-Bassins regions of Burkina Faso between April and August 2010 as part of the WASHCost project. Census data was collected from 7,399 households, followed by detailed household surveys collected in 492 household for the dry season and 518 households for the wet season. 363 households were visited in both seasons. The household survey data was complemented with 7,854 individuals surveyed at 87 water points (out of the 133 water points in the nine sites). Households were also found to collect water from numerous traditional sources located in the communities.

In this paper, four categories of information were collected and analysed: financial costs, economic costs, service level indicators and poverty status.

The *financial expenditures* captured were based on the life-cycle cost categories developed by WASHCost. Life-cycle cost categories include one-time expenditure, capital expenditures or CapEx, given in US$/ person, and recurrent expenditures (capital maintenance or CapManEx and operation expenditure or OpEx) given in US$/ person/ year. Other recurrent expenditures such as direct and indirect support expenditures were found to be irrelevant in the case of household expenditure and therefore were not considered in this research. Since none of the households paid capital costs for accessing water—the Cost of Capital category was also not referred to.

Economic expenditures were calculated from the sum of time dedicated to the collection, transport and storage of water, multiplied by the financial value of this time. To capture economic expenditures made by households, estimates were made from data obtained from the household and water point surveys. This data included: 1) type and number of containers used to collect water at each water point, 2) distance from the household to their primary, secondary, and tertiary water points, 3) the time spent queueing at each water point, 4) the type of transportation used to arrive at each water point and to carry water to and from the house, and 5) annual household income.

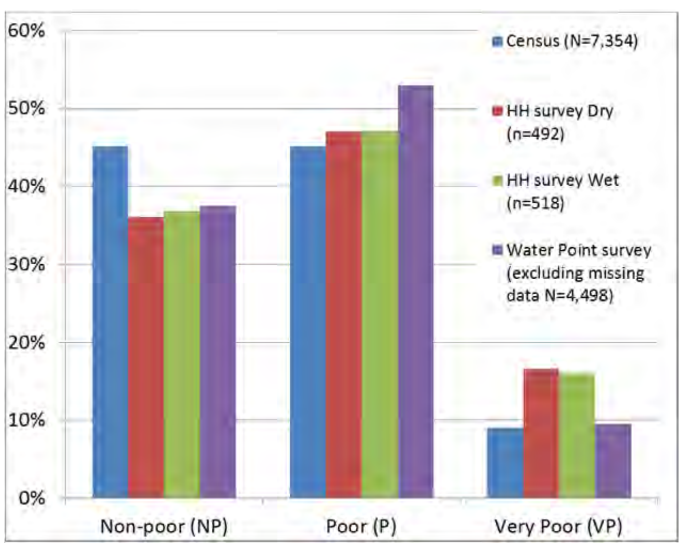
Defining *service level indicators* was a necessary condition for comparing costs across geographic regions. The indicators that are used in WASHCost to define a water service include: 1) the quantity of water used by households, 2) the quality of the water provided, 3) the accessibility of the water sources (distance or time required to access the water source(s), and 4) the reliability of the service (i.e., functionality).

The service level categories used in WASHCost are presented in a five-category "ladder": No service, Sub-standard service, Basic service (matching country norms), Intermediate service and High service. The benchmarks used to determine these categories were derived from national norms and standards in each country. In Burkina Faso, a Basic level is achieved with 20 litres per person per day in rural areas and 40 litres per person per day in urban areas, while accessibility (i.e., distance and crowding) is defined according to the system. For a handpump, a Basic level of service is provided when the distance does not exceed 1km and crowding is limited to 300 users per day, whereas a Basic level of service for a standpipe is reached within 500 metres and reaches up to 500 people per day.

To determine the service level for each individual household, data was obtained from the household surveys (e.g., distance to water points, volume of water consumed daily), water point surveys (e.g., number of people observed using individual water points), and government records (e.g., design capacity of water provision technologies). In Burkina Faso the water quality data collected did not include sufficient detail to accurately compare water quality across all technologies and communities. As the reliability indicator was not considered in the Burkinabè policy, reliability was excluded from the service level analysis, and the water quality indicator was modified. As a result, the quality indicator in this paper is termed "water quality monitoring" and is determined by the source type (e.g., formal or informal) and the frequency with which water quality testing is conducted. The authors recognise that although the frequency of water quality testing could be a useful proxy for the quality of service—it can NOT be used as a proxy for water quality.

Finally, in this paper, *poverty* has been measured using a participatory assessment of socio-economic status classified in three groups: Non-Poor (NP), Poor (P) and Very Poor (VP). For this indicator, poverty is defined locally based on perceptions of well-being and how neighboring informants rank this perception. WASHCost Burkina Faso conducted focus group sessions in each of the nine communities where data collection took place to determine existing socio-economic status. Criteria used included access to adequate food, clothing, housing, and agricultural lands.

Socio-economic status distribution across communities included in the research



Key findings on financial and economic costs

The annual per person costs for water supply technologies used in the nine communities in Burkina Faso are shown in the table below. The technologies designed to provide higher service levels (i.e., private connections) required higher financial contributions, but lower economic contributions. Households with private connections spent three times as much per person per year as those accessing handpumps. However households with private connections and standpipes benefited from the close proximity of their water source (either at home or located less than 500 metres away) and dedicated four to six times less in terms of time to collect water. Because those households with private connections and standpipes had a higher value of time, derived from the annual income, the opportunity costs of these households were higher, on average, than households using handpumps.

Financial and economic cost spent on primary water point by technology. Sample size is shown (N).

Water supply Technology	N	Financial_EX (US$/ person/ year)	Opportunity costs of water collection		
			OPEXecon (US$/ person/ year)	Time investment (min/ person/ day)	Value of time (CFA/ person/ hour)
Private connection	16	$ 23.5	$ 9.5	2.4	88
Standpipe	323	$ 15	$ 7.5	4.0	57
Handpump	382	$ 8	$ 7.5	14.5	29

In the communities in Burkina Faso where the research took place, capital expenditure on water sources was on average, US$ 1.5 per person—however only 37% of households reported making a contribution to the installation of a water system (CapEx). Similarly, only one third of households made some additional contribution towards the renewal and/ or replacement of their water system, averaging US$ 2 per person per year. Most of this expenditure was directed towards the replacement of their equipment to collect, transport and store water. Financial operating expenditure (OpExFIN) ranged from US$ 7.5 in the wet season to US$ 9.5 per person per year in the dry season.

As expected, the economic costs for collecting, transporting and storing water for households further from their primary source was high when compared with households with a water source closer to their homes. Households with less reported income consumed less water but spent approximately twice as much time collecting water. However, considering the lower value of their time, their calculated opportunity costs were lower.

Both the wet and dry seasons and a rural or urban context affected household financial expenditures significantly.

In areas where the primary source was not functioning, households travelled 60% further in the dry season to access their secondary water source. In the dry season, household financial expenditure increased by approximately US$ 1.5 per household per month (25%), and economic expenditure increased by approximately US$ 2 per household per month (87%). For economic expenditure, the average ranged from US$ 5 in the wet season to US$ 9 per person per year in the dry season. Assuming that Burkina Faso had four wet season months and eight dry season months, the average cumulative expenditures was US$ 19.5 per person per year.

Rural households had lower financial expenditure but higher annual economic expenditures per person per year than peri-urban households of the same size. Controlling for seasonal differences, compared to peri-urban households, rural households spend, on average—US$ 17.5 per household per year less in financial terms. No statistically significant difference between rural and peri-urban communities was observed for economic and cumulative expenditures. Households with an additional member spent US$ 2.5 per household per year less in economic terms and US$ 5 per household per year more in financial terms.

Key findings on poverty and service levels received

Overall, one third of rural households and one sixth of urban households do not receive any service. Rural households fare poorly compared to their urban counterparts for distance to their source, water quality monitoring and quantity. 29% of rural households met part of their domestic needs with unsafe water, and 7% for urban households.

In rural areas, one third of households received less than 20 lpcd. The further away the primary sources, the less quantity of water consumed by the household: a primary source that is 100 metres futher would reduce the quantity of water consumed by 1.6 liter per person per day). Non-Poor households consumed approximately 6 litres per person per day more than Poor or Very Poor households. Households had to spend an additional 1000 CFA (US$ 2.00) per year per person to receive an extra litre of water per person per day, putting the implied marginal financial cost of a cubic meter of water (1,000 litres) at 2,740 CFA (US$ 5.5).

At secondary sources, the Very Poor and Poor households experienced greater crowding than the Non-Poor households. Crowding was assumed to exist when more than: ten people used a private connection, 300 people visited a borehole with handpump, or 500 people visited a standpipe. These are the design thresholds used by the Burkinabè government, and when the daily number of users exceeds these thresholds it is expected that the availability of water will be insufficient.

Interestingly, a larger percentage of households was more likely to cite an informal water source as their primary source in the wet season (39 of 430 households) when compared with the dry season (2 of 422 households). Compared to the formal sources, which are protected, the informal sources in the research communities were at a higher risk for contamination.

Different service levels are associated with different costs. Providing "No Service" was found to be costly and the largest financial cost differences were associated with, on one hand, capital expenditure: going from a Sub-Standard service to a Basic service and, on the other hand, recurrent yearly expenditure: climbing from Basic to higher service levels (see table on page 10). This movement had implications for the type of service chosen and the requirements on regular financial expenditures.

Not surprisingly, from an economic perspective, it cost more to have No Service (US$ 7.5/ person/ year) than the Sub-Standard or Basic levels of service (US$ 6-6.5/ person/ year) (see table on next page). Economic expenditures were directly related to the time spent collecting water. Fetching more water from a public water point (standpipe or handpump) required more time: often households using public water points had lower household income and as such, a lower value of time compared to those who can afford a private connection. This is the reason that the economic expenditures were also high for those with high service levels.

Households with higher financial recurrent expenditure received better services in terms of accessibility, and consumed more water. It can therefore be concluded that households with closer and less crowded primary sources have been willing to use and pay more for their water services.

The difference in services received by the Very Poor, Poor and the Non-Poor was striking. Although the Very Poor spent as much as other income groups in financial terms and more when considering the time dedicated to water collection, no Very Poor household received a High level of service.

Average capital and recurrent costs per service level

Service level category	CapEx (US$/ person)	Recurrent expenditure				
		CapManEx (US$/ person/ year)	OpExfin (US$/ person/ year)	OpExecon (US$/ person/ year)	Financial_EX (US$/ person/ year)	Cumm_EX (US$/ person/ year)
High	$ 3	$ 1	$ 37	$ 10	$ 38	$ 36
Intermediate	$ 4	$ 3.5	$ 17	$ 12	$ 20	$ 32
Basic	$ 3.5	$ 2	$ 8	$ 6	$ 10.5	$ 20.5
Sub-Standard	$ 0.5	$ 2	$ 8	$ 6.5	$ 10	$ 16
No Service	$ 1.5	$ 2	$ 6	$ 7.5	$ 9	$ 18.5

Contrary to expectations, the absolute financial and economic expenditure did not vary between different socio-economic strata. However when comparing water expenditure relative to total household reported expenditure or income, there was a difference between Very Poor households and the Poor and Non-Poor. All households had financial expenditures between US$ 10 and US$ 11.5 per person per year, yet the income of Non-Poor households was 3.5 times higher, on average, than that of the Very Poor households.

Financially, the Very Poor expenditure represent 8% more relative to their total household expenses compared to all other households when controlling for the effects of season, size and rural-urban differences. About 23% of the Very Poor household expenses go to water versus about 14%-15% for the Poor and Non-Poor. Financial expenditure on water as a percentage of household income was found to be well above the affordability threshold of 5%—a common benchmark used in the sector. This raises serious concerns about equity and non-discrimination.

Absolute expenditures were found to be shockingly high in the Burkinabè context. Households that used a handpump as their primary source spent an average of US$ 8 per person per year—16 times higher than the US$ 0.50 (250 CFA) per person per year affordability target that the Burkina government uses for households accessing a handpump. Existing water subsidies were limited to urban areas operated by the ONEA, and not targeted to any specific customer income category.

In conclusion, the research findings suggest that targeting subsidies to increase private connections amongst the low-income urban population would lead to financial savings, in addition to enabling a significant decrease in economic expenditure. While a pro-poor policy in rural area is more complex to achieve because of the prevalence of alternative water sources, it is not impossible. Should a pro-poor policy be developed for these areas, as a priority it would need to address the low functionality rate of formal sources in the dry season (to the benefit of all poverty categories) and provide strategic support—such as point-of-use treatment options—so that households may continue to rely on informal sources. These forms of self-supply are ways used by households to cope with over-crowded, distant or expensive formal water points—these will also need to be retained. Finally, an important issue uncovered by the research is the large proportion of population utilising water sources whose water quality is not being monitored. This is clearly a public health risk that must be addressed along with the issue of water service affordability.

1 Introduction

Research has demonstrated the inequality in access to improved water sources between rich and poor households. The most recent Joint Monitoring Programme (JMP) report showed 97% access to improved water sources for the richest quintile in urban areas worldwide, while only 10% of the poorest quintile in rural areas had similar access (WHO/ UNICEF, 2012). Often the poor pay more for their services. For example, in Jakarta, Lima, Manila and Nairobi, households living in informal settlements and low-income settlements typically pay 5–10 times or more for their water than high-income residents of the same city (UNDP, 2006).

Most of the present research on household expenditures on water is limited to financial expenditure and based on self-reported aggregate expenditure on water, mainly from private water vendors (Keener, Luengo, and Banerjee, 2010). In addition, considering the economic expenditure related to water (i.e., opportunity costs of water collection, transport, and storage) is very import when determining the total cost of water services for households.

Economic expenditure is particularly relevant in the context of gender roles and the household division of labour. It is well established that water collection is more commonly carried out by women and girls (Hutton and Haller, 2004). For adult women, water collection reduces the time available for other activities including child care, productive work or rest which reinforces time-poverty, disempowers women and lowers household income. This tends to exacerbate gender differences in school attendance and lower school attendance for girls, and has significant and far-reaching consequences. Educated girls are more likely to have smaller, healthier families as adults and their children are less likely to die and more likely to receive an education than children of less educated mothers (Pushpangadan, 2000).

Analysis of household economic expenditure on water services in developing countries has primarily taken place through demand estimation studies—almost all of which were conducted in medium to large-sized cities focusing on piped household connections (Nauges and Whittington, 2009). Few focus on non-tap sources (Nauges and Strand, 2007) or communities with less than 10,000 inhabitants (Mu, Whittington and Briscoe, 1990) and fewer provide empirical evidence about the financial costs of collecting water from non-tap sources (Nauges and Whittington, 2009). This research analyses total household expenditure— including both financial and economic (i.e., opportunity costs)—on water services and seeks to rectify the lack of information on this topic. Determining the total expenditure made by households in rural and peri-urban areas is not only novel, but most importantly, useful to understanding the decisions that households make/ are forced to make regarding water services. This information is also necessary for those designing policies that address poverty, health, and equity. Furthermore, this research is timely considering the development of the post-2015 monitoring framework, which is likely to include indicators for equity and inclusion, and the affordability of water services.

This research complements analyses developed under the WASHCost project about the life-cycle costs of water systems (boreholes, piped networks) and the service levels they provide to rural and peri-urban populations in Burkina Faso (Pezon and Bassono, 2012; Pezon, 2013). Burkina Faso is one of the poorest countries in the world, with a gross domestic product per capita of 219,843 F CFA or US$ 438 (IMF, 2011).

The first objective of this research is to determine how household expenditure—financial, economic, and cumulative—on formal water sources varies across socio-economic status in rural and peri-urban areas. The second objective is to characterise this expenditure and the water service levels (i.e., quantity, quality, distance and crowding) provided to the households and their socio-economic classification. The final objective is to uncover any seasonal differences in household expenditure or additional factors that may influence household expenditure on water services.

The methodology used in this research is described in Section 2 and a summary of the findings is presented in Section 3. The expenditures are described (Section 4) as well as the service levels (Section 5), followed by the conclusions (Section 6) and implications of this research (Section 7).

2 Methodology

2.1 Sample strategy

Data were collected in nine sites in three regions of Burkina Faso between April and August 2010 as part of the WASHCost project[2]. Table 1 provides an overview of the nine data collection sites. The table shows that three peri-urban and six rural sites were included, and the population of the sites ranged from 1,519 to 15,014.

Table 1 Overview of the Burkina Faso sites **selected for data collection**

Region	Site	Density	Population
North	Ouahigouya, Sector 1	peri-urban	7,418
	Aorema	rural	4,096
	Margo	rural	2,101
Hauts-Bassins	Hounde, Sector 2	peri-urban	1,568
	Bouere	rural	7,299
	Dossi	rural	3,688
Centre	Ougadougou, Sector 30	peri-urban	15,014
	Yagma	rural	1,519
	Komsilga	rural	1,704

Source: WASHCost Census.

A general census was conducted between April and June 2010. In addition to demographic information about the household and *concession* (i.e., family compound), detailed surveys were conducted in randomly selected sub-set of households to determine information on user preferences and behaviour related to water, sanitation and hygiene. A second sample of households was selected and surveyed in August 2010 to capture the variation in WASH practices between the dry and wet seasons. In addition to the household surveys, data were collected at 87 out of 133 water points in nine communities over 37 days between April and August 2010. Table 2 provides an overview of the information collected.

[2] For more information on the WASHCost methodology, see: Moriarty, et al., 2010.To access the reports from Burkina Faso as well as all other WASHCost documents visit www.washcost.com.

Table 2 Overview of data collection tools and results used for nine Burkina Faso sites

Census	Household surveys	Water point surveys
7,399 households	492 households (Dry season)	7,854 individuals surveyed
GIS data of concession	518 households (Wet season)	GIS data of 87 water points
Household size	363 households (both)	Household information
Water source	GIS data of concession	Name/ age of water collector
(1st and 2nd preferred)	Household information	Container type/ quantity
Daily water usage	Water point information	Number of trips
Sanitation type	Daily water usage	Total quantity of water
Qualitative socio-economic status	Collection containers	Time at water point
Data collected in the Dry season only (April-June)	Satisfaction	Transportation mode
	Water Storage/ transport	Improved water points only
	Sanitation/ hygiene information	Dry season April-June (n=6,928)
	Assets/ income/ expenses	Wet season August (n=954)

Looking at household size and water usage (table 3)[3], there is a noticeable difference between the averages for the census and the detailed household surveys in both the wet (HH Wet) and dry (HH Dry) seasons. The average household size is smaller in the census as compared to the detailed household surveys. This could be because in the household surveys in the dry and wet season, Non-Poor (NP) households, which are typically smaller, were under-represented and Very Poor (VP) households, which are typically larger, were over represented (See section 2.2.3 for more details).

The difference in water usage between the census (conducted in the dry season) and the detailed household survey from the dry season is likely attributable to the difference in how the data were obtained in the respective surveys. Respondents in the census were asked to directly estimate the average amount of water collected each day, while in the detailed household survey the respondents were required to review the type and number of containers used to collect water each day. The latter survey was more in-depth and involved several triangulation questions that were used to validate responses.

Comparing the HH Dry and HH Wet data, the only statistically significant difference observed was for water usage in rural areas during the wet season (table 3). This was expected as a rural household can more easily access informal water sources, which are more abundant during the wet season, and hence is likely to draw less water from formal water sources. Overall, households were 19 times more likely to cite informal sources as their primary source in the wet season (39 of 430 households) versus in the dry season (2 of 422 households).

[3] Water usage data from each survey were analysed and extreme outliers were removed following accepted methods (Tabachnick and Fidell, 2007). The following numbers of cases were removed from each source: 23 HH Dry, 20 HH Wet, and 296 Census, all subsequent analyses excluded these cases.

Table 3 Household size and water usage in rural and peri-urban areas

Data source		Household size (persons/ household)		Water usage (L/ person / day)	
		Average	Standard Deviation	Average	Standard Deviation
Rural	Census	6.7	4.8	27.0	14.2
	HH Dry	8.9	5.0	39.8	25.0
	HH Wet	8.8	5.0	28.4	24.5
Peri-urban	Census	5.5	3.8	33.7	15.9
	HH Dry	6.6	3.6	43.8	25.0
	HH Wet	6.7	3.1	41.1	23.6

2.2 Service levels

Moriarty, et al. (2011) developed the use of water service levels in WASHCost in order to provide a framework for aggregating and benchmarking critical indicators of water services for use in planning and analysis. Defining service levels is a necessary condition for comparing costs; for example in comparing the costs between management models or across geographic regions. The indicators that are used in WASHCost to define service levels include: 1) the quantity of water used by households, 2) the relative quality of that water[4], 3) the accessibility of the water source, and 4) the reliability of the service (i.e., functionality). The service level categories used in WASHCost are: 1) High, 2) Intermediate, 3) Basic, 4) Sub-Standard, and 5) No Service. Table 4 has a summary of the service level categories.

The benchmarks used to determine these categories were derived from national norms and standards in each country. A more complete discussion on how these service levels and benchmarks were determined for Burkina Faso is provided by Pezon and Bassono (2012). The benchmarks and corresponding service level categories are provided in table 4. To determine the service level for each individual household, data were obtained from the household surveys (e.g., distance to water points, volume of water consumed daily), water point surveys (e.g., number of people observed using individual water points), and government records (e.g., frequency of water quality testing, design capacity of water provision technologies).

WASHCost service level categorisation includes reliability of services as an indicator; however the government of Burkina Faso does not have a benchmark for this indicator—reliability is excluded from the overall service level determination and the subsequent analyses presented in this report. In addition, it is important to note that the thresholds or benchmarks are different in rural and peri-urban areas for the Quantity indicator. Also, the Accessibility indicator is based on the system or technology (e.g., for a handpump, the distance is 1km max and crowding 300 users per day, whereas a standpipe is 500m away max and supplies 500 people per day). Finally, the Water quality monitoring indicator is determined by the source type (e.g., formal/ informal) and the frequency of the monitoring of that source. The authors recognise that although the frequency of water quality testing could be a useful proxy for the quality of service, it can NOT be used as a proxy for water quality. In addition, research has demonstrated that water quality can deteriorate significantly between the source and the household (Gundry, et al., 2006), suggesting that the most meaningful way to gauge water quality is to measure

[4] In Burkina Faso the water quality data collected did not include sufficient detail to accurately compare water quality across all technologies and communities, therefore the frequency of water quality monitoring activities was used as the service level indicator.

it at the point of use. Section 5.4 further discusses the water quality monitoring indicator considered in this research.

Table 4 Water service level indicators and the corresponding source of data for each

<table>
<tr><th rowspan="2">Service level categories</th><th rowspan="2">Quantity (litres/ capita/ day)</th><th rowspan="2">Water quality monitoring</th><th colspan="2">Accessibility</th></tr>
<tr><th>Distance from household</th><th>Crowding</th></tr>
<tr><td>Data Source</td><td>Household surveys</td><td>Burkina Faso government</td><td>GIS information</td><td>Burkina Faso government and water point surveys</td></tr>
<tr><td>High</td><td>Rural
X ≥ 60 lpcd
peri-Urban
X ≥ 100 lpcd</td><td>Formal sources
Annual testing</td><td>Household connection</td><td rowspan="3">Population observed at water point is less than or equal to design population</td></tr>
<tr><td>Intermediate</td><td>Rural
60> X ≥ 40 lpcd
peri-Urban
100> X ≥ 80 lpcd</td><td rowspan="3">Formal sources
Tested once at installation or rehabilitation</td><td rowspan="3">Handpump
X ≤ 1,000 meters
Standpipe
X ≤ 500 meters</td></tr>
<tr><td>Basic</td><td>Rural
40> X ≥ 20 lpcd
peri-Urban
80 > X ≥ 40 lpcd</td></tr>
<tr><td>Sub-Standard</td><td>Rural
20> X ≥ 5 lpcd
peri-Urban
40 > X ≥ 10 lpcd</td><td rowspan="2">Population observed at water point is greater than the design population</td></tr>
<tr><td>No service</td><td>Rural
5 > X lpcd
peri-Urban
10 > X lpcd</td><td>Formal sources
No testing
All informal sources</td><td>Handpump
X > 1000 meters
Standpipe
X > 500 meters</td></tr>
</table>

Key: GIS-Geographic Information System; lpcd- litres per capita per day
NB: The first column lists the service level categories, and subsequent columns contain the thresholds or benchmarks which define each category.

Consistent with methods used in WASHCost, each household received an overall service level score by identifying the lowest individual indicator score. Refer to table 4 and the following example to understand how the overall score is determined. A hypothetical household in a peri-urban area is considered, with access to a single water source that is: 1) close by (i.e., Distance indicator = High), 2) monitored frequently (i.e., Water Quality Monitoring indicator = High), and 3) has few people using it (i.e., Crowding indicator = High). However, if the source can only provide 30 litres/ person/ day (i.e., Quantity indicator = Sub-Standard) then the overall service received by this peri-urban household is actually Sub-Standard. A rural household with similar results is considered as receiving a Basic level of service: 20 litres/ person/ day is the threshold for Basic level in quantity in rural areas.

2.3 Socio-economic status

Socio-economic status or poverty can be measured in absolute and relative terms. The former affords the advantage of comparison between different geographic locations and time periods. Therefore, for monitoring and evaluation purposes, governments and development agencies have created various frameworks and thresholds for defining poverty in absolute terms. Poverty can also be defined in relative terms, which proponents argue provides more context specific and therefore perhaps more relevant results. However, the ability for comparison between countries or regions may be limited with relative poverty measures. Therefore, the following two methods were utilised in this analysis to categorise households by socio-economic status:

1) Comparison of household expenditure (SES-1) against national poverty level: Non-Poor (NP) or Poor (P)

SES-1 is a quantitative classification that incorporates a national poverty benchmark of 108,454 CFA/ person/ year[5], established by the National Institute of Statistics and Demography (INSD) of Burkina Faso. This value is based on data obtained from the preliminary Survey on Household Living Conditions 2009 (EICVM-*Enquête intégrale sur les conditions de vie et des ménages*) and Demographic and Health Survey. WASHCost surveys collected information on household income and expenditure. Research has demonstrated that expenditure may be a more accurate measure of welfare than income (Meyer and Sullivan, 2006). Therefore self-reported "usual" monthly expenses were used as consumption measures based on shorter recall periods are not suitable for the construction of welfare classification categories (Zaidi and Deaton, 2002). These monthly expenses were aggregated over a year and compared to the national poverty level previously mentioned to categorise households as Poor or Non-Poor.

2) Participatory assessment of socio-economic status (SES-2): Non-Poor (NP), Poor (P), Very Poor (VP)

Participatory assessments measure poverty in terms of local perceptions of poverty, which are identified and then extrapolated and quantified in order to construct a regional poverty categorisation system. Proponents argue that such a poverty categorisation system is more comprehensive and represents the multi-dimensional nature of poverty, and the processes that create and maintain it. With this indicator, poverty is defined locally in terms of perceptions of well-being and how neighbouring informants rank this perception. Utilisation of this measure is thus limited to areas where people know about their neighbours, usually rural communities or within neighbourhoods in urban or peri-urban settings. The number and location of communities in a chosen area are selected using a maximum-variation sampling strategy, taking into account factors that may explain expected variation in perceptions of well-being in the area of study.

WASHCost Burkina Faso conducted focus group sessions in each of the nine communities where data collection took place to determine socio-economic status (SES-2). Criteria for the inclusion in one of three groups used in SES-2: VP, P, or NP, were identified by focus group participants. Households were subsequently assigned socio-economic status (SES-2) based on these criteria by people within the community. These criteria included access to adequate food, clothing, housing, and agricultural lands. Appendix A.1 provides additional information on the criteria used to classify households. The quantitative classification (SES-1) was used to verify the qualitative

[5] Equivalent to US$ 215.93 / person/ year at exchange rate: US$ 1=502.271 CFA (September 2012).

classification system (SES-2)[6]. Figure 1 shows the socio-economic status (SES-2) distribution across each of the four data collection activities. The corresponding population size (N) or sample size (n) is also provided.

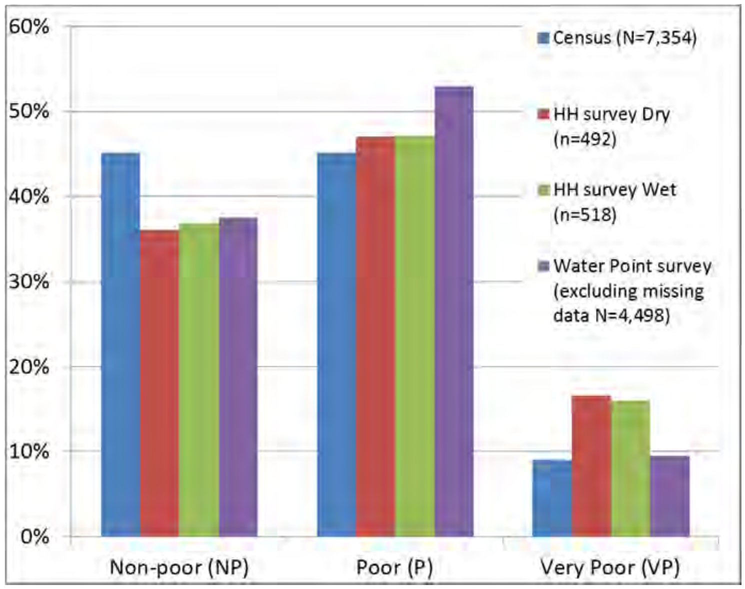


Figure 1 Socio-economic status distribution across communities included in the research expenditure

2.3.1 Cost categories

The life-cycle cost categories used in this research are based on the categories developed by the WASHCost project (table 5)[7]. Life-cycle cost categories include one-shot expenditure, the capital expenditure (CapEx), given in US$/person, and recurrent expenditure (capital maintenance or CapManEx and operation expenditure or OpEx) given in US$/ person/ year. Other recurrent expenditure such as direct and indirect support expenditure are not relevant in the case of household expenditure, and were not considered in this research. No household was paying capital cost for accessing water so the Cost of Capital category is not mentioned further in this paper.

WASHCost categories are financial: they capture the real expenditure. In order to also capture economic expenditure made by households, two operational expenditures are considered in this research, the financial operational expenditure $OpEx_{FIN}$ (WASHCost OpEx), and the economic operational expenditure, $OpEx_{ECON}$.

[6] In no cases were households listed as VP for the qualitative system (SES-2) listed as NP for the quantitative system (SES-1). Similarly in no cases were households listed as NP for the qualitative system (SES-2) listed as P for the quantitative system (SES-1).

[7] For information on these categories, see Fonseca, et al., 2011. To read more on life-cycle costing water systems and water services in Burkina Faso, see: Pezon and Bassono, 2012 and Pezon 2013.

Table 5 Components of WASHCost's life-cycle costs

Cost components		Brief description
Capital Expenditure (CapEx)	Capital Expenditure Hardware (CapExHrd)	Capital investment in fixed assets, such as concrete structures, pumps, pipes and latrines either to develop or to extend a service.
	Capital Expenditure Software (CapExSft)	Expenditure on one-off work with stakeholders prior to construction or implementation, extension, enhancement and augmentation.
Recurrent expenditure	Operational Expenditure (OpEx)	Recurrent (regular, on-going) expenditure on labour, fuel, chemicals, materials and purchases , etc.
	Capital Maintenance Expenditure (CapManEx)	Asset renewal and replacement cost; occasional and lumpy costs that seek to restore the functionality of a system.
	Cost of Capital (CoC)	Cost of interest payments on micro-finance and any other loans.
	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, and support to decentralised service authorities.

2.3.2 Financial expenditure

The equations used to determine the household financial expenditure are separated into one time investments (CapEx) and recurrent expenditure ($OpEx_{FIN}$ and CapManEx). Each expenditure is discussed below. The data for the financial expenditure calculations were derived from the household surveys. The capital, or "one-off" expenditure is determined using Equation 1. No differentiation was made between hardware and software expenditure.

$$\text{CapEx} = \frac{\text{INV8}}{\text{HH size}} \qquad \textbf{Eqn 1}$$

Where:

CapEx = one-off expenditure (US$ per person)
INV-8 = value of investment in implementation of infrastructure (all sources)
HH size = number of members of the household

There are two types of recurrent expenditure made by households: OpEx and CapManEx. From the household survey data it is possible to calculate the financial OpEx via two different methods, as shown in Equations 2 and 3.

$$\text{OpEx1} = \frac{\text{INV13}}{\text{HH size}} \qquad \textbf{Eqn 2}$$

$$\text{OpEx2} = \frac{\text{INV4 x 365 days}}{\text{HH size}} \qquad \textbf{Eqn 3}$$

Where:

OpEx = recurrent operating cost of water (US$ per person per year)
INV-13 = estimated yearly expenditure on water (all sources)
INV-4 = daily amount paid for filling all receptacles (all sources)
HH size = number of members of the household

OpEx2 is based upon a recall of daily activities (i.e., the number of receptacles used to collect water each day and the cost of filling each receptacle), while OpEx1 requires that the respondent estimates the average expenditure on water for the previous year. Research has suggested that long-term recall of expenditure may introduce significant bias (Kasprzyk, 2005). Therefore OpEx2 is assumed to be a more accurate estimate of operation expenditure and is used in subsequent calculations of total financial expenditure (Financial_EX). OpEx2 is called $OPEX_{FIN}$ in the rest of the document.

CapManEx is calculated according to Equation 4.

$$\text{CapManEx} = \sum_{N=1}^{i} \frac{\text{INV10} + \text{INV11} + \text{INV12}}{\text{AGE x HH size}} \qquad \textbf{Eqn 4}$$

Where:

CapManEx = asset renewal and replacement (US$ per person per year)
INV-10 = value of investment on renewal and replacement i^{TH} source
INV-11 = current cost of containers used to transport water
INV-12 = current cost of storage containers
AGE = age of i^{TH} water soured
HH size = number of members of the household

The financial expenditure on water for each household (Financial_EX) **is the total recurrent financial expenditure** calculated by adding CapManEx and $OpEx_{FIN}$ (Equation 5).

$$\text{Financial\_EX} = \text{CapManEx} + \text{OpEx}_{\text{FIN}} \qquad \textbf{Eqn 5}$$

2.3.3 Economic expenditure

In determining the economic expenditure in water collection, previous studies have considered: 1) round trip walking time to the source (Strand and Walker, 2005), 2) walking and waiting time at the source (Larson, Minten, and Razafindralambo, 2006), and 3) linear distance from the household to the source (David and Innocencio, 1998). However, all of these studies occurred in urban areas, using self-reported data, and did not quantify, in financial terms, the costs of collecting water (Mu, Whittington, and Briscoe, 1990). To estimate the costs of water collection, data obtained from the household and water point surveys were used. This data includes: 1) type and number of containers used to collect water, 2) total quantity of water collected, 3) number of trips to carry water back to the household after filling, 4) the time spent queuing at the water point, 5) the type of transportation used to arrive at the water point, and 6) the value of time spent by the person collecting the water.

The total economic expenditure is the sum of time dedicated to the collection, transport, and storage of water multiplied by the financial value of this time and normalised by the size of the household. This is also known as $OpEx_{ECON}$, which has the units of US$ per person per year (see Equation 6[8]).

$$\text{OpEx}_{\text{ECON}} = \frac{v}{\text{HH size}} * \sum_{N=1}^{i} \left\{ \frac{(2d_N \ * \ r_N)}{s} + t_N \right\} \qquad \textbf{Eqn 6}$$

[8] See appendix B for a detailed description of the value of household time (v) and the other assumptions used in determining the input values for Equation 6.

Where:

$OpEx_{ECON}$ = total opportunity cost for handling of water (e.g., collection, transport, storage)
HH size = number of members of the household
i = total number of water sources
d_N = one-way distance (in metres) travelled from household to source N
t_N = average queue time at source N
s = speed of travel (assumed to be 55 metres per minute)
r_N = number of trip back to the household per fill up at the water point N
v = value of household's time (derived from household surveys)

One difficulty in determining the opportunity costs of the time dedicated to water collection is the time valuation of the water collector. Variables such as age, sex, education level, local labour markets and unemployment levels can factor into the earning potential calculations. The case has been made for using the GDP per capita value added in manufacturing, based upon the idea of loss of productivity for adults and the long-term earning potential of children (Hutton and Haller, 2004). Others suggest using minimum wage rate for unskilled labour (Whittington, Mu and Roche, 1990), which in Burkina Faso is 162.37 CFA (US$ 0.32) per hour. The Inter-American Development Bank uses a more conservative value, 50% of the market wage rate for unskilled labour (i.e., 81 CFA per hour), as the valuation of time based upon transportation research in the developing world (Whittington, Mu and Roche, 1990). For this study the value of the households' time (*v)* is based upon the annual household revenue (Rev_TOT) reported in the detailed household surveys (see Equation B.2 in appendix B). Though different methodologies have been tested, household income has been selected for calculating opportunity costs.

Proxies are used in many situations when household income is not available, however these data were collected during the census (see table 2). In the sample used by the study, only 15% of households report an income above US$ 1 per day; Non-Poor households earn, on average, 3.5 times more than the Very Poor households. Using a single proxy to value the time of all households would neutralise these differences. Using, for instance, the minimum wage rate for an unskilled worker would under-estimate the value of the time of the Non-Poor and considerably over-estimate those of the very Poor or Very Poor. So calculating household opportunity costs based on reported income is the best way to analyse the economic expenditure defined as the time spent accessing water.

The mean and median value of time for each socio-economic class is shown in table 6. Table 6 shows that the values of time used in Burkina Faso are more conservative than opportunity cost calculation procedures described elsewhere: Hutton and Haller (2004) and Whittington, Mu and Roche (1990).

Table 6 Value of time used to calculate opportunity costs

	Sample size	Mean		Median	
	(household)	(CFA/ hour)	(US$ cents / hour)	(CFA/ hour)	(US$ cents / hour)
Non-Poor	178	79.8	15.9¢	34.7	6.9¢
Poor	232	46.8	9.3¢	23.0	4.6¢
Very Poor	82	27.5	5.5¢	16.5	3.3¢
All	493	55.6	11.1¢	24.3	4.8¢

Data Source: HH Dry.

2.3.4 Absolute and relative recurrent expenditure

For the households that were surveyed in both the wet and dry season (n=363), a cumulative expenditure on water was calculated using the financial and economic expenditure (see Equation 7). An eight-month dry season (October through May), and four month wet season (June through September) were used to determine the annual expenditure.

$$\text{Cumulative\_EX} = \text{CapManEx} + \frac{8}{12}(\text{OpExfin}_{DRY} + \text{OpExecon}_{DRY})$$

$$+ \frac{4}{12}(\text{OpExfin}_{WET} + \text{OpExecon}_{WET}) \qquad \textbf{Eqn 7}$$

In order to understand the true financial and economic burden of household expenditure on water it is necessary to consider, not only **absolute** expenditure, but also expenditure on water **relative** to total household income. Therefore the total financial expenditure of the household on water (Financial_TOT) was normalised by the annual reported household income (Rev_TOT)[9]. Declarations of individual or household income are often seen as underestimates of actual values, and therefore total household expenditure on all goods and services is commonly used to reflect welfare (Somda, Kone, and Sawadogo, 1999). Accordingly the financial expenditure is also normalised by the cumulative household spending (Exp_TOT). These calculations are shown in Equations 8 and 9.

$$\text{Financial\_\%\_expenses} = \frac{Financial\_TOT}{Exp\_TOT} \qquad \textbf{Eqn 8}$$

$$\text{Financial\_\%\_income} = \frac{Financial\_TOT}{Rev\_TOT} \qquad \textbf{Eqn 9}$$

The average household size, annual household expenditure, and annual household income broken down by socio-economic status are summarised in table 7. Household income is composed of wages, remittances, and one-off payments from the sale of agricultural goods and services, but does not include the value of bartered goods and services. Only 15% of households in this study had income over US$ 1 per person per day, and only 10% had income over US$ 1.25 per day. These are the values commonly used as international thresholds for absolute poverty.

Average expenditure and income were as expected: that is, Non-Poor > Poor > Very Poor. Average annual reported income was much greater in NP households compared to their average expenditure. Conversely, the average annual expenditures were greater than average annual income for the VP households. This implies that VP households cannot meet their expenses and perhaps are in debt. Findings of comparing the median expenditure and incomes to socio-economic status suggest that the qualitative classification system used here (SES-2) is valid.

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[9] In order to control for household size effects the data were analysed both on a: 1) cost per person per year, which is denoted by variables with an "EX" suffix; and a 2) cost per household per year, which is denoted by "TOT" suffix. For example, the units of Financial_EX are US$/ person/ year, while Financial_TOT are US$/ household/ year.

Table 7 Average household size, annual household expenditure and income by socio-economic status

Socio-economic Status (SES-2)	Sample size households	Household size people/ household		Expenditure (Exp_TOT) US$/ household/ year		Income (Rev_TOT) US$/ household/ year	
		Rural	Peri-Urban	Median	Mean	Median	Mean
Non-Poor	183	10.3	6.8	$ 1,224	$ 1,266	$ 1,047	$ 2,332
Poor	232	8.7	6.5	$ 696	$ 861	$ 687	$ 1,109
Very Poor	77	7.2	6.2	$ 354	$ 709	$ 501	$ 577
All	492	8.9	6.6	$ 716	$ 983	$ 755	$ 1,463

3 Overview: expenditure and service levels

The average per person expenditure on water from the detailed household surveys during dry and wet seasons (HH Dry and HH Wet) is summarised in table 8. CapEx is on average US$ 1.5[10] per person and the average CapManEx) is US$ 2 per person per year. This expenditure is very low compared to the other expenditure categories. From the detailed household surveys, during the dry season, only 37% of households (n=183) reported making a contribution to the installation of a water system (CapEx). The variability of CapEx was very high, and the range of reported CapEx was greater than any other financial expenditure (US$ 0-245 per person, median US$ 0.5). Similarly, only one third of households made some additional contribution to renew or replace their water system (n=160). Most CapManEx concerns household investment in transportation and storage containers. Both CapEx and CapManEx were only collected in the dry season, as they do not vary with season.

Unlike CapEx and CapManEx, $OpEx_{FIN}$ and $OpEx_{ECON}$ can vary seasonally as is shown in table 8. Depending on the season, financial expenditure ranged from US$ 7.5 to US$ 9.5 per person per year, and economic expenditure ranged from US$ 5 to US$ 9 per person per year. Operation expenditures, both financial and economic, are lower in the wet season when water is more readily available from rainwater and/ or traditional sources—hence expenditure on formal sources decreases. The cumulative recurrent expenditure (Cumulative EX), which accounts for four months of wet season expenditure and eight months of dry season expenditure, is on average US$ 19.5 per person per year.

[10] All expenditure data were collected in West African Francs and converted to US dollars. Expenditure is reported in US$ and rounded off to the nearest half dollar.

Table 8 Average per person expenditure on water by WASHCost category in the dry and wet seasons
(Statistical difference between seasons is shown)

<table>
<tr><th>Eqn #</th><th>Cost category</th><th>Unit</th><th>Dry</th><th>Wet</th><th>Sig (2-tailed)</th></tr>
<tr><td></td><td></td><td></td><td colspan="2">In US$</td><td></td></tr>
<tr><td>1</td><td>CapEx</td><td>US$/ person</td><td colspan="2">$ 1.5</td><td>N/A</td></tr>
<tr><td>4</td><td>CapManEx</td><td rowspan="5">US$/ person/year</td><td colspan="2">$ 2</td><td>N/A</td></tr>
<tr><td>3</td><td>$OpEx_{FIN}$</td><td>$ 9.5</td><td>$ 7.5</td><td>0.025</td></tr>
<tr><td>6</td><td>$OpEx_{ECON}$</td><td>$ 9</td><td>$ 5</td><td>0.000</td></tr>
<tr><td>5</td><td>Financial_EX</td><td>$ 12</td><td>$ 10</td><td>0.003</td></tr>
<tr><td>7</td><td>Cumulative_EX*</td><td colspan="2">$ 19.5</td><td>N/A</td></tr>
</table>

*Sector 1 data were not included in the calculation of these average expenditures. In addition, the statistical outliers for water usage were excluded. This is covered more in Section 4.

Table 9 shows an overview of the communities by service level category for each of the four indicators, as well as for overall service (refer to Section 2 for details of the service ladder). Of the communities surveyed, 130 households receive a Basic level of service while 97 additional households have higher overall service (i.e., Intermediate or High). However, 72% of households do not receive a Basic service; 333 receive a Sub-Standard level of service, and 255 households do not have any service at all[11].

Table 9 Disaggregation of households by service levels (including the four service level indicators and overall service

<table>
<tr><th>Service level category</th><th>Quantity</th><th>Water quality monitoring*</th><th>Distance</th><th>Crowding</th><th>Overall service*</th></tr>
<tr><td>High</td><td>109</td><td>262</td><td>17</td><td rowspan="3">499</td><td>3</td></tr>
<tr><td>Intermediate</td><td>107</td><td rowspan="3">360</td><td rowspan="3">693</td><td>94</td></tr>
<tr><td>Basic</td><td>300</td><td>130</td></tr>
<tr><td>Sub-Standard</td><td>285</td><td rowspan="2">316</td><td>333</td></tr>
<tr><td>No Service</td><td>14</td><td>192</td><td>105</td><td>255</td></tr>
</table>

*Primary and secondary water points were considered in the scoring. The lower value was used in the case of Water quality monitoring.

Most households do not receive a Basic service due to crowding at their water points. Approximately two of every five households (316 households in total) go to water points that are used by more than 300 people per day. In addition, 299 households receive less than 20 or 40 lpcd of water (rural and peri-urban areas respectively) which are the quantity indicator thresholds for a Basic service. With regard to the water quality monitoring indicator, 192 households obtain at least part of their domestic water from informal sources where the water quality is not monitored.

[11] The model describing the influence of different variables on overall service levels can be found in appendix D.1.

4 Analysis of household expenditure

A summary of the average financial expenditure on water disaggregated by socio-economic status is shown in table 10. The **absolute** financial expenditure does not vary significantly across poverty categories. Households spend between US$ 10.5 and US$ 11 per person per year to access the water services (Financial_EX), on top of a one-time investment (CapEx) ranging from US$ 1 to US$ 2.5 per person.

Table 10 Average per person financial expenditure on water by cost category and socio-economic status

Socio-economic status (SES-2)	CapEx US$/ person	CapManEx US$/ year	$OpEx_{FIN}$ US$/ year	Financial_EX US$/ year
Non-Poor	$ 2.5	$ 2.5	$ 8.5	$ 11
Poor	$ 1	$ 2	$ 8.5	$ 10.5
Very Poor	$ 2	$ 2	$ 8.5	$ 11
All	$ 1.5	$ 2	$ 8.5	$ 11

However, compared to financial expenditures, the situation with regard to economic expenditures are more complex. The difference in time dedicated to collecting water at the primary (WtPt1) and secondary water points (WtPt2) was statistically different between SES groups (p=0.022 and 0.013 respectively[12]). On average, VP households spend almost 30-60% more time collecting water from their primary water point than P or NP households, and between 120-270% collecting their water from their secondary water point than P and NP. However, because VP households have a lower value of time (see table 6 in section 2.4.3), it is possible that a given household would dedicate more time to water collection but have a lower economic expenditure ($OPEX_{ECON}$) compared to a household that has much higher value of time, yet spends less time collecting water. As a result of this dynamic, the difference in household economic expenditure ($OPEX_{ECON}$) is statistically different—with the **absolute** expenditures of VP households less as compared to the P and NP. This dynamic in addition to **relative** expenditures is explored more in section 4.2.

Table 11 Average household economic expenditure (i.e., opportunity costs) and time dedicated to collecting water [excludes Sector 1 data]

Socio-economic status (SES-2)	$OpEx_{ECON}$ (US$/ person/ year)	Time dedicated to collecting water (minutes/ day/ person)*			
		WtP1t	WtPt2	WtPt3	All water points
Non-Poor	$7.5	7.8 (3.1)	5.6 (3.6)	3.2 (0.8)	13.5 (8.5)
Poor	$7.5	9.8 (3.5)	9.4 (5.7)	11.5 (11.5)	15.3 (8.7)
Very Poor	$6	12.3 (4.5)	20.7 (7.9)	6.7 (6.7)	21.1 (9.8)
All	$7.5	9.6 (3.5)	9.6 (4.4)	5.4 (3.9)	15.8 (8.8)

* The mean values of time for each water point are shown along with the median value, which is shown in parenthesis.

12 Determined using a Kruskal-Wallis Test, excluding Sector 1 data and statistical outliers for water usage.

The remaining sections will continue to explore the relationships between these household expenditure, household characteristics, rural and peri-urban differences, and socio-economic status.

4.1 Correlation analysis of household expenditure

To begin to understand the relationships between household expenditure and additional variables included in the research (e.g., household size, location) a correlation analysis was performed. Although correlation analysis does not determine causation, it is a starting point for building multivariate regression models that can help isolate effects of multiple variables from one another, providing insight into causation(for a full presentation of results, see appendix C). For the purpose of this study, multivariate regression analyses were used to better understand causal effects and isolate the effects of potential confounding variables[13].

4.1.1 Household size

In the sample communities, household size was positively correlated, at the 99% confidence level, to water usage. Larger households consumed more water as a household (r=.36[14]) but less on a per person basis (r=-.28). Correspondingly these households had higher financial and economic costs as a household but lower per person financial, economic, and cumulative costs than households with fewer members[15].

4.1.2 Source distance

Households whose primary water point (WtPt1) was further away also had a secondary water point (wtPt2) that was further away. However when comparing water point preference and distance for all formal water points available to households, the data suggest that distance is not the only factor that influences preference. As can be observed from figure 2, the first preferred water point for 38% of the households was not the closest.

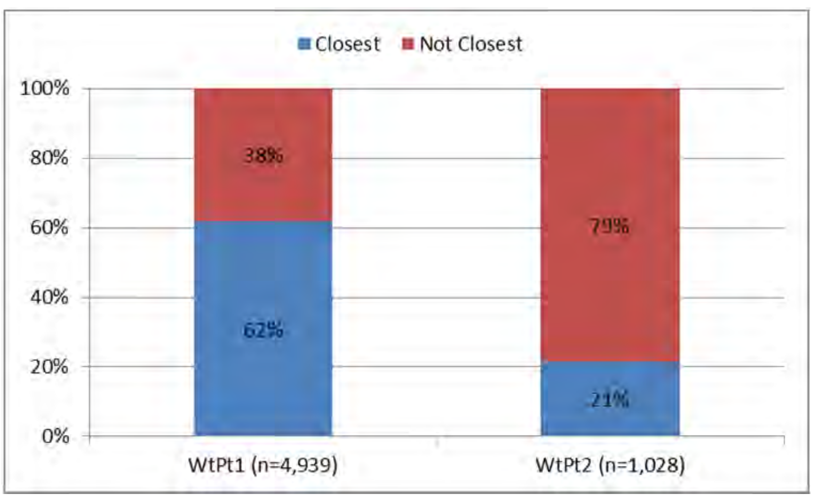

Figure 2 Water point preference and distance from the home

Source: WASHCost Census, 2010.

[13] Results are presented in section 4.2, and the methodologies used are discussed in detail in appendix D.

[14] See appendix C.1 for a list of the correlation coefficients (r) and a definition of correlation strength.

[15] Household expenditures (e.g., Financial_TOT) are not included in appendix C.1.

From the correlation analysis, the further the preferred water point the greater the number of trips made to it (r=.1). As the distance travelled increases, the quantity of water that may be carried on any single trip decreases—therefore more trips will be required to transport the same total quantity of water.

Households with a closer primary source had higher per person financial operating expenditure (r=-.12), while those households whose primary sources were further dedicated more time to water collection and hence had higher per person opportunity costs (r=.14). The seasonal difference in average distance from the household to the water source was greater for secondary water points (see table 12).

Table 12 Average distance from household to water sources in wet and dry seasons [Sample size (n) shown in parenthesis]

Preferred water point	Wet season (metres)	Dry season (metres)
Wtpt1	369 (n=391)	352 (n=418)
Wtpt2	355 (n=67)	575 (n=132)

4.1.3 Water usage

As previously mentioned, **household water use** was found to be greater in larger households. Conversely, **per person water use** was lower in larger households (see figure 3). Both household water use and per person water use were positively correlated to total household income and expenditure. This trend between income and water use has been well documented in the developed world (Mihelcic and Zimmerman, 2010). Per person water use is positively correlated to the WASHCost cost categories of CapManEx and OpEx (financial and economic). In other words, expenditure per person on water increases with the quantity of water used per person. Surprisingly, this trend applies to the water provided by a handpump, even though the *Direction Générale des Ressources en Eau* (National Department for Water Resources-DGRE) establishes a fixed contribution of 2500 FCFA (US$ 5) per household per year to access this kind of facility. It is possible that this guideline is not enforced in these communities; more likely, households contribute to more than a single handpump to ensure year-round access to water.

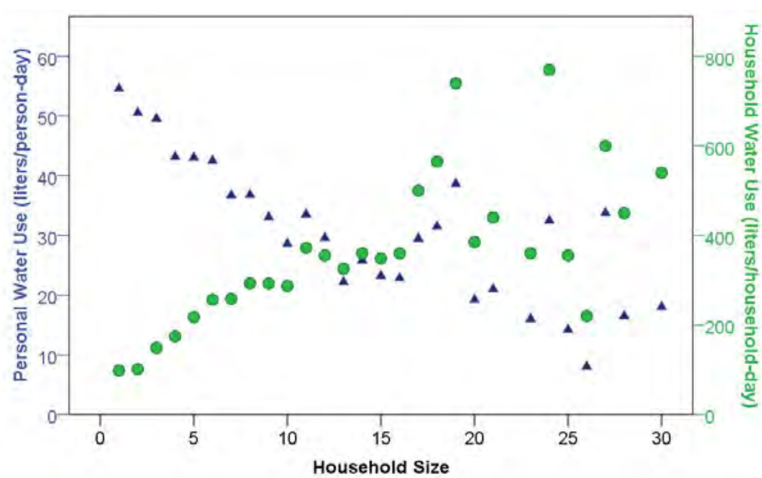

Figure 3 Average personal and household water use by household size (Per person water use is shown by the triangles and average household water use is shown by circles)
Source: Dry and wet season surveys.

4.1.4 Household income and expenses

Households with higher annual reported income invested more in capital expenditure (CapEx) and spent more in operating expenditure (r=.12) than other households. Households with less reported income (rev_TOT) used less water and dedicated more time to water collection, however because of the lower economic value of their time (see table 6), their calculated per person opportunity costs ($OPEX_{ECON}$) were lower than household who reported higher income. This is discussed further in the subsequent section.

4.2 Inter-variable effects on household expenditure

To determine how household expenditure on formal water sources is related to or influenced by factors such as socio-economic status, season, water service levels (e.g., quantity, quality, distance and crowding), or other factors, multivariate analyses were performed. This section will explore the effects of socio-economic status, development, household size, and season on expenditure.

4.2.1 Socio-economic status

Socio-economic status has no effect on **absolute** financial expenditure on water (see table 10); however there is a statistically significant difference between socio-economic categories when these expenditure are considered **relative** to the income and expenses of each household. Table 13 shows the average household income and total expenses, as well as the average recurrent financial expenditure on water ($OpEx_{FIN}$ and Financial_EX) as a percentage of household income and expenses.

Table 13 Recurrent expenditure on water (OpExFIN and Financial_EX) relative to household income and total expenses

Socio-economic status (SES-2)	Income* (US$/ per year)	Expenses* (US$/ per year)	$OPEX_{FIN}$**		Financial_EX**	
			% Income	% Expenses	% Income	% Expenses
Non-Poor	$ 356	$ 192	12%	10%	20%	15%
Poor	$ 183	$ 137	18%	11%	25%	14%
Very Poor	$ 108	$ 130	28%	19%	37%	23%
All	$ 233	$ 156	17%	12%	25%	16%

**Source: HH Dry survey*
*** Source: HH Dry and HH Wet surveys. Financial_EX = $OPEX_{FIN}$ + CAPMANEX. See equation 5.*
Note: "% income" and "% expenses" corresponds to similarly named variables in appendix D.1.

Considering just the average values, in terms of total reported expenses, VP households spend 1.5 times as much as NP and P households on water, e.g., on average about 23% of their expenses goes to water versus approximately 14-15% for P and NP. Considering only the cost of filling containers—tariffs or user fees (e.g., $OpEx_{FIN}$) as a percentage of expenses—VP households spend 19% while NP and P households spend, on average, between 10-11%. These relative expenditures on water exceed the affordability threshold of 5% used by the World Bank and others (Banerjee and Morella, 2011); it does not include economic expenditures.

Table 13 presents the average values, however when controlling for rural-peri-urban differences, seasonal variables, and household size, the impact of socio-economic status on relative expenditure the situation is not as straightforward. With regard to **financial and cumulative expenditure** the difference between VP households and NP and P is only significant **relative to** total household **expenses** (i.e., "% expenses" from table 13) and not relative to household income (i.e., "% income" from table 13). Controlling for rural-peri-urban differences, season variables, and household size, VP household financial expenditure on water as a percentage of total household expenses are 8.3% greater compared to P and NP households (See "Financial_%_expenses" in appendix D.1). As described previously, the cumulative expenditure on water was determined by the combined financial (CapManEx and $OpEx_{FIN}$) and economic ($OpEx_{ECON}$) expenditure from both the wet and dry seasons. Comparing these cumulative expenditure on water to the reported total expenses of each household ("Cumm_%_expenses") VP households spend 13.9% more in relative terms compared to P and NP households.

Unlike the financial and cumulative expenditure, household **economic expenditure ($OpEx_{ECON}$) relative to** total household **income** is significantly different across SES. Despite having ABSOLUTE economic expenditure ($OpEx_{ECON}$) that is US$ 24 per household less than NP or P households (See appendix D), VP household still spend more in RELATIVE terms—VP households spend 1.5% more on $OpEx_{ECON}$ than NP and P households, relative to their total household income.

4.2.2 Level of development, season, and household size

The previous section showed that socio-economic status did not affect absolute financial expenditure on water, but did impact upon the relative expenditure on water. Unlike socio-economic status, the effects of the level of development (rural vs. peri-urban), season, and household size were statistically significant in terms of absolute expenditure (see appendix D). Development (rural/ urban) and seasons are equal drivers for household financial expenditure. A rural household spends US$ 17 less than a peri-urban household in $OpEx_{FIN,}$ and in the dry season a household pays US$ 18 more than the same household in the wet season.

For economic expenditure ($OpEx_{ECON}$), socio-economic status and season have equal effects. In the dry season, a household has opportunity costs greater than in the wet season by US$ 23 household per year (when controlling for other variables). Similarly a VP household has lower opportunity costs, approximately US$ 24 per household per year, compared to NP and P households, when controlling for season, household size and development. However, VP households dedicate, on average, approximately 40% more time to accessing water from its primary source than the other households.

Finally, looking at household size and controlling for SES, seasons and development, if a household were to have an additional member, they could expect to pay US$ 1.5 more in CapManEx—US$ 5 more per year in $OpEx_{FIN}$ and US$ 2.5 less in $OpEx_{ECON}$. This results in an increased cumulative recurrent cost to households of US$ 5.5 for each additional member.

4.3 Summary of general trends in household expenditure

Capital expenditure (**CapEx**) was approximately **US$ 1.5 per person** and capital maintenance expenditure (CapManEx) averaged US$ 2 per person per year. Excluding investments in transportation and storage containers, very few households made CapEx or CapManEx contributions. Financial operating expenditure estimated from daily water collection (**$OpEx_{FIN}$)** ranged **from US$ 7.5 in the wet season to US$ 9.5 per person per year in the dry season**. Using reported household income to determine the value of time for collecting water, the average economic expenditure (**$OpEx_{ECON}$**) ranged **from US$ 5 in the wet season to US$ 9 per person per year in the dry season**.

Assuming four wet season months and eight dry season months, the average annual per person cumulative costs were approximately US$ 19.5.

Larger households consume more water as a household but less on a per person basis. Households with less reported income consumed less water and had higher economic expenditure. The capital and operating expenditure per person and per household increases with the volume of water consumed per person.

Households with primary water sources that were further away had lower financial costs but higher economic expenditure. Water source distance did not differ significantly between dry and wet seasons for the primary water source. However if the primary source was not functioning households travelled 60% further in the dry season to access their secondary water source.

Absolute financial expenditure did not vary across socio-economic strata, however when comparing these expenditure relative to reported total household expenses there was a significant difference between VP households and P or NP households.

Relative to their total household expenses, the expenditure of VP on water was greater by 8% (in financial terms) and 14% (cumulatively) compared to all other households when controlling for the effects of season, households size, and rural-urban differences.

Economic expenditure of VP households were, on average US$ 24 less per household in ABSOLUTE terms compared to NP and P households after controlling for the effects of season, households size, and rural-urban differences. However RELATIVE to household income, VP households had higher economic expenditure by 1.5%. VP households also dedicated on average, approximately 40% more time to accessing water from their primary water source.

Rural households had lower annual financial expenditure (by US$ 17-18 per household per year) than peri-urban households of the same size.

In the dry season household financial costs increased by approximately 20% (US$ 1.5 per household per month), opportunity costs by approximately 38% (US$ 2 per household per month).

One additional person resulted in a per person savings of approximately US$ 0.5 in capital expenditure but resulted in higher annual cumulative costs of US$ 5.5 per household per year.

5 Analysis of service levels

The following section explores the relationships between households' expenditure and the level of service received, as measured by the WASHCost service level indicators for Burkina Faso (see table 4 in page12). The results of ordinal and linear regression models are presented alongside descriptive statistics. For more on the interpretation of linear and ordinal regression models, and the results of these analyses, see appendix D.

5.1 Expenditure per service level and technology type

The costs for accessing different overall service levels vary greatly, notably recurrent expenditure (See table 14). The expenditures to access the High level of service must be interpreted with caution due to the small sample size used to calculate these expenditures. The *Office National de l'Eau et de l'Assainissement* (National Office for Water and Sanitation or ONEA) which operates in the peri-urban areas included in this research, charges a minimum fee to install a private connection of 30,000 CFA (US$ 60) per household. All households receiving a High level of service have private connections, yet the average reported CapEx for High service was only US$ 3 per person or US$ 17.5 per household. When including all households with private connections (i.e., including those households with private connections but lower overall service levels, n=16 in table 16) the average CapEx is US$ 6 per person or US$ 57 per household.

Table 14 Average costs by overall service level, excluding Sector 1 data [Sample size is shown (N)]

Service level category	N†	CapEx (US$ /person)	Recurrent expenditure				
			CapManEx (US$/ person/ yr.)	$OpEx_{FIN}$ (US$/ person /yr.)	$OpEx_{ECON}$ (US$/ person/ yr)	Financial_EX* (US$ / person/ yr)	Cumm_EX** (US$/ person / yr)
High	3	$ 3	$ 1	$ 37	$ 10	$ 38	$ 36
Intermediate	84	$ 4	$ 3.5	$ 17	$ 12	$ 20	$ 32
Basic	114	$ 3.5	$ 2	$ 8	$ 6	$ 10.5	$ 20.5
Sub-Standard	274	$ 0.5	$ 2	$ 8	$ 6.5	$ 10	$ 16
No Service	227	$ 1.5	$ 2	$ 6	$ 7.5	$ 9	$ 18.5

Financial_EX = CapManEx + $OpEx_{FIN}$, see equation 5.

*** Cumm_EX = Financial_EX + $OPEX_{ECON}$, see equation 7.*

† Sample size is list wise (i.e., minimum sample size for the different expenditures). For total sample size of each overall service level see table 9 in page 23.

It was expected that the CapManEx for the households with High service (i.e., a private connection) would be low since over 95% of all CapManEx reported in this research were for transportation and storage containers. These containers are typically not needed by households with private connections. Few households reported expenditures for rehabilitation or major repair of water points (n=160)— of these households the average expenditures were less than US$ 1 per person.

The range of recurrent expenditure is far greater than the range of capital expenditure. Financial recurrent expenditure (CapManEx + $OpEx_{FIN}$ or Financial_EX) ranges from US$ 9 to over US$ 20 (Intermediate and High). The opportunity costs vary from US$ 6 to US$ 12 and the cumulative recurrent expenditure (Cumm_EX) varies from US$ 16 (Sub-Standard level) to over US$ 30 per person per year (Intermediate and High).

Financial operating expenditure ($OpEx_{FIN}$) increases with the level of service: it costs at least two and perhaps as much as six times more to access a High level of service (US$ 37) as compared to No service (US$ 6). The difference in $OPEX_{FIN}$ is extremely limited between No service, Sub-Standard and Basic services (US$ 6 vs. US$ 8). Conversely, financial operating expenditure doubles from Basic to Intermediate level (US$ 8 vs. US$ 17) and more than doubles from Intermediate to High level (US$ 37 vs. US$ 17). Looking at the financial recurrent expenditure (Financial_EX), a household accessing a High level of service spends in average, in one year, what a household accessing a Basic level spends in 3.6 years, or what a household accessing no service spends in 4.2 years.

The profile of economic expenditure is very different: it costs only slightly more to have High Service (US$ 10/ person/ year) compared to No Service (US$ 7.5/ person/ year). Having No Service actually costs more than Basic and Sub-Standard levels as it requires more traveling time to reach (further) water sources. Those with No Service dedicate on average 20 minutes per person per day to water collection, while those with Sub-Standard and Basic levels dedicate on average 8 and 11 minutes per person per day respectively (see table 15). Intermediate service is the most expensive level of service in terms of economic expenditure—an average of US$12/ person/ year—twice as much as Basic service (See table 14). Note that the only difference with regard to thresholds between Basic and Intermediate service is an increase in quantity of water per person per day (See table 4 in page 15). Fetching more water from a public water point (e.g., standpipe or handpump) requires more time, leading to higher economic expenditure. To reach the High level of service requires an increase in water quantity and also a private connection. Receiving more water from a much closer water source offsets the time spent on water collection. Consequently the $OpEx_{ECON}$ for high level is US$2/ person/ year lower than for the Intermediate level. Households with Intermediate service dedicate 18 minutes per person per day while those with High level of service only dedicate on average, two minutes per person per day.

Table 15 Time dedicated to water collection at primary water point by overall service level received

Overall service levels	Collection time WtPt 1 (minutes/ person/ day)			
	Non-Poor	Poor	Very Poor	All
High	3	<1	NA	2
Intermediate	13	16	31	18
Basic	10	11	11	11
Sub-Standard	9	8	7	8
No Service	13	22	28	20

Considering the cumulative recurrent expenditure (financial and economic), the expenditure on High level of service is nearly twice as much as the average expenditure for Basic service (See Table 14 in page 30). This is due to the large increase in financial expenditure. There is also a significant gap between Basic and Intermediate levels of service, originating equally from financial and economic expenditure. Cumulative recurrent expenditure for Basic is similar to those for Sub-Standard service, and even closer to the expenditure made by those with No service. With higher economic expenditure (because of lower accessibility), the households with No service spend nearly as much as those households with Basic service in cumulative terms. This can be seen in table 15 where those with No Service dedicate on average, 20 minutes per person per day compared to those with Sub-Standard or Basic service that only spend 8 or 11 minutes per person per day respectively.

The annual per person expenditure disaggregated by water supply technologies (primary water point) used in the nine communities in Burkina Faso are shown below in table 16. The technologies designed to provide higher service levels (i.e., private connections) require higher financial contributions but require less time investment. However due to the higher average value of time for those households accessing water *via* a private connection, the average economic expenditure of these households is higher. If the value of time is kept constant for all households, the economic expenditure for those accessing a handpump is higher than for those with private connections.

Table 16 Financial and economic cost spent on primary water point by technology [Sample size is shown (N)]

Water supply technology	N†	CapEx US$/ person	CapManEx US$/ person/ yr	Financial_ EX US$/ person/ yr	Opportunity costs of water collection		
					$OpEx_{ECON}$ US$/ person/ yr	Time Investment min/ day-person	Value of time CFA/ person/ hr.
Private connection	16	$6	$3	$23.5	$9.5	2.4	88
Standpipe	323	$1	$2	$15	$7.5	4.0	57
Handpump	382	$1.5	$2.5	$8	$7.5	14.5	29

† Sample size is shown (N) list wise (i.e. minimum sample size for the different expenditures).
Source: Dry and wet season household surveys excludes Sector 1 data.

Households with private connections spent three times as much per person per year as those accessing handpumps (Financial_EX). However households with private connections and standpipes benefited from the close proximity of their water source (either at home or located less than 500 meters away). These households, on average, dedicated 6 and 4 times less respectively, in terms of time investment (minutes per person per day) to collect water than households accessing handpumps. Time poverty combined with the fact that financial contributions made by poor households relative to their total household expenses to access the same service levels means that water access costs more to poorer households.

5.2 Service levels of rural and peri-urban households

Table 17 shows a breakdown of the service level scores for rural and peri-urban areas (see table 4 in page 12 for the definition of rural and peri-urban service levels). The proportion of rural households which receive a Basic or High level of service is slightly above the proportion of the peri-urban (29% against 26%). However rural households fare poorly compared to their peri-urban counterparts for water quality monitoring and distance to their source. While 7% of peri-urban households access water whose quality is not monitored, 29% of rural households meet part or all of their domestic needs with water whose quality is not monitored and could be unsafe. 94% of peri-urban households access primary water points at a distant less than 500 metres when 83% of rural households fetch water from sources up to 1 km away, and 15% go even further. All peri-urban households receive at least 10 lpcd, and more than half receives more than 40 lpcd. In rural areas, one third of households get between 5 and 20 lpcd, one third benefits from 20 to 40 lpcd (Basic level) and the remaining third of households use more than 40 lpcd. Overall, one third of rural households and one sixth of peri-urban households do not receive any service. One third of rural households receive a Sub-Standard level of service mostly because of limited quantity of water and crowding. Almost 60% of peri-urban households get a similar level of service mostly because they fail to access 40 lpcd.

Table 17 Household service level categories segregated by rural and peri-urban area [Shown as a percentage]

<table>
<tr><th rowspan="2">Service level category</th><th colspan="2">Quantity</th><th colspan="2">Water quality monitoring*</th><th colspan="2">Distance</th><th colspan="2">Crowding</th><th colspan="2">Overall service*</th></tr>
<tr><th>Rural</th><th>Peri-urban</th><th>Rural</th><th>Peri-urban</th><th>Rural</th><th>Peri-urban</th><th>Rural</th><th>Peri-urban</th><th>Rural</th><th>Peri-urban</th></tr>
<tr><td>High</td><td>16%</td><td>6%</td><td>14%</td><td>88%</td><td>1%</td><td>4%</td><td rowspan="3">61%</td><td rowspan="3">61%</td><td><1%</td><td><1%</td></tr>
<tr><td>Intermediate</td><td>16%</td><td>5%</td><td rowspan="3">57%</td><td rowspan="3">5%</td><td rowspan="3">83%</td><td rowspan="3">90%</td><td>13%</td><td>6%</td></tr>
<tr><td>Basic</td><td>35%</td><td>41%</td><td>15%</td><td>19%</td></tr>
<tr><td>Sub-Standard</td><td>31%</td><td>48%</td><td rowspan="2">39%</td><td rowspan="2">39%</td><td>35%</td><td>59%</td></tr>
<tr><td>No Service</td><td>2%</td><td><1%</td><td>29%</td><td>7%</td><td>15%</td><td>6%</td><td>37%</td><td>15%</td></tr>
</table>

[*] *Primary and secondary water points were considered in the scoring. The lower value was used in the case of Water quality monitoring.*

5.3 Expenditure, development, poverty, and service levels

When analysing the recurrent cost of service levels disaggregated by socio-economic status, it is observed that the cost of each service level varies across poverty categories. Figures 4, 5, and 6 show the average annual per person financial, economic and cumulative expenditure for each service level disaggregated by socio-economic status as defined in this analysis.

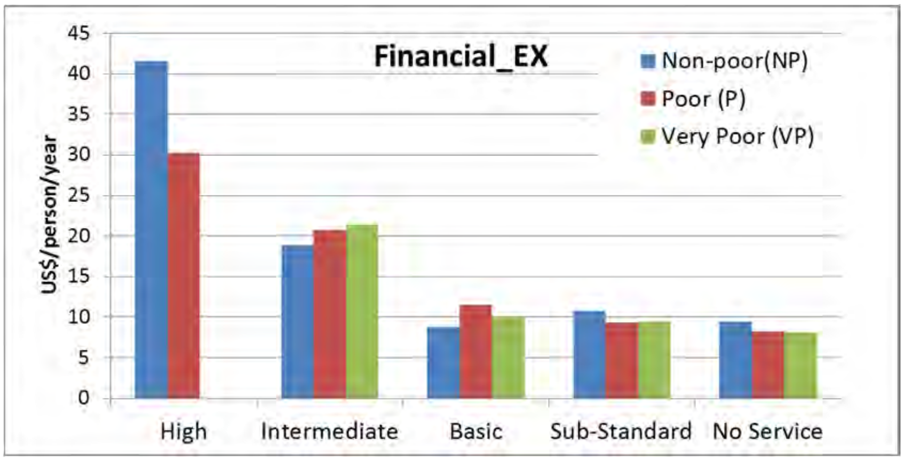

Figure 4 Financial expenditure on water by service level and socio-economic status

Figure 4 shows that there is a large gap in expenditure between those accessing Basic service and accessing Intermediate service, for all poverty categories. No VP households receive a High level of service, yet VP households spend as much as P and NP households to access Basic, Intermediate, and No Service levels.

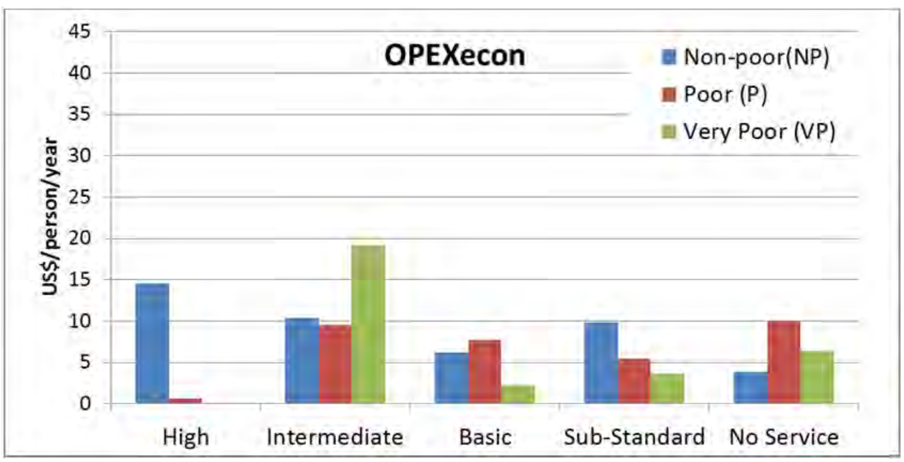

Figure 5 Economic expenditure on water by service level and socio-economic status

Figure 5 demonstrates that amongst those with No service, VP and P households actually have higher expenditure than similar households (i.e., SES group) with Sub-Standard service. Comparing within each SES group between service levels, the economic expenditure is found to be eight times more for VP with Intermediate service compared to VP with Basic service. Comparing the same increase in service (Basic to Intermediate) for P and NP households results in the difference of only 1.5 to twice as much. Since households within each SES group have similar values of time, this shows that more TIME investment is required to increase service levels from Basic to Intermediate. Curiously NP households with High service have higher economic expenditures than NP households with Intermediate service. This could be due to the small sample size for High service levels. Overall, from Figures 4 and 5 it appears that to receive higher service levels, VP households invest more time (i.e., increase economic expenditure), while NP households pay for higher service (i.e., increase financial expenditure). Figure 6 shows that overall, VP households spend as much and in some cases more for similar levels of service compared to P and NP households, with the exception of Basic service.

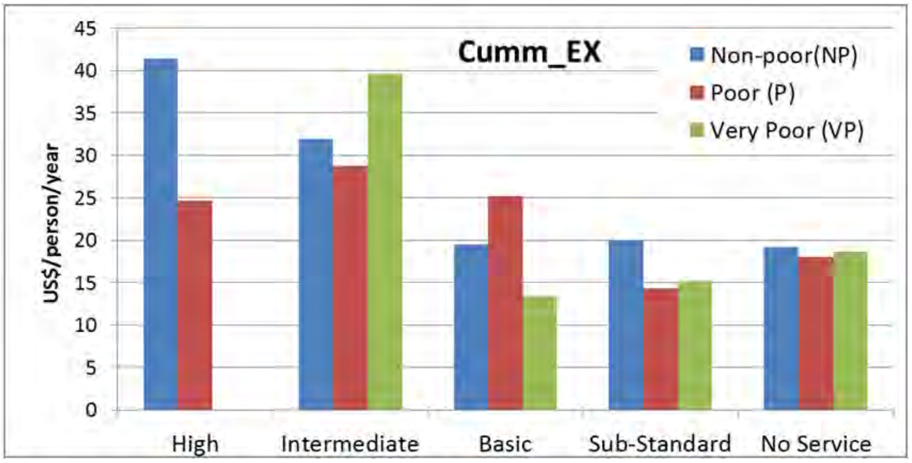

Figure 6 Cumulative expenditure on water by service level and socio-economic status

Tables 18 and 19 show the service levels disaggregated by socio-economic status for peri-urban and rural areas respectively. The peri-urban NP households have higher overall service levels than all other households. Approximately 17% of peri-urban NP households have Intermediate or High service levels.

Table 18 Service level categories for peri-urban households, segregated by socio-economic status

<table>
<tr><th rowspan="2">Service level category</th><th colspan="3">Quantity</th><th colspan="3">Water quality monitoring*</th><th colspan="3">Distance</th><th colspan="3">Crowding</th><th colspan="3">Overall service*</th></tr>
<tr><th>NP</th><th>P</th><th>VP</th><th>NP</th><th>P</th><th>VP</th><th>NP</th><th>P</th><th>VP</th><th>NP</th><th>P</th><th>VP</th><th>NP</th><th>P</th><th>VP</th></tr>
<tr><td>High</td><td>12%</td><td>4%</td><td>0%</td><td>73%</td><td>94%</td><td>100%</td><td>9%</td><td>2%</td><td>0%</td><td rowspan="3">71%</td><td rowspan="3">53%</td><td rowspan="3">68%</td><td>2%</td><td>1%</td><td>0%</td></tr>
<tr><td>Intermediate</td><td>11%</td><td>3%</td><td>0%</td><td rowspan="3">11%</td><td rowspan="3">4%</td><td rowspan="3">0%</td><td rowspan="3">89%</td><td rowspan="3">90%</td><td rowspan="3">93%</td><td>15%</td><td>3%</td><td>0%</td></tr>
<tr><td>Basic</td><td>36%</td><td>43%</td><td>39%</td><td>18%</td><td>18%</td><td>25%</td></tr>
<tr><td>Sub-Standard</td><td>39%</td><td>50%</td><td>61%</td><td rowspan="2">29%</td><td rowspan="2">47%</td><td rowspan="2">32%</td><td>45%</td><td>65%</td><td>68%</td></tr>
<tr><td>No Service</td><td>2%</td><td><1%</td><td>0%</td><td>17%</td><td>3%</td><td>0%</td><td>2%</td><td>8%</td><td>7%</td><td>19%</td><td>14%</td><td>7%</td></tr>
</table>

**Primary and secondary water points were considered in the scoring. The lower value was used in the case of Water quality monitoring.*
NP-Non-Poor; P-Poor; VP-Very Poor

Focusing on peri-urban households (Table 18), NP households have higher water quantity scores: 59% receive more than 40 lpcd, whereas 50% of P and 61% of VP receive less than the Basic level of service in water quantity. NP households also have higher accessibility scores—both in distance and crowding. Almost one in ten enjoy a private connection and less than 30% go to over-crowded water points. The only indicator where NP households do not have better service levels is water quality monitoring. All eleven of the NP households with No Service (17%) cited using an informal source to supplement their domestic water needs.

Table 19 presents the results for service levels that rural households receive. In rural areas, no segregation is made between NP and other categories, such as in peri-urban areas. A larger proportion of VP households receive Basic and Intermediate overall levels of service compared to P and NP. In addition, a smaller proportion of VP receive No Service (30%) compared to P and NP households. Rural NP households have higher accessibility scores—both in distance and crowding. 3% have private connection and 63% access water points with less than 300 users. However rural NP households fall in terms of water quality monitoring, with only 31% meeting part or all of their needs as water quality is not monitored and may potentially be unsafe. Though fewer VP households receive more than 40 lpcd compared to NP and P (i.e., Intermediate and High service levels), the same proportion of VP and NP receive at least a Basic level of service in terms of water quantity (e.g., 20 lpcd).

Table 19 Service level categories for rural households, segregated by socio-economic status

<table>
<tr><th rowspan="2">Service level category</th><th colspan="3">Quantity</th><th colspan="3">Water quality monitoring*</th><th colspan="3">Distance</th><th colspan="3">Crowding</th><th colspan="3">Overall service*</th></tr>
<tr><th>NP</th><th>P</th><th>VP</th><th>NP</th><th>P</th><th>VP</th><th>NP</th><th>P</th><th>VP</th><th>NP</th><th>P</th><th>VP</th><th>NP</th><th>P</th><th>VP</th></tr>
<tr><td>High</td><td>17%</td><td>16%</td><td>14%</td><td>13%</td><td>13%</td><td>16%</td><td>3%</td><td>1%</td><td>0%</td><td rowspan="3">63%</td><td rowspan="3">61%</td><td rowspan="3">59%</td><td>1%</td><td>0%</td><td>0%</td></tr>
<tr><td>Intermediate</td><td>17%</td><td>17%</td><td>12%</td><td rowspan="3">56%</td><td rowspan="3">56%</td><td rowspan="3">62%</td><td rowspan="3">82%</td><td rowspan="3">82%</td><td rowspan="3">88%</td><td>12%</td><td>13%</td><td>17%</td></tr>
<tr><td>Basic</td><td>36%</td><td>31%</td><td>45%</td><td>15%</td><td>13%</td><td>20%</td></tr>
<tr><td>Sub-Standard</td><td>27%</td><td>34%</td><td>28%</td><td rowspan="2">37%</td><td rowspan="2">39%</td><td rowspan="2">41%</td><td>34%</td><td>36%</td><td>33%</td></tr>
<tr><td>No Service</td><td>2%</td><td>2%</td><td>1%</td><td>31%</td><td>31%</td><td>22%</td><td>15%</td><td>17%</td><td>13%</td><td>38%</td><td>39%</td><td>30%</td></tr>
</table>

**Primary and secondary water points were considered in the scoring. The lower value was used in the case of Water quality monitoring.*
NP: Non-Poor; P: Poor; VP: Very Poor

5.4 Inter-variable effects on water service indicators

5.4.1 Water quantity

The variables analysed include: WASHCost expenditure, season, rural-peri-urban differences, household size, socio-economic status, and the sum of the distance between the household and each of its preferred water points. Controlling for all other variables, a household that increases its economic expenditure ($OpEx_{ECON}$) by US$ 5 (2,500 CFA) per person per year will receive an extra litre of water per person per day. Households that spend an additional US$ 2 (1000 CFA) per year per person will have a similar increase (1 lpcd). The marginal financial cost of a cubic meter of water (1,000 litres) is US$ 5.5 (2,740 CFA). In the dry season, households consume six litres more per person and rural households use approximately seven litres per person less than peri-urban households, when controlling for the other variables mentioned. A primary source that is located 100 metres further away from the household would result in 1.6 litres less per person per day.

Across all surveyed communities, NP households consumed an average of 40 lpcd, P: 36 lpcd, and VP: 33 lpcd. After controlling for rural-urban development, seasons, and expenditure, it was determined that NP households consume approximately six lpcd more than P or VP households. NP households in peri-urban areas use the most water, approximately 17 lpcd more, when controlling for the effects of season, household size, and household expenditure. VP households in rural areas use the least amount of water—an average of 7.5 lpcd less than other households, after controlling for other confounding variables[16].

5.4.2 Water quality monitoring

Water quality testing results were not included in this analysis, but rather the frequency of water quality testing. In Burkina Faso this is based upon the: 1) service provider and 2) water source (refer back to table 4, page 15). After controlling for household expenditure, rural households had less frequent water quality monitoring compared to peri-urban households (See appendix D.4). Those households with higher financial expenditure had higher water quality monitoring indicator scores for both primary and secondary water points. Households

[16] Results of these models are not shown.

with higher economic investment in their primary source[17] had lower water quality monitoring scores, while those with higher economic investment in their secondary source had higher water quality monitoring scores. This suggests that perhaps water quality is not a driver of household time investment, but rather water quality monitoring can be obtained through increased financial expenditure. Figure 7 explores this theory by comparing the water quality monitoring service levels (e.g., No Service, Basic and High) disaggregated by season and household investment tiers. Households are grouped into three categories—T1-T3—based upon their total financial expenditure on water (Financial_EX). T1 was found to have the highest 33% of expenditure, T2 the middle third, and T3 the bottom third. It is clear that most of those households that receive a High level of service spend more money—a trend which is most apparent in the dry season.

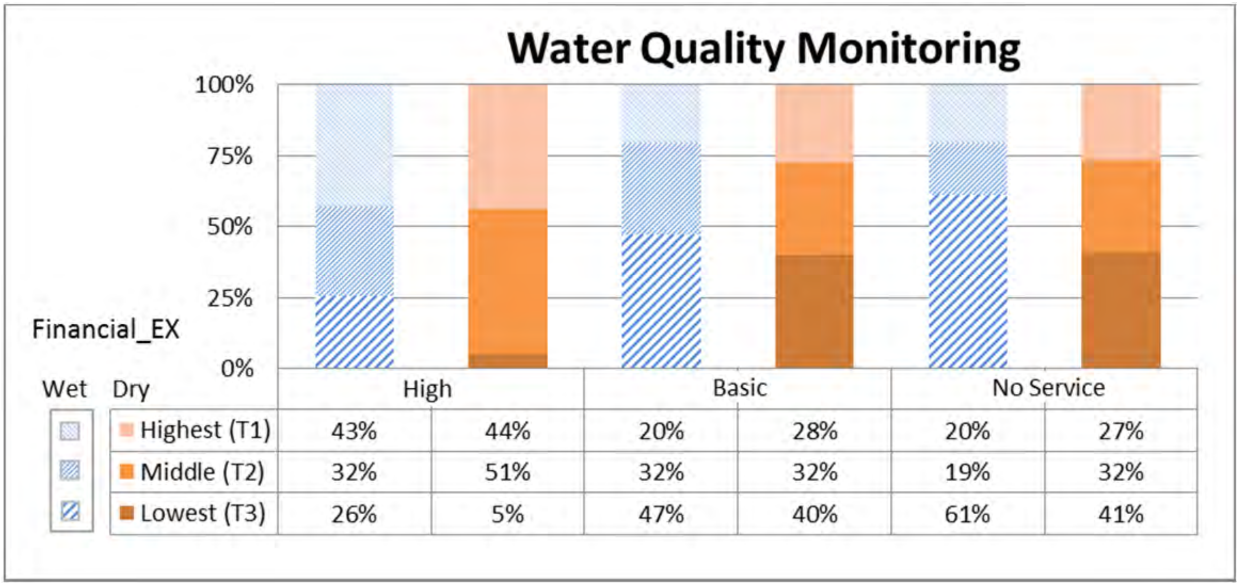

Figure 7 Water quality monitoring service levels by season and households expenditure. Dry season is the solid and wet season is the hatch pattern.

In the dry season, the primary and secondary water points for households had higher water quality monitoring scores[18]. It is possible that this was due to the fact that there was greater availability of water during the wet season as households had a tendency to use more informal sources. For the water quality monitoring scores of the second preferred water point, NP scored higher in monitoring as opposed to P and VP households.

5.4.3 Accessibility

The accessibility indicator is composed of two criteria, which were evaluated separately: 1) **Distance** from household to source; and 2) **Crowding** at the source. The relationships between these indicators and the different independent variables are discussed below[19].

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[17] $OpEx_{ECON}$ was only significant at 90% level for the primary water point (see appendix D.4).

[18] Appendices D.4 and D.5 present the results of the statistically significant parameters for water quality monitoring of the primary and secondary water points respectively.

[19] More details are presented in appendix D.

Seasonality and socio-economic status did not make a statistically significant impact on the distance to primary source after controlling for the other variables; hence these were excluded from the model. Rural households were located approximately 112 metres (β_3 in appendix D.3) further than urban households from their primary water source. Households with higher financial expenditure had closer primary sources (negative sign of β_1 in appendix D.3). Those who had higher cumulative household expenditure of US$ 2 (1000 CFA) per household per year (Cumm_TOT) had a source that was approximately 1 metre closer (appendix D.3).

The relationships for crowding were less strong than those for the distance criterion. There was a weak fit for models for both the primary source and secondary source (see appendices D.6 and D.7)[20]. Excluding Sector 1 data and controlling for socio-economic status, expenditure, rural-urban development, season, and other factors, crowding at the primary water point was greater for households that had higher economic expenditure (appendix D.6). The opposite was true for the secondary water point: as $OpEx_{ECON}$ increased crowding as the secondary water point decreased (appendix D.7) Crowding was also less, in general, at the secondary source for households that had higher financial expenditure per person (Financial_EX).

The difference between socio-economic status was not found to be significant for the crowding criterion at the primary water source (appendix D.6). However, when evaluating crowding at the secondary water source, there was more crowding in VP and P households than NP households (appendix D.7). More crowding also occurred when households increased the volume of water collected at their primary water point. Although, counter intuitively, as the collection time for at the primary water increased, the crowding scores improved even after controlling for the distance to the primary water point (appendix D.6). Crowding scores at the second water point were better in the dry season as there were more formal water points available in the dry season (appendix D.7).

5.4.4 Overall service

The model describing the influence of different variables on overall service levels can be found in appendix D.7. Controlling for rural-urban development, seasons, and socio-economic status households with higher financial expenditure (p=0.000) resulted in higher overall service level scores. Rural households had lower service levels than peri-urban households (p=0.012). In general, NP households in urban areas have the highest service levels of all groups.

5.5 Summary of service levels and expenditure

Higher financial expenditure, at both person and household levels, resulted in **higher scores for all the service level indicators** except for crowding at the primary water point.

Peri-urban households and households that had **higher financial expenditure** saw **higher water quality monitoring scores**.

It is possible that households do **not use water quality monitoring as the basis for determining their economic expenditure**, however those households with higher water quality monitoring scores had higher financial expenditure.

[20] Model fit strength is determined by R^2 and ρ^2. The closer these values are to 1.0, the stronger the fit of the model.

Households had to spend an additional **1000 CFA** (US$ 2.00) **per year per person to receive an extra litre of water per person per day**, putting the implied marginal financial cost of a cubic metre of water (1,000 litres) at 2,740 CFA (US$ 5.45).

A primary source that is located **100 metres further** away from the household would result in **1.6 lpcd less. Non-Poor households** consume approximately **6 lpcd more** than Poor or Very Poor households, with urban NP consuming the most, and the VP in rural areas consuming the least.

Households with **higher financial costs** had primary sources that **were closer**. In general, rural households were **112 meters further** from their sources.

Crowding service levels were lower (i.e., more crowding) at the primary water point for households with **higher economic expenditure**, but the opposite was true at the secondary water point. Non-Poor had less crowding at their secondary source than Poor and Very Poor households.

6 Conclusions

The objectives of this research were to: 1) determine how household expenditure—financial, economic, and cumulative—in formal water sources vary across socio-economic status categories in rural and peri-urban areas; and 2) evaluate the influence of this expenditure on the water service levels received by households. Additionally, the analyses uncovered the impacts of seasonality and other influences on spending behaviour.

One-off HH capital expenditure (**CapEx**) was approximately **US$ 1.5 per person**. The **cumulative recurrent expenditure—**including both financial and economic—**was approximately US$ 19.5 per person per year**. **Financial recurrent expenditure** ranged **from US$ 7 in the wet season to US$ 9.5 per person per year in the dry season**. **Economic expenditure** ranged **from US$ 5 in the wet season to US$ 9 per person per year in the dry season**.

In financial terms, households that use a **handpump** as their primary source spent an average of **US$ 8 per person per year** on that source; households using **standpipes** spent **US$ 15 per person per year** on that source; households with **private connections** spent approximately **US$ 23.5 per person per year**.

In economic terms, households that use a **handpump** or **standpipe** as their primary source spent an average of **US$ 7.5 per person per year,** while those with **private connections** spent approximately **US$ 9.5 per person per year**. However when looking at the time investment, handpump users spent an average of 14.5 minutes per person per day collecting water; standpipe users and those with private connections spent only 4 and 2.4 minutes per person per day respectively.

Absolute financial and cumulative expenditure **did not vary between different socio-economic strata**—meaning that VP households spent similar amounts as P and NP households on water. However when comparing these expenditures **relative** to reported total household expenses there was a **significant difference between VP and P or NP households**. For VP, comparing the expenditure on water to household expenses, they **are greater by 8%** (in financial terms) and 14**%** (cumulatively) **compared to all other households**,

Economic expenditure of VP households were, on average **US$ 24 less per household in absolute terms compared to NP and P** households after controlling for the effects of season, households size, and rural-urban differences. However, **relative** to household income, VP households had **higher economic expenditure by 1.5%.** VP households also dedicated on average, approximately **40% more time** to accessing water from their primary water source.

The average financial expenditure on water as a percentage of household income for all socio-economic categories in this research (25%) was well **above the affordability threshold of 5%** which is used by the World Bank and others (Banerjee and Morella, 2011). Just looking at the financial operating expenditure as a percentage of total income, the average value (17%) is still well above the affordability threshold. **For VP households, financial expenditure in water amounted to 37% of total reported income and 23% of total reported expenses—this raises serious equity concerns.**

Even absolute expenditures were shockingly high in the Burkina Faso context. **Households that used a handpump as their primary source spent an average of US$ 8 per person per year on that source—16 times greater than the US$ 0.50 (250 CFA) per person per year affordability target** that the Burkina Faso government uses for households accessing a handpump.

31% of households received No service at all, and 41% a Sub-Standard level of service. Overall, **one third of rural households and one sixth of peri-urban households did not receive any service**. Rural areas fared poorly compared to their peri-urban counterparts for **water quality monitoring, distance** to their source and water **quantity**. **29% of rural households met part of their domestic needs with unsafe water** vs. 7% for peri-urban households. 94% of peri-urban households travelled to water points with a distance of less than 500 metres, while **one in six rural households travelled a distance of more than 1 km to reach the primary water point**. All peri-urban households received at least 10 lpcd, half receiving above 40 lpcd. **In rural areas, one third of all households received less than 20 lpcd**.

The costs of service levels varied greatly. Notably financial recurrent expenditure (Financial_EX), which is far higher than capital one-off expenditure varied, on average, from US$ 9 to US$ 38 per person per year.

Financial operating expenditure ($OpEx_{FIN}$) increased with the level of service: it cost three and perhaps as much as six times more to access an Intermediate (US$ 17) or High (US$ 37) level of service as compared to No service (US$ 6). In terms of economic expenditure, it cost more to have No service (US$ 7.5 per person per year) than receiving a Basic or Sub-Standard service (US$ 6-6.5 per person per year).

Overall recurrent expenditure—both financial and economic—for a Basic level was found to be close to paying for a Sub-Standard service and even closer to the cost of No service. **With higher economic expenditure (because of lower accessibility), the households with No service spent nearly as much as those households receiving a Basic service**.

VP households spent more in relative terms for similar levels of service than the P and NP, except for Basic service. **To access similar levels of service, VP households had similar financial expenditure as P and NP households**. No VP households received a High level of service.

Unsurprisingly the **peri-urban NP households scored higher in overall service levels than all other households**. In peri-urban areas, **NP received higher scores than P and VP for all indicators, except water quality monitoring**—one in ten enjoyed a private connection. In rural areas, **NP households had higher accessibility scores, both in terms of distance and crowding. However they fell short in terms of water**

quality monitoring, with 31% of NP households meeting part or all their needs with informal sources. Although fewer VP households enjoyed more than 40 lpcd compared to NP and P (Intermediate and High levels), **the same proportion of VP and NP receive at least a Basic level of service in water quantity (e.g., 20 lpcd)**.

7 Research implications

In a review of Africa's water and sanitation infrastructure, Banerjee and Morella (2011) found that, on average, African households spent US$ 4 per month on water. They calculated this expenditure, representing approximately two per cent of household income. They cited indicative tariff ranges of US$ 2-8 per household per month for consumption between 25 and 60 lpcd, with the upper range representing CapEx recovery tariffs. In Burkina Faso, the range of monthly expenditure for the average household is between US$ 6-8.5 per household (Financial_TOT) with expenditure on tariffs and user fees ($OpEx_{FIN}$) between US$ 5-6 per household per month. Banerjee and Morella (2011) looked primarily at peri-urban areas and used GDP per capita as the metric for determining affordability to households. They concluded that approximately 60% of the African population can NOT afford to pay cost recovery tariffs, which appears to be the case in many of the households in this study in Burkina Faso where the financial investments represented a significantly greater percentage of reported income. Considering the lower service levels received by P and VP households, and their greater relative contribution to these services—affordability and equity are paramount, ushering in an added human rights dimension to the situation.

Research has demonstrated that most water subsidy mechanisms in Africa are poorly targeted and fail to reach the poor, in part because the poor lack access to water networks which operate under the subsidies (Banarjee and Morella, 2011). In Burkina Faso the existing water subsidies are limited to urban areas operated by ONEA, and not targeted to any specific customer income category—the ONEA does not even organise customer data by income category (Newborne, Tucker and Bayliss, 2012).

In urban areas in Burkina Faso, a pro-poor policy would subsidise connection in order to offset the economic expenditure spent on public point sources by P and VP households. Water from a private connection is the same or even less expensive compared to the unit price of water from standpipes. So targeting subsidies to increase private connections amongst the low-income population would also entail a financial savings, in addition to a significant decrease in economic expenditure. This type of pro-poor subsidy in urban settings is well known and has been advocated in the water sector for a long time (Komives, Foster and Banerjee, 2005) although there has been little uptake of these subsidies in the sector. Any subsidies must be accompanied by micro-finance initiatives and flexible payment options to avoid "inactive connections". These are situations where households with private connections return to using public or informal sources because of low and/ or irregular income that is insufficient to cover the monthly bill. In Ouagadougou, in 2009, 6.8% of all connections were registered as "inactive" (Newborne, 2011).

A pro-poor policy in rural areas is more complex to achieve because of the prevalence of alternative water sources and the higher likelihood of seasonal income and low cash flow within communities. This research showed that even in the dry season, when formal sources are more utilised as compared to the wet season, one third or more of households utilise water from informal sources, increasing crowding and average distance to the sources.

Rural households are particularly vulnerable to non- or poorly functioning primary water points in the dry season when compared to the wet season since secondary water points require 60% more travel time. 10% of rural households revealed that their primary water points are informal water sources in the rainy season. The quality of unprotected water sources (i.e., informal or traditional sources) poses a significant health risk to the populations utilising water for drinking, cooking and bathing. The benefits of rural water supply infrastructure projects may not be fully realised if households switch between formal and informal sources. Informal and formal water points complement each other, depending on seasons, crowding and affordability. A pro-poor policy would certainly prioritise a high functionality rate of formal sources in the dry season (to the benefit of all poverty categories) and in addition, provide strategic support such as point-of-use treatment options so that households may continue to rely on informal sources. These forms of self-supply are ways that households cope with over-crowded, distant or expensive formal water points.

A major public health issue uncovered by the research in Burkina Faso is related to water quality at informal and formal water sources. Even amongst peri-urban NP households—who generally enjoy the highest level of service—7% (11 out of 164) received low service levels in terms of water quality monitoring because they supplemented their domestic water with water from a traditional unprotected source. In peri-urban areas, NP households may have the financial capacity to monitor the water quality of private sources themselves or buy water treatment devices to treat water collected from unprotected sources. However in rural areas, water quality monitoring is likely beyond the capacity of households. In these areas it is necessary to not only improve the monitoring frequency of formal water points, but also to develop a strategy to support the demand for monitoring water from informal sources.

Beyond source protection, in many areas in Burkina Faso, there was no mechanism to ensure water quality at community water points (i.e., no water treatment processes)—emerging water quality monitoring as an important component in a public health campaign could help integrate/ promote household water treatment, safe storage and social marketing/ behaviour change. These considerations are crucial to developing appropriate WASH policies and strategies in Burkina Faso, and in similar contexts throughout the world.

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Appendices

Appendix A

Focus group discussion summary notes describing the characteristics used to establish socio-economic status groups (SES-2)

		Very Poor (VP)	Poor (P)	Non-Poor (NP)
Rural communities	Aorema	Insufficient food or clothing for all members of household	No other income generating activities other than agricultural	One that can meet their needs and also those of others, with livestock or working in the trade
	Bouere	Insufficient food to eat Shelter of poor quality No/poor quality shoes No/poor quality clothes No mat in home No groundnuts or millet 0.5 hectares or less	Less than 3 meals per day Doesn't have crops after October 2 ha cotton, 1 ha corn, 1 ha millet Takes seed and money on loan At harvest forced to pay back loans	Able to eat all year and has no problems if crops fail Durable housing and has a motorcycle or other motor vehicle 15 to 20 ha of cotton and 3-4 pairs of oxen yoked or tractors
	Dossi	Insufficient food to eat Shelter of poor quality No/poor quality shoes and clothes 0.5 ha sorghum or millet, No corn Can't afford fertiliser No plough or oxen	Can meet their needs but has none left to help family or friends It can operate 5ha composed of 2ha cotton 1ha but 1ha white sorghum and red sorghum 1 ha Up to two oxen	Whoever gets to take charge, who can help others and comes to realize all these projects Operates 10-30 ha, composed of 15ha cotton 10ha but 3ha of white sorghum, red sorghum 1ha, 0.5 ha and 0.5 ha groundnut cowpea Has at least five pairs of oxen or a tractor
	Komsilga	Insufficient food to eat Shelter of poor quality No/poor quality shoes No/poor quality clothes	Can feed and clothe themselves A means of transport (bike) Less than 5,000 CFA in bank Educates children with difficulty	Three meals a day Durable house Educates children with ease Has a motor vehicle
	Margo	Insufficient food to eat	Can meet their needs but has none left to help family or friends	Has sufficient millet and can help others Has invested in cattle and the village
	Yagma	A single coat No shoes Can't meet basic food requirement without help No animals, No transportation Simple shelter	Has at most two chickens and one goat or sheep, eat no more than twice a day, house of 10 sheets or mud hut Has a bicycle as a means of travel	Has sufficient food Has cattle Well-dressed Motor vehicle Educated children Large house/ durable materials
Peri-urban communities	Sector 1	Insufficient food to eat Requires external assistance to survive	Can meet their needs but has none left to help family or friends	Whoever gets to meet his basic needs and can help others

		Very Poor (VP)	Poor (P)	Non-Poor (NP)
	Sector 2	Physical disability, needs assistance to meet basic needs	Can meet their basic needs but may not eat 3 times a day Willing to work but may not have means	Has something at the end of the month and eat three times a day
	Sector 30	House can be built in 3 days Can't afford rice Precarious housing Insufficient dishes Difficulty covering costs of schooling for children Unemployed/No income Must sell sand or gravel	A person who can manage to ensure its daily meal Has a flat of millet or maize Limited purchasing power	Able to afford a bag of millet, who dresses well Brick house A good means of transport That can be treated Which can provide three meals Who may have access to education

Source: WASHCost Focus Group Discussions

Appendix B

The five assumptions made to calculate the economic expenditure are:

1) One-way distance in metres from household to source (*d_N*) was obtained from GIS data from all communities except Sector 1 in Ouahigouya. Therefore, Sector 1 was excluded from the analysis for OPEXecon and cumulative expenditure.

2) Average queue time (*t_N*) was determined for each individual water point from the water point surveys. Although queue time may vary between days of the week or hours of the day previous observations have shown that these differences are not significant and will normalize over the course of the year (Mu, Whittington, and Briscoe, 1990).

3) Speed of travel (*s*) is assumed to be that of the slowest mode of travel. Various modes of travel were observed at the Burkina Faso study locations: walking, bicycle, donkey, wheel barrel, handcart, donkey carriage and motorized vehicle (motorcycle, car, tractor, etc.). For the human and animal driven modes, literature suggests that the transportation speeds are similar (Pushpangadan 2000; Wickler et al., 2000; Maloly et al., 1986). Only a small percentage of households, less than 3 per cent, used motor vehicles to transport water and field observations determined that any time savings through these modes of transport were partially offset by the time to load/unload containers. Also, there is the difficult issue of accounting for the additional costs for the operation and maintenance of motorized vehicles, which can vary by orders of magnitude. Furthermore, the savings achieved by motor vehicles, bicycles, or animals can be accounted for in the differential carrying capacity (volume per trip) of each method. Considering these issues and the general range of values available in the literature, a standard speed of 55 meters/minute was used to obtain estimates of collection times from distance data for all modes of travel.

4) Value of time (*v*) can be calculated in many ways. A detailed discussion of different methods used in the determination of the costs of water collection is available elsewhere (Nauges and Whittington, 2009). However, among the only authors to provide empirical evidence about the pecuniary costs of collecting water from non-tap sources were Whittington, Mu, and Roche (1990). They determined, in one of the few water demand estimation studies conducted in Sub-Saharan Africa (and the only study performed in a small town) that the value of time for households relying on non-household water sources was greater than previously estimated and likely equal to that for unskilled labor in some cases (Whittington, Mu, and Roche,1990). The minimum daily wage rate for unskilled labor in Burkina Faso is 162.37 CFA (US$ 0.32) per hour. The Inter-American Development Bank uses a more conservative value, 50 per cent of the market wage rate for unskilled labor (i.e. 81 CFA per hour), as the valuation of time based upon transportation research in the developing world. However, for this research the value of time was derived from household surveys conducted in the dry season using the annual household income (Rev_TOT). The hourly value of time was calculated as follows assuming an 8 hour work day, 240 work days a year:

$$v = \frac{(Rev\_TOT / HH\ size)}{1920\ hours/year} \qquad \textbf{Eqn B.1}$$

5) Number of trips (*r_N*) was determined using data from the household surveys. Knowing the mode of travel and the type and number of containers used to collect water at each of the preferred water sources the total number of trips required to transport water containers back to the household was determined. This, however, requires knowledge of the transportation capacity (i.e. number of containers) of each mode of travel. The values for transportation capacity of different travel modes (Table B.1), was based upon the field experience of the authors of this report and was confirmed by observation in Burkina Faso.

Table B.1 Container transportation capacities for different travel modes.

Travel Mode	220L Barrel (L)	20L Jerry-can (J)	15L Basin (N)	10L Bucket (T)	Combinations
Walking	0	1	1	2	1N 1T; 1J 1T
Bicycle	0	2	1	2	1J 1T
Hand cart	1	6	1	8	1L1J;1L1N; Any combo of J and T up to 6
Beast (no cart)	0	2	0	2	1J1T
Wheel barrel	1	3	1	2	2J1T, 1J2T
Animal cart	2	10	4	14	1L2N;1L5J;1L7T; 5J2N; 5J7T; 2N7T
Other	2	10	4	14	Same as animal cart

Note: For a given mode of travel the total number of each type of container that could be transported per trip is listed for Barrels (L), Jerry-cans (J), Basins (N), and Buckets (T). The last column labelled "Combinations" lists possible combinations of containers that may be carried per trip. For example, with a wheel barrel it is possible to carry 3 jerry cans or 2 buckets. It is also possible to carry, with a wheel barrel, 2 jerry cans and a bucket or 1 jerry can and 2 buckets.

Appendix C

Correlation analysis

The life-cycle cost categories (CAPEX, CAPMANEX, $OPEX_{FIN}$, $OPEX_{ECON}$) as well as total financial expenditure (Financial_EX) and cumulative expenditure (Cumm_EX) were compared to other continuous variables using SPSS version 20.1 (Armonk, New York). Sample size (n), Pearson product statistics, and the statistical significance (95 and 99 per cent are indicated with asterisks) are presented in Table C.1. The columns of Table C.11 are labelled A through O and the rows are numbered 1 through 15 so that results can be referenced[21][22]. This table contains results for the dry and wet season surveys. For cost categories involving GIS data (e.g. water point distance and opportunity costs) Sector 1 data were excluded from the analysis (columns J through O and rows 10 through 15).

Key (see table c.1 on next page)

size_hh: number of people per household
wtpt1_dist: distance in meters to water point 1
wtpt1_trips: trips to water point 1
water use: total volume (litres/person/day)
HH_water_use: total volume (litres/household/day)
Rev_TOT: annual household income (US$/HH/yr.)
Exp_TOT: annual household expenses (US$/HH/yr.)
CAPEX: capital expenditure (US$/per.)
CAPMANEX: capital maintenance expenditure (US$/per/yr.)
OPEX1: financial operations expenditure (US$/per/yr.)
OPEX2: financial operations expenditure (US$/per/yr.)
OPEXeconB: economic operation expenditure (US$/per/yr.)
Financial_EX: Total financial expenditure on water (US$/per/yr.)
Cumm_EX: Minimum cumulative expenditure on water (US$/per/yr.)

[21] Output tables from bivariate correlations are symmetric about the diagonal axis. So for example, the values from the correlation between "HH size" and "Cumm_EX" are shown in A15 and O1.

[22] Output tables from bivariate correlations are symmetric about the diagonal axis. So for example, the values from the correlation between "HH size" and "Cumm_EX" are shown in A15 and O1.

Table C.1 Correlation Analysis Results

Data from water point 3 is not presented as none of results were statistically significant. A1 thru I9 includes Sector 1 data, but the remainder of the table (i.e. GIS related variables) does not include Sector 1 data.

			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
			HH_size	water use	HH water use	Rev_TOT	Exp_TOT	CAPEX	CAPMANEX	OPEXfin	Financial_EX	wtpt1_dist	wtpt2_dist	wtpt1_trips	wtpt2_trips	OPEXecon	Cumm_EX
1	size_hh	Pearson (r)	1	-.284**	.363**	.060	.152**	-0.030	-.123**	-.116**	-.149**	.007	-.036	.230**	.201**	-.257**	-.293**
		N	968	968	968	878	878	878	878	968	878	774	178	815	288	758	702
2	water use	Pearson (r)	-.284**	1	.648**	.106**	.104**	0.037	.217**	.369**	.385**	-.045	.155*	.148**	.047	.283**	.348**
		N	968	968	968	878	878	878	878	968	878	774	178	815	288	758	702
3	HH water use	Pearson (r)	.363**	.648**	1	.149**	.217**	.005	.058	.272**	.257**	-.040	.060	.343**	.263**	.000	.079*
		N	968	968	968	878	878	878	878	968	878	774	178	815	288	758	702
4	Rev_TOT	Pearson (r)	.060	.106**	.149**	1	.322**	.119**	.026	.078*	.080*	-.143**	-.137	-.066	-.088	.296**	.273**
		N	878	878	878	878	878	878	878	878	878	719	165	757	269	757	702
5	Exp_TOT	Pearson (r)	.152**	.104**	.217**	.322**	1	0.057	.136**	.038	.067*	-.131**	-.087	-.068	-.022	0.032	.078*
		N	878	878	878	878	878	878	878	878	878	719	165	757	269	757	702
6	CAPEX	Pearson (r)	-0.030	0.037	0.005	.119**	0.057	1	-0.009	0.019	0.017	-0.020	-0.043	-0.044	-0.060	0.017	.075*
		N	878	878	878	878	878	878	878	878	878	719	165	757	269	757	702
7	CAPMANEX	Pearson (r)	-.123**	.217**	.058	.026	.136**	-.009	1	.075*	.295**	-.019	0.088	.007	.014	.127**	.482**
		N	878	878	878	878	878	878	878	878	878	719	165	757	269	757	702
8	OPEXfin	Pearson (r)	-.116**	.369**	.272**	.078*	.038	0.019	.075*	1	.975**	-.123**	-.066	.044	.286**	.121**	.376**
		N	968	968	968	878	878	878	878	968	878	774	178	815	288	758	702
9	Financial_EX	Pearson (r)	-.149**	.385**	.257**	.080*	.067*	0.017	.295**	.975**	1	-.120**	-.070	.038	.284**	.144**	.469**
		N	878	878	878	878	878	878	878	878	878	719	165	757	269	757	702
10	wtpt1_dist	Pearson (r)	.007	-.045	-.040	-.143**	-.131**	-0.02	-.019	-.123**	-.120**	1	.489**	.105**	.026	.142**	0.020
		N	774	774	774	719	719	719	719	774	719	774	166	774	276	720	664
11	wtpt2_dist	Pearson (r)	-.036	.155*	.060	-.137	-.087	-.043	0.088	-.066	-.070	.489**	1	.103	-.043	0.078	-0.018
		N	178	178	178	165	165	165	165	178	165	166	178	178	175	165	147
12	wtpt1_trips	Pearson (r)	.230**	.148**	.343**	-.066	-.068	-0.044	.007	.044	.038	.105**	.103	1	.501**	0.061	.012
		N	815	815	815	757	757	757	757	815	757	774	178	815	288	758	702
13	wtpt2_trips	Pearson (r)	.201**	.047	.263**	-.088	-.022	-.060	.014	.286**	.284**	.026	-.043	.501**	1	-0.036	0.079
		N	288	288	288	269	269	269	269	288	269	276	175	288	288	270	242
14	OPEXecon	Pearson (r)	-.257**	.283**	.000	.296**	0.032	.017	.127**	.121**	.144**	.142**	0.078	0.061	-0.036	1	.624**
		N	758	758	758	757	757	757	757	758	757	720	165	758	270	758	702
15	Cumm_EX	Pearson (r)	-.293**	.348**	.079*	.273**	.078*	.075*	.482**	.376**	.469**	0.020	-0.018	.012	0.079	.624**	1
		N	702	702	702	702	702	702	702	702	702	664	147	702	242	702	702

	Pearson (r)	Strength
red	0.5 ≤ r	large
orange	0.3 ≤ r <0.5	medium
yellow	0.1 ≤ r 0.3	small
white	r <0.1	no correlation

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

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

Appendix D

Multivariate Models

Multivariate models can determine how well a set of variables is able to predict an outcome, which variable in the set of variables is the best predictor, and whether a particular variable is still able to predict an outcome when controlling for the effects of another variable. Two types of multivariate models were used: linear and ordinal regression models.

Linear Regression Models

Linear regression models are used to determine the relationships between a response (dependent) variable and a weighted combination of predictor (independent) variables. The independent variables (e.g. household size, rural or urban, and socio-economic status) are entered into an equation that is designed to predict the value of the dependent variable (e.g. CAPEX, OPEX). The equation is composed of estimation coefficients (β values), which describe how changes in the predictor variables affect the response variable. The units of the estimation coefficients (β values) are the same units as the response (dependent) variable. The dependent variables considered are shown in column 2 of Table D.1 and the independent variables are shown in the top row (e.g., Very Poor, Rural, Dry, HH_size).

Interpreting the Table D.1 can be best understood through an example. Looking only at Row 3: household financial expenditure or OPEXfin_TOT. From this row we see that increasing the household size by one person while holding all other independent variables constant (i.e. household with same socio-economic status, location, and season) will result in an increase of the household financial expenditure by US$5 (i.e. the value of β_4 Row 3) for the household over the course of the year. In this case the increase is statistically significant to the 99.9% (or 1 minus the "p- value").

For predictor variables that are not continuous or ordinal, the beta values represent how change will affect the dependent variable. For example, holding all the other parameters constant, OPEXfin_TOT will be US$18/HH/year greater in the dry season compared to any other season (in this case there is only one other season-"Wet"). Similarly rural households have lower financial operating costs compared to peri-urban households, US$17.5 per household per year less. There are no other statistically significant results in Row 3. All model parameters that are statistically significant (i.e. p-values less than 0.05) are shaded. Looking at Row 4 (OPEXecon_TOT), the β_1 value, US$ 24/ HH/ year, represents the difference between Very Poor and all other socio-economic categories (i.e., Poor and Non-Poor combined).

In Table D.1 the financial, economic, and cumulative expenditure on water are presented as a percentage of total reported annual income (e.g. Financial_prctg_rev) or total reported expenses (e.g. Financial_prct_exp). When controlling for household size, rural-peri-urban effects, and seasonality, the difference in expenditure between VP and other households (i.e., NP and P) is statistically significant.

Table D.1 Linear regression analysis of household expenditure.

Row	Dependent variable (units)	Independent Variables (p-values)				
		Constant β_0	Very Poor β_1	Rural β_2	Dry β_3	HH_size β_4
1	**CAPEX_TOT†** (US$/HH)	$9 (.256)	$5 (.569)	$10.5 (.148)	NA	-$0.5 (.701)
2	**CAPMANEX_TOT** (US$/HH/yr.)	$3.5 (.083)	-$3 (.204)	$2.5 (.159)	NA	$1.5 (.000)**
3	**OPEXfin_TOT** (US$/HH/yr.)	$23.5 (.006)**	$2 (.846)	-$17.5 (.017)*	$18 (.008)**	$5 (.001)**
4	**Financial_TOT** (US$/HH/yr.)	$38.5 (.000)**	-$0 (.985)	-$17 (.040)*	NA	$6.5 (.000)**
5	**OPEXecon_TOT** (US$/HH/yr.)	$42.5 (.000)**	-$24 (.011)*	$12 (.158)	$23 (.001)**	-$2.5 (.002)**
6	**Cumm_TOT** (US$/HH/yr)	$95.5 (.000)**	$28 (.061)	$3 (.830)	NA	$5.5 (.000)**
7	**Financial_%_income** (%)	1.1% (.888)	11.7% (.143)	21.2% (.001)**	NA	0.5% (.431)
8	**Financial_%_expenses** (%)	1.5% (.649)	8.3% (.016)*	7.4% (.008)**	NA	0.5% (.064)
9	**OPEXecon_%_income** (%)	3.7% (.000)**	1.5% (.023)*	3.5% (.000)**	2.5% (.000)**	-0.4% (.000)**
10	**OPEXecon_%_expenses** (%)	6.1% (.000)**	0.8% (.617)	5.9% (.000)**	4.1% (.001)**	-0.6% (.000)**
11	**Cumm_%_income** (%)	14.3% (.165)	11.7% (.260)	35.4% (.000)**	NA	-0.2% (.819)
12	**Cumm_%_expenses** (%)	15.9% (.004)	13.9% (.014)*	19.4% (.000)**	NA	-0.4% (.450)

*. Relationship is significant at the 0.05 level (2-tailed), or 95 per cent significance.
**. Relationship is significant at the 0.01 level (2-tailed), or 99 per cent significance.
†. In order to include household size in the models the absolute expenditure are shown as US$ PER HOUSEHOLD (i.e., "TOT")
Note: Only Very Poor was included as a model parameter as there was no statistically significant difference between Poor and Non-Poor households. Sector 1 data were excluded for those variables that are calculated using GIS data (e.g. OPEXecon , Cumm_TOT, etc.).

The impact of select variables on services level indicators was also evaluated using linear regression models. For the service level indicators that are determined only by continuous variables (i.e., quantity of water and distance to water source) a linear regression and for the indicators that are ordinal in nature (i.e., water quality monitoring and crowding) ordinal regressions were performed. In addition, an ordinal regression was performed for the overall service level which is a function of Water Quantity, Water Quality Monitoring, and Accessibility (distance and crowding). The following section will discuss ordinal regression models in more detail.

Using data from the household surveys a linear model was created (R^2=0.310) to understand the effects of different variables on the quantity of water consumed across all water sources (Table D.2).

Table D.2 Effects of select variables on the quantity of water consumed across all water sources

Dependent variable (units)	Model parameters (p-values)[1]							
	Constant β_0	OPEXecon (CFA) β_1	Financial_EX (CFA) β_2	Wtpt1_dist (meter) β_3	HH_size (members) β_4	Non-Poor β_5	Dry β_6	Rural β_7
Water use (lpcd)	37.674	3.95×10^{-4}	0.001	-0.016	-1.099	5.920	5.952	-6.647

[1].Sector 1 data were not included in this model. All parameters are significant (p<0.01)

The model describing the influence of expenditure and other factors on the distance to the household's primary source is show in Table D.3. It is important to note that the model shown in Table D.3 is for the distance travelled to the primary source and not the indicator score for Accessibility: Distance. For example a "higher" indicator score for distance (i.e. Intermediate vs. Basic) would mean a shorter distance travelled to the water source (refer back to Table 4 for the thresholds). Table D.3 is interpreted in the same way as the previous tables.

Table D.3 Effects of expenditure on the distance to water source.

Units of the estimation coefficients (β values) are meters and the model fit is (R^2=0.213).

Dependent variable (units)	Model parameters (p-values)				
	Constant β_0	Financial_TOT β_1	Cumm_TOT β_2	Rural β_3	Wtpt2_dist β_4
Distance to primary source (meters)	93.912 (.014)*	-0.001 (.050)*	0.001 (.015)*	112.053 (.004)**	0.099 (.001)**

[1]Sector 1 data were not included in this model.
**. Relationship is significant at the 0.05 level (2-tailed), or 95 per cent significance
**. Relationship is significant at the 0.01 level (2-tailed), or 99 per cent significance.

Ordinal Regression Models

The results of the ordinal regression models are shown in the tables below. Unlike linear regression models the results of ordinal regression do not describe the magnitude of the effect between the independent model parameters (or variables) and the dependent variable (model outcome). The quantitative effects in linear regression are the beta values (β). Ordinal regression models are only able to describe the nature (positive or negative) of relationships and the statistical significance of each relationship. This significance is described by the p-value, which if less than 0.05 is considered to be statistically significant. The strength of the models is described by rho squared (ρ^2).

Table D.4 Effects on water quality monitoring of primary water source (ρ2=0.319). Sector 1 data were excluded from the model. Data missing for at least one of the parameters for 60 households.

Parameter	Estimate	Std. Error	p-value
Quality = No Service	-6.753	.497	0.000
Quality = Basic	-2.791	.469	0.000
Quality = High	---	---	---
Financial_EX	7.685E-05	1.671E-05	.000
OPEXeconB	-6.866E-06	8.733E-06	.432
Rural	-4.686	.468	.000
Dry	.812	.191	.000

Table D.5 Effects on water quality monitoring of secondary water source (ρ2=0.056). Sector 1 data were excluded from the model. Only statistically significant parameters are shown. Data missing for at least one of the parameters for 60 households.

Parameter	Estimate	Std. Error	p-value
Quality = No Service	2.336	.189	0.000
Quality = Basic	3.462	.220	0.000
Quality = High	---	---	---
Financial_EX	2.836E-05	1.049E-05	.007
OPEXecon	2.212E-05	8.089E-06	.006
Dry	.921	.195	.000
Non-Poor	.588	.187	.002

Table D.6 Effects on accessibility crowding at the primary water source (ρ2=0.021). Sector 1 data were excluded from the model. Data missing for at least one of the parameters for 95 households.

Parameter	Estimate	Std. Error	p-value
Crowding = Sub-Standard	-.664	.143	0.000
Crowding =Basic	---	---	---
OPEXeconB	-2.248E-05	9.322E-06	.016
collxn_time_wtpt1_ per person	.023	.007	.001
vol_wtpt1	-.001	.001	.047
urban_NP	.509	.294	.084

Table D.7 Effects on accessibility crowding at the secondary water source (ρ2=0.189). Sector 1 data were excluded from the model. Only statistically significant parameters are shown. Data missing for at least one of the parameters for 118 households.

Parameter	Estimate	Std. Error	p-value
Crowding = Sub Standard	2.371	.193	0.000
Crowding =Basic	---	---	---
OPEXeconB	4.133E-05	1.118E-05	.000
Financial_EX	2.478E-05	1.109E-05	.025
Dry	.917	.197	.000
NP	.549	.191	.004

Table D.8 Effects on overall service level (ρ2=0.017). Sector 1 data were excluded from the model. Data missing for at least one of the parameters for 58 households.

Parameter	Estimate	Std. Error	p-value
Overall_service = No Service	-.739	.165	.000
Overall_service = Sub-Standard	.998	.166	.000
Overall_service = Basic	2.072	.184	.000
Overall_service = Intermediate	5.695	.604	.000
Overall_service = High	---	---	---
Rural	-.382	.152	.012
Financial_TOT	5.132E-06	1.134E-06	.000
OPEXeconB_TOT	-9.838E-07	1.353E-06	.467
Dry	.085	.135	.529