Oxford Policy Management

Improving value for money and sustainability in WASH programmes (VFM-WASH)

Regional assessment of the operational sustainability of water and sanitation services in South Asia

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List of abbreviations

ASHWAS	A Survey of Household Water and Sanitation
BBS	Bangladesh Bureau of Statistics
CDC	Centres for Disease Control and Prevention (United States)
DACAAR	Danish Committee for Aid to Afghan Refugees
DFID	Department for International Development (United Kingdom)
DHS	Demographic and Health Survey
DPHE	Department of Public Health Engineering
EC	Electrical Conductivity
FIETS	Financial, Institutional, Environmental, Technical and Social
EA	Enumeration Area
JMP	Joint Monitoring Programme (WHO/ UNICEF)
LPCD	Litre per Capita per Day
MICS	Multiple Indicator Cluster Surveys
OPM	Oxford Policy Management
PBS	Pakistan Bureau of Statistics
PSU	Primary Sampling Unit
RWSN	Rural Water Supply Network
SHEWA-B	Sanitation, Hygiene Education and Water in Bangladesh
TDS	Total Dissolved Solids
TOR	Terms of Reference
VFM	Value for Money
WARM-P	Water Resources Management Programme
WASH	Water, Sanitation and Hygiene
WHO	World Health Organisation
WP	Water Point
WPM	Water Point Mapping

Glossary

This section summarises some of the definitions of key terms used. Further details of terms used in primary data collection are available in the VFM-WASH household survey reports.

Operational sustainability

Operational sustainability is one dimension of the broader concept of service sustainability. The operational dimension is specifically concerned with the functionality of water and sanitation systems over time (operational service) and how these contribute to household's experience of effective service levels over time (effective service).

Primary Sampling Unit (PSU)

The Enumeration Area (EA) defined by the census authority of the country will be considered as the Primary Sampling Unit (PSU) in this survey. Usually they refer to average village or communities. In some cases large villages are divided into more than one enumeration areas.

Public water point

Public water points are those which can be used by multiple households and are available for anyone to use, either free of cost or with a charge. Public water points will almost always be located in a public place, NOT inside a household compound. For the water point listing and community interviews, we are only looking at public WPs. "Public" is about accessibility and permission rather than ownership or payment. A public water point can be accessed by anybody at almost any time of day (depending on who is operating it), whether or not they have to pay.

Private water point

A private WP can only be accessed by those permitted by the manager/owner, e.g. a tubewell on a HH's plot that they and their 2 neighbouring HHs use, whether or not they have to pay. There are some grey areas, e.g. a privately-owned WP managed by a shop-owner in the market is a public WP because anyone can use it. Another key grey area is private WPs from "public" systems, is for example, a tap in someone's HH/plot that comes from a deep tubewell with distribution to many HHs. We have considered this as private water point, because the point of collection is private.

Water point

A water point (WP) is the place from which someone draws water (e.g. tapstand, tubewell etc.). In this survey we are primarily focusing on water-points, not on water source or water systems.

Water source

A water source is the place the 'bulk water' for the water point comes from, e.g. groundwater, river, lake, dam etc. Please note that sometimes the water source and the water point can be the same, e.g. if it is a well

Water system

A water system is a means of distributing water and can have multiple water points. For example, water from a tubewell pumped up to a tank, with pipes going to 3 taps around the community. For listing, we want to count all the taps as separate water points.

Executive Summary

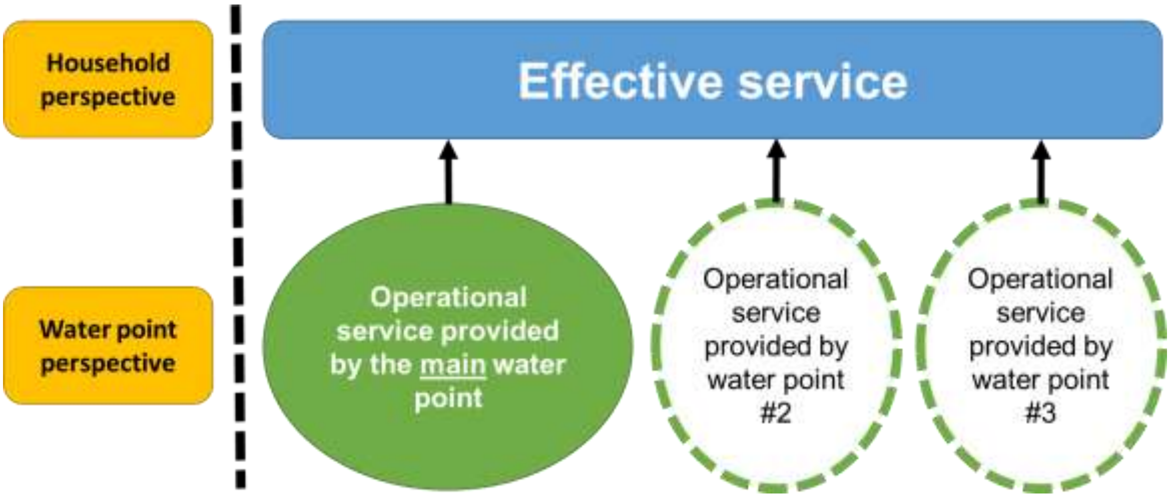
Conceptualising service levels of rural water and sanitation services

The purpose of this report is to provide an evidence-based overview of the 'operational sustainability' of water and sanitation services across the South Asian region. It brings together large-scale representative data collected in Bangladesh and Pakistan as part of the VFM-WASH project, as well as robust secondary data and literature on service sustainability related to all South Asian countries.

Indicators of operational sustainability are organised around two key perspectives: the level of **effective water/sanitation service** understood as the household experience of service over time; and **operational service**, understood of as the functionality of water and sanitation systems over time and associated service attributes. These represent the *outcome* of the financial, institutional, environmental, technical and social dimensions of a water or sanitation service. As such **operational sustainability will falter if any of these dimensions are not sustained.**

While it is well-understood that most households use more than one water point, at different times of the day, for different purposes, more work is needed to develop an approach for assessing the combined use of multiple water points. As a result – even though the team collected data on the use of multiple water points by the same household – this report only focusses on the operational and effective service for the "main" water point of the household (represented by the filled green circle in Figure 1). A similar concept is valid for sanitation, discussed further below.

Figure 1 Relationship between multiple water points and effective service



Primary data collection: In this project, the main research tool used was the household survey. This provided detailed and nationally-representative data on the household perspective of water service delivery over time, allowing the VFM-WASH team to assess elements of effective water service with a high degree of confidence. Estimates of temporal dimensions of effective water service could be made along with a qualitative assessment of aspects of level of service, including time spent collecting water. However it was not within the scope of this research to undertake comprehensive water quality testing of micro-biological, chemical and physical parameters so these water quality dimensions have not been assessed.

State of rural water services in South Asia

In Figure 2 we summarise primary and secondary data on the effective and operational dimensions of water service delivery in South Asia, collated together over different time periods.

This figure shows that across South Asian the household experience of water services is largely positive. Over ninety percent of rural household's access and use an improved water source. Representative primary data from Bangladesh and Pakistan shows that the main source for all household provides a very reliable water service. The high density of water supply infrastructure in much of rural South Asia means that for most households water collection times are well below 30 mins per round trip and also that a high proportion of the population access an acceptable quantity of water according to WHO guideline standards. The exception to this summary is Afghanistan where household water services are much worse than elsewhere in South Asia.

From an individual water-point perspective, collated primary and secondary data indicate that rural water point functionality in South Asia varies between 77-90% according to the four most comparable data sets. However it is not possible to come up with a point estimate for the entire region in the absence of data for so many large countries. Indeed the main message of emerging from available data is that the most pressing constraint to operational sustainability in South Asia is not infrastructure functionality or reliability but rather the safety of water being supplied, particularly in the face of high level of bacteriological and arsenic contamination. This has important implications for policy. Since many households already experience a relatively high effective water service in some South Asian countries, investments and support to communities in those countries will need increasingly to focus on specific aspects of level of service; particularly water quality.

Figure 2 Operational sustainability of rural water services in South Asia

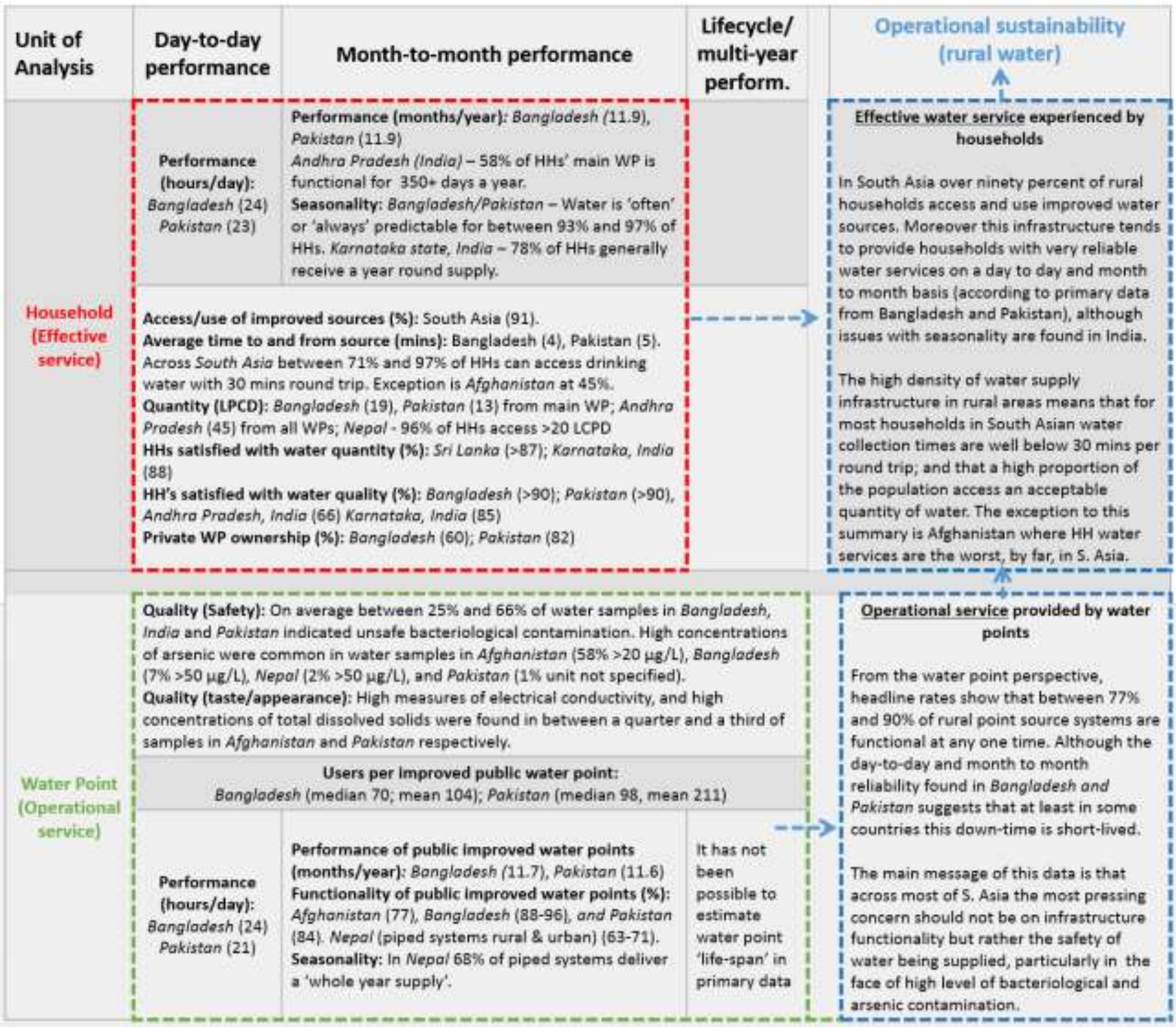


Table 1 organises this same data by operational service indicators. Collating results in this manner demonstrates the limits of the existing secondary data in the sector. Typically in South Asia any insights into rural water services are based on a small number of indicators: i) the cross-sectional functionality of public water points drawn from water point mapping studies and ii) household access to water infrastructure and their distance from it, available in representative households studies e.g. MICS/DHS.

There is no available secondary data on the day to day performance of water supply infrastructure and only sporadic data on month to month or seasonal performance. There are some understandable reasons for this: i) day-to-day performance is generally more of an issue with networked schemes, which are not particularly common in rural areas of South Asia, and ii) rural water policy for point sources such as wells or boreholes has generally been based on a binary measure of functionality, rather than an ongoing assessment of performance. Corresponding service level data is also patchy, with information on water consumption and water quality available in a handful of countries, with no systematic data on water point crowding. Our understanding of how people experience and access water on a day to day and month to month basis is drawn almost exclusively from primary data collected in Bangladesh and Pakistan.

Table 1 Summary of primary and secondary date on rural water services in South Asia

Period	Indicators used to guide primary and secondary data collection	Primary data		Secondary data*	
		Ban	Pak	*Other South Asian countries*	JMP regional average
Day-to-day performance	**Household experience:** Mean hours per day during which water is available from the main household water point	24	23	-	
	Water point perspective: Mean hours per day during which water is typically available from public improved water points	24	21	-	
Month –to-month performance	**Household experience:** Mean months per year during which water is usually available from the main water point	11.9	11.9	-	
	Household experience: % of households who state that water flows are "always" or "often" predictable from the main water point / do not experience significant seasonal water shortages throughout the year	93	97	Bangladesh: 45 Karnataka state, India: 55 Andhra Pradesh state, India: 58	
	Water point perspective: % public improved water points functional at time of inspection	90	92	Afghanistan: 77 Bangladesh: 88 Nepal: 62	
	Water point perspective: % public improved water points always of sometimes functional as reported by the community	96	84	-	
Water services levels	**Access - household perspective**				
	% households using an improved water point	-	-	-	91
	% households using an improved water point as main water point	90	95	-	
	% households that own their main water point	60	82	-	
	Mean time per round trip to fetch water from their main water point (mins)	4	5	Afghanistan: 14 Bangladesh: 13 Andhra Pradesh state, India: 6	
	% of households that access their main water point in less than a 30 minute round trip	-	-	Afghanistan: 45 Bangladesh: 96 India: 85 Nepal: 71 - 81 Pakistan: 90 - 94	
	Access – water point perspective				
	Median number of households using each public improved water point	70	98	-	
	Mean number of households using each public improved water point	104	211	-	
	Quantity - household perspective				
	The quantity of water accessed by water point type (LPCD)	19	13	Andhra Pradesh state, India: 45	
	Quality - household perspective				
	% of users satisfied with all perceptions of water taste and appearance	>90	>64	Andhra Pradesh state, India: 66 Karnataka state, India: 85	
	Quality – water point perspective				
	% of water samples failing water quality standards for:				
	Arsenic (%)	25	-	Afghanistan (>20 µg/L): 58 Bangladesh (>50 µg/L): 7 Nepal (>50 µg/L): 2 Pakistan (not specified): 1	
	Bacteriological contamination (%)	-	-	Bangladesh: 24 Karnataka state, India: 38 Pakistan: 64	
	Electrical conductivity (%)	-	-	Bangladesh: 30	
	Fluoride (%)	-	-	Karnataka state, India: 60 Pakistan: 7	
	Total dissolved solids (%)	-	-	Pakistan: 25	
	Turbidity (%)	-	-	Pakistan: 14	

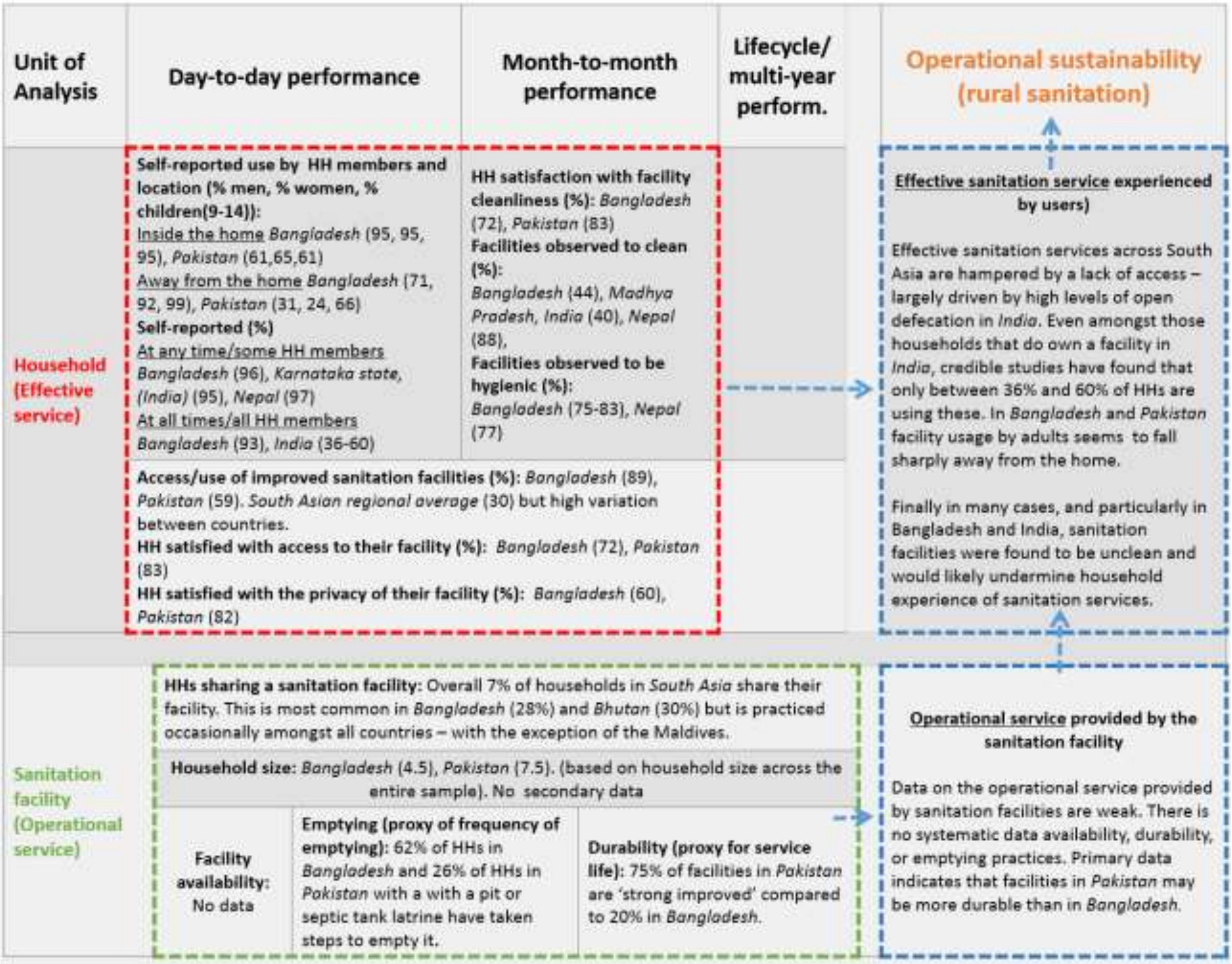
(*) Note that the secondary data is not directly comparable amongst different countries, nor directly comparable with the primary data, as secondary studies used different methodologies and definitions for their indicators. Each secondary data point is discussed in more detail in Section 5.

State of rural sanitation services in South Asia

Figure 3 summarises the primary and secondary findings relating to the operational sustainability of sanitation services in South Asia. This data shows that effective sanitation services across South Asia are hampered by a lack of access – largely driven by high levels of open defecation in India. Even amongst those households that do own a sanitation facility in India, credible studies have found that only between 36% and 60% of households are using the sanitation facilities. Moreover sanitation facility usage at different times seems to be a particular challenge. In Bangladesh and Pakistan for example facility usage by adults declines sharply when they are working away from the home, particularly in Pakistan. In contrast sanitation facility usage by children falls far less sharply when they are away from the home, likely reflecting the availability of School WASH facilities. These values suggest that sanitation and hygiene promotion initiatives in Pakistan have created sufficient pressure for individuals not to practice OD when a sanitation facility is present nearby, whereas the interventions in Bangladesh have been effective at changing social norms at all times. In other words, there are enough facilities available such that there is increased pressure for individuals *not* to practice OD *at any time*.

Nonetheless usage is not only driven by the availability of sanitation facility infrastructure. The primary data highlights that household's satisfaction with sanitation facility privacy and cleanliness is quite high at around 70% to 80% – likely encouraging ongoing usage, maintenance and emptying of the toilets. In contrast secondary data from Bangladesh and India suggest that over half of toilets are not perceived to be clean. More secondary data is needed for other countries to better understand these medium- and long-term dimensions of sanitation facility functionality and how it interacts with the households' experience of service.

Figure 3 Operational sustainability of rural sanitation services in South Asia



Summarising the primary and secondary data on rural sanitation service levels (Table 2) showcases that there are even more gaps regarding the household's experience of short and long-term service levels across South Asia more widely.

Table 2 Summary of primary and secondary data on rural sanitation services

Period	Indicators used to guide primary and secondary data collection	Primary data		Secondary data*	
		Ban	Pak	*Other South Asian countries*	JMP regional average
Day-to-day performance	**Household perspective on sanitation use**				
	% of household members using a sanitation facility when at home (sample of all households)				
	Adult men	95	61	-	-
	Adult women	95	65	-	-
	Children (9-14 years of age)	95	61	-	-
	Children (3-8 years of age)	89	59	-	-
	% of all household members using a sanitation facility when away from the home (i.e. at work/school)				
	Adult men	71	31	-	-
	Adult women	92	24	-	-
	Children (9-14 years of age)	99	66	-	-
	Children (3-8 years of age)	97	62	-	-
	% of all households that are using their household sanitation facility (sampled from those households with a sanitation facility)	-	-	Bangladesh: 93-99 India: 60-95 Nepal: 97-98	-
Month-to-month performance	**Household experience:** % of households who state that they are "satisfied" or "very satisfied" with the cleanliness of their sanitation facility; secondary data is based on observations of cleanliness	72	83	Bangladesh: 44-83 India: 40-88 Nepal: 77-88	-
	Sanitation facility perspective: % of functioning sanitation facilities that are have a durable superstructure with cleanable slab, roof, privacy and a water seal	20	75	-	-
Sanitation service levels	% of households using an improved sanitation facility	86	59	-	30
	% of households using a shared or unimproved sanitation facility	10	8	-	16
	Household experience: % of households who state that they are "satisfied" or "very satisfied" with the ease of access they have to their sanitation facility	90	95	-	-
	Household experience: % of households who state that they are "satisfied" or "very satisfied" with the privacy of their sanitation facility	60	82	-	-

(*) Note that the secondary data is not directly comparable amongst different countries, nor directly comparable with the primary data, as secondary studies used different methodologies and definitions for their indicators. Each secondary data point is discussed in more detail in Section 6.

1 Introduction

During the MDG era, since 2000, much policy and practice within the rural water and sanitation sector has focused on increasing coverage through new infrastructure construction. Increasingly, recognition is now being given to a service delivery approach focussed on maintaining delivery of reference levels of water or sanitation service over time. This approach is founded on the belief that while sustainability is multi-dimensional, at its core it is about ensuring that households continue to enjoy water supply and sanitation services over time. However, achieving sustained service delivery is a significant challenge. Specifically the sector has yet to find common metrics which would enable the measurement and benchmarking of performance over time.

The purpose of this report is to provide an evidenced-based overview of the 'operational sustainability' of water and sanitation services across the South Asian region. It brings together large-scale representative data collected in Bangladesh and Pakistan as part of VFM-WASH project, as well as robust secondary data and literature on service sustainability related to all South Asian countries. In this context 'operational sustainability' is specifically concerned with the functionality of water and sanitation systems over time and how these contribute to household experience of effective service levels over time. Improving understanding of the dynamics of system functionality and operational sustainability will enable practitioners and programme managers to reflect on whether adequate processes have been put in place to sustain services in the long-term.

1.1 Background and introduction

As part of the DFID-funded VFM-WASH research project, Oxford Policy Management is leading a consortium of five organisations examining the increasingly important concepts of operational sustainability and Value for Money (VFM) in Water, Sanitation, and Hygiene (WASH) programmes across sub-Saharan Africa and South Asia. The project spans two years (2013-2015) and includes research in six different countries (Bangladesh, Ethiopia, Mozambique, Nigeria, Pakistan and Zambia), with two main objectives:

- **Objective 1 (Obj1):** identify how value for money (VFM) and sustainability can be improved in DFID-funded WASH programmes using operational research, and
- **Objective 2 (Obj2):** provide updated regional assessments on the operational sustainability[1] of rural water and sanitation services in Africa and South Asia using primary and secondary sources of data.

This report is one of two regional outputs of **Objective 2** and evaluates the current status of operational sustainability across South Asia, and where possible, provides an indication on how services vary between countries and wealth quintiles (in order to give a picture of equity from one perspective). The findings in this report are based on primary data from our household surveys in two countries funded under this project (Bangladesh and Pakistan), and secondary data drawn from

[1] The TOR for this research contains two different ideas and terminologies. A: Under the objectives section: "updated regional assessments of the operational sustainability of provided water and sanitation services in Africa and South Asia", and B: Under the outputs section: "regional assessments of operational status of installed water and sanitation facilities". We interpreted this to be a result of unresolved internal discussions within DFID during TOR development, and took the overall objective as our key focus. This elision of "sustainability of services" and "status of facilities" is nonetheless important and reflects the general confusion in the sector on the relationship between functionality and sustainability. By one view, B above is part of A – functional facilities are required for sustainable services, but they are only one of the many determinants. In our analysis we have investigated both the status (i.e. cross-sectional functionality) and the sustainability (i.e. how services are experienced over time). Either way, our starting point is a robust definition of "operational sustainability".

a range of academic and sector sources. The primary focus of objective 2 is on rural water services, but we also provide an analysis and discussion of the operational sustainability of sanitation.

The report is structured as follows: Section 1.2 explains our rationale for this assessment, with Section 1.3 presenting our framework for operational sustainability for rural water and for rural sanitation. Section 1.5.3 indicates the scope and approach of this report. Section 2 outlines our sources and methods for primary and secondary data collection and Section 3 provides an overview of the service delivery context in Bangladesh and Pakistan. Sections 4 and 5 present operational sustainability findings on water services for both primary and secondary. Section 0 presents primary and secondary findings in relation to sanitation. Section 7 provides a discussion and synthesis of findings for both water and sanitation, and finally Section 8 presents conclusions and recommendations arising from this study.

1.2 Rationale for this regional assessment

Across the WASH sector, data on the overall sustainability of services is weak and is based on a limited number of programme-specific studies utilising diverse methodologies. The rationale for this regional assessment is that by analysing high-quality nationally-representative data for two countries in the region, plus secondary data for others, we can draw robust yet broad conclusions about operational sustainability in South Asia. The report aims to provide the most reliable estimates yet for how rural households in South Asia experience the sustainability of water and sanitation services.

Our overall approach was informed by the project ToR provided by DFID which emphasised the need for more information on the operational sustainability of services, specifically for:

> *"larger studies, looking across different programmes and technologies and including a wider range of countries and applying rigorous and transparent methodologies to establish up to date benchmarks against which the sector can assess comparative performance."*[2]

In terms of scope, it should be emphasised that we are focusing on WASH services in rural areas only, with "rural" interpreted as per each country's national definition for census enumeration areas. The reason for excluding urban areas was mainly related to policy relevance, since WASH services in rural and urban contexts are generally delivered in very different ways, and the TOR referred mainly to sustainability of rural water supply.

1.3 Operational sustainability: definition

Over the past two decades there have been much discussion but little consensus of what comprises a sustainable water and sanitation service (see: Lockwood and Smits, 2011; WaterAid, 2011; Carter et al., 1999; and Arlosoroff et al., 1987).

Our understanding of overall sustainability follows the WaterAid / DFID definition:[3]

[2] The TOR also notes: "Data on overall sustainability of WASH services is weak and as a consequence the potential to benchmark performance is limited. There are very few high quality studies that provide evidence on sustainability beyond small-scale studies. For instance there is heavy reliance on one paper looking at sustainability of handpumps in Africa published in 2004 (Harvey and Reed, 2004). More recently the rural water supply network presented data from 20 countries indicating that between 20% and 70% of handpumps were non-functioning (RWSN, 2009). However, the methodologies used are not clearly stated and as most of the data appear to be 'estimates' they must be treated with caution"

[3] This definition is from the DFID WASH portfolio review but comes from the WaterAid (2012) sustainability framework, and is ultimately based on the definition of Abrams (1998) that 'sustainability is about whether or not WASH services and good hygiene practices continue to work and deliver benefits over time'

> *"Sustainability is about whether or not WASH services and good hygiene practices continue to work and deliver benefits over time. No time limit is set on those continued services, behaviour changes and outcomes. In other words sustainability is about lasting benefits achieved through the continued enjoyment of water supply and sanitation services and hygiene practices"* (DFID, 2011)

In other words, sustainability is about permanent service. Infrastructure can be mended, replaced and upgraded - but the service should remain. Within this body of literature the term 'operational sustainability' is not a well-established and requires further consideration. Through discussions with sector stakeholders, we found that the "operational" dimension of sustainability is considered a sub-component of the broader concept and is related both to the functionality of infrastructure and the way in which households experience the service provided. Using a similar approach to the above definition, we define operational sustainability as follows:

> ***Operational sustainability** is one dimension of the broader concept of service sustainability. The operational dimension is specifically concerned with the **functionality** of water and sanitation systems over time **(operational service)** and how these contribute to **household's experience** of effective service levels over time **(effective service)**.*

Key elements of our definition therefore include functionality, time and service levels. Our view is that operational sustainability is the *outcome* of the financial, institutional, environmental; technical and social dimensions of a water or sanitation service (i.e. the elements of the "FIETS" model of sustainability promoted by the Dutch WASH Alliance). [4] Operational sustainability will fall if any of these dimensions are not themselves sustained.

1.4 Conceptual framework for rural water supply

This section further explains the definitions and indicators of operational sustainability over time in a new conceptual framework for rural water supply (Both the household and water point perspectives on operational sustainability are bought together in single conceptual framework (Figure 4). This framework is organised along three temporal dimensions relating to the day-to-day, month-to-month, and multi-year performance of the water service.

Figure 4). The concept is viewed from two different perspectives: the household user and the water point. From both these perspectives, system performance is conceptualised over three temporal dimensions: the day-to-day performance, month-to-month performance, and multi-year performance, each combined with a measure of the level of service experienced/delivered.

Each part of the framework is discussed in turn, alongside two indicators for measuring the key concepts discussed. It should be emphasised that some of the conceptual thinking cannot be completely captured empirically through the data we have collected. Section 1.4.3, for water, and section 1.5.3, for sanitation, explains how we have approached this problem in this report.

1.4.1 Household perspective

From the water user perspective, operational sustainability can be measured by the **effective service** experienced by users, from the set of water points available to them (equivalent to the

[4] Schweitzer *et al.* (2014) reviewed a number of different tools and frameworks for sustainability, noting that: "Five categories emerged from the coding: technical, institutional or management, financial, environment, and social or cultural." This maps closely onto the FIETS model.

outcome level of the Value for Money (VFM) framework[5]). Effective service considers the **availability** of water over time from all water points (i.e. the hours per day and months per year when services are available) adjusted to reflect the **level of service** experienced by the user **overall** (time to collect water, water quantity and perceived and actual water quality).

These service measures are used to calculate effective service – reported as the**% of the year that the household experiences a water service adjusted to reflect level of service (EWS%)**. In the context of programme design and monitoring, changes in EWS% can be used to express the change in effective service experienced by a household as a result of installation or rehabilitation of some or all of the water points that they use to access domestic water supplies.

Because it includes multiple dimensions of quality of service, EWS% can be used to contrast interventions which have different effects (for example, the construction of a new water point may reduce distance and hence time to source for some households or it may improve the quality of water available or it may achieve both objectives). Some households may move from using a low-yielding source to using a higher-yielding source where others may not.

Calculating effective water service

In terms of the household user, a 24-hour supply available for use 7 days a week with no regular service breakdown, providing high quality water in unlimited quantities at the household would have an EWS% of 100% in a given year. However, where the level of service is lower, effective service would be scaled according to service level coefficients. For example, insufficient water quantity, poor water quality, or excessive queueing at the water point would all result in a reduction in EWS%. The extent of this reduction would be determined by the subjective weightings (coefficients) given to each element of the water service. Similarly, day-to-day or monthly breaks in service would also result in a reduction in EWS%. These relationships can be expressed mathematically.

Equation 1:

$$Effective\ Water\ Service(\%\ of\ year) = \left[\left(f_d \times \frac{t_d}{24}\right) + \left(f_m \times \frac{t_m}{365}\right)\right] \times T \times los_{qual} \times los_{quant} \times 100$$

Where:

$$f_d + f_m = 1.0$$

f_d = weighting for daily hours of service from preferred/ main water point
t_d = typical daily hours of service
f_m = weighting for days per month and months per year typical service from main water point
t_m = typical days per year of service (combining days per month and months per year)
T = index of time to collect water where 1 represents on-plot supply
los_{qual} = an index of the microbial, physical, and chemical quality of water supplied where 1 represents potable water of high quality
los_{quant} = an index of the quantity of water available where 1 means full water demands are met.

1.4.2 Water point perspective

From the perspective of water points, operational sustainability is measured by the **operational service** provided by that water point over time. This can be thought of as the availability of water at

[5] The VFM framework is a way of understanding and comparing water, sanitation, and hygiene programme performance linking inputs, output, and outcomes. For more information on the terminology and application of a VFM analysis to WASH programmes, please see the accompanying project website www.vfm-wash.org.

that water point over its lifetime (equivalent to the *output* level of the VFM framework), adjusted to reflect the **number of regular users**[6] and the **level of service** provided. Operational service can be reported in terms of **adjusted water-person-years (AWPY)** of service provided by that water point. In the context of programme design and monitoring, AWPYs can be used to express the change in effective service provided to the community at large because of the installation or rehabilitation of a water point.

Calculating operational water service

In terms of operational service, if a water point operates for 24 hours a day, and has no regular or major breakdowns, then operational service provided by that water point tends to equal the lifecycle (in years of service) of that water point multiplied by the number of users. This can be expressed in **Adjusted Water Person Years**. A water point which operates only six months of the year for the same period would have only half the operational service. In a similar manner to the effective service dimension, operational services outcomes are moderated by the level of service delivered (quantity and quality of the water provided at the water point, scaled according to subjective weightings), but in addition present the total number of people who use the water point as their main or preferred source of water.

Equation 2: Calculating person/years of operational service

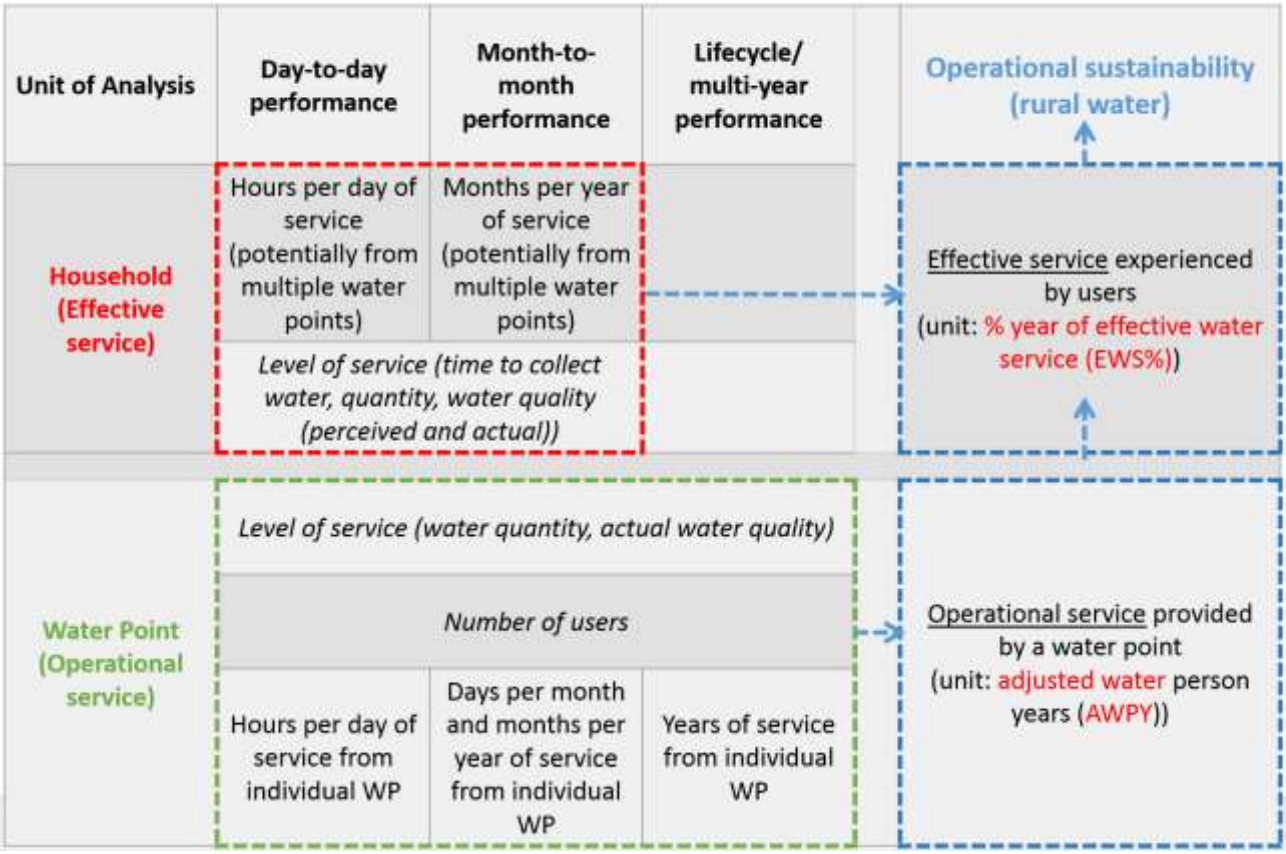
$$Operational\ Water\ Service\ (in\ adjusted\ water -\ person - years) = \left[\left(f_d \times \frac{t_d}{24}\right) + \left(f_m \times \frac{t_m}{365}\right)\right] \times L \times U\ \times los_{qual} \times los_{quant}$$

Where:
f_d = weighting for daily hours of service from water point
t_d = typical daily hours of service
f_m = weighting for days per month and months per year typical service from water point
t_m = typical days per year of service (combining days per month and months per year)
L = years of operation of water point before major infrastructure rehabilitation or replacement
U = number of people who use the water point as their main/ preferred source of household water
los_{qual} = an index of the quality of water supplied where 1 represents potable water of high quality
los_{quant} = an index of the quantity of water available where 1 means full water demands are met.

Both the household and water point perspectives on operational sustainability are bought together in single conceptual framework (Figure 4). This framework is organised along three temporal dimensions relating to the day-to-day, month-to-month, and multi-year performance of the water service.

[6] The number of 'users' reflects the total number of people living in households that access a particular water point.

Figure 4 Conceptual framework for operational sustainability for rural water supply



Day-to-day performance – this is inter-day continuity of services, i.e. whether a service is unavailable for a few hours or days. This indicator can be seen from the perspective of the household (which may use multiple WPs) and of each individual WP.

Month-to-month performance – this is inter-month functionality[7] or seasonality, i.e. whether services are unavailable for more than a few weeks at a time, whatever the reason (breakdown, seasonal groundwater fluctuations etc.). This indicator can be seen from the perspective of the household (which may use multiple WPs) and of each individual WP.

Multi-year performance – this is the years of service provided by an individual water point. It is not conceptualised for the household perspective. This is because while individual the water point being used may change, households always use a water service (improved or unimproved) to survive.

1.4.3 Using the conceptual framework for water in this report

The equations used to calculate 'effective' and 'operational' service provide an important demonstration of the how the conceptual framework for water can be operationalised given the availability of multi-dimensional data at both user and water point level. As noted above, we need to

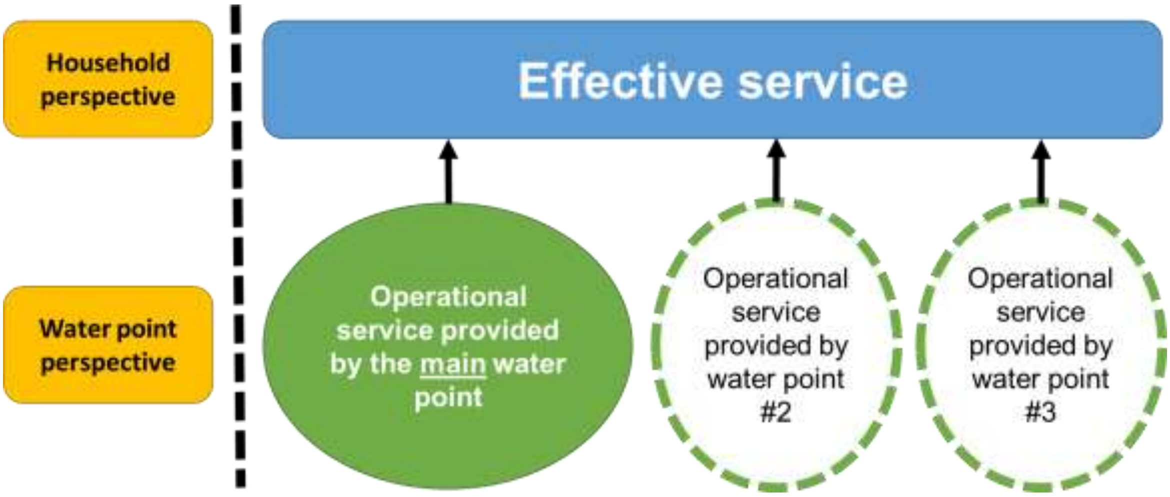
[7] The means of measurement of indicators can also influence the extent to which day-to-day, month-to-month or multi-performance can be estimated. Consider the example of functionality. If an enumerator visits a WP and tries to draw water, the result reflects what is happening at the time. However, it would not be possible to know whether this is a day-to-day break in service a monthly or seasonal drop in performance, or a terminal failure. On the other hand, asking a household whether that WP was working last time they visited may give a more reliable indication of inter-day (most likely, if they use it almost every day) or intra-week functionality. Asking a group of community members about whether that WP "usually" works (a common survey question structure) will deliver information which could be used to assess the combined effects of day-to-day and month-to-month functionality. All three of these indicators were collected in our survey, as is discussed further below.

temper the overall framework to allow for data collection and analytical challenges – this is the focus of this section.

Effective water service: In this project, the main research tool used was the household survey, and this provided detailed and representative data on the household perspective of water services delivery over time, allowing the VFM-WASH team to assess elements of effective water service with a high degree of confidence. Estimates of temporal dimensions of effective water service can be made along with a qualitative assessment of aspects of level of service, including volumes of water collected and time spent collecting water. However it was not with the scope of this research to undertake comprehensive water quality testing of micro-biological, chemical and physical parameters so these water quality dimensions have not been assessed.

The team did collect data on the use of multiple water points, but more work is needed to develop an approach for summing the effects of use of multiple water sources. It is well-understood that most households use more than one water point, at different times of the day, for different purposes. Yet whereas it is relatively straightforward to ask households about the effective service they use from each individual water point, it is far more difficult to understand the *overall* effective service, when their patterns of usage of multiple water points are considered. In the analysis in this report, therefore, we have focused on assessing effective service used only from the “main” water point (represented by the filled green circle in Figure 5).

Figure 5 Relationship between multiple water points and effective service



Operational Service: In terms of water point performance, the study was set-up to collect some information about the performance of public water points but not to a similar level of detail as for household water use. There is some primary data measuring the technical reliability, functionality, the years of service provided by public water points but it is limited by the data collection methods which were available to the team.

While the data allow us to make a preliminary assessment of some aspects of operational service provided at water points, in this report **we are not presenting quantitative, calculated, values** for effective service per year or for person-years of operational service. Instead our overall understanding of effective and operational service will be reported qualitatively based on available primary and secondary data.

1.5 Conceptual framework for rural sanitation

This section explains the definitions and indicators of operational sustainability over time in a new conceptual framework for rural sanitation (Figure 6).

1.5.1 Household perspective

From the household perspective, operational sustainability is measured by ***effective sanitation service*** provided by the range of sanitation facilities in the community (equivalent to outcomes in the VFM framework), as a % of the year. Effective service takes into account temporal and intra-family issues around **access** to and **use** of the sanitation facility. These service measures are used to calculate effective sanitation service – reported as the **% of the year that the household experiences a sanitation service adjusted to reflect level of service (ESS%)**. The ESS% metric allows both the quality of the infrastructure and the extent to which a household makes use of it to be assessed by programme designer or managers when monitoring the outcomes of sanitation programmes.

Calculating effective sanitation service

Effective sanitation service would be 100% in the case of a sanitation facility which is close to the house, used by all family members, on all occassions, and in all circumstanceswhen they are in or near the houseand when sharing does not create a reduced level of amenity of use.

Reductions in effective sanitation service occur when: i) one or more family members do not routinely use the toilet for any reason; ii) one or more family members regularly uses the toilet but not for all defecation episodes when they are at or near home; and ii) the sanitation facility is not available for some days in the year due to the pit being full, flooding, or any other reason.

Effective service also declines when distance to the sanitation facility is high, when accessibility is low (for example when a user has to climb steep steps, or cross a narrow bridge to reach the toilet), or where the toilet is shared by more than one househld.

The relationship between indicators is expressed mathmatically in the box below.

Equation 3:

$$Effective\ sanitation\ service\ (\%\ of\ year)\ = \frac{P_u}{P_t} \times \frac{I_u}{I_t} \times \frac{t_m}{365} \times los_{dist} \times los_{access} \times los_{share} \times 100$$

Where:
P_u= number of household members who regularly use the toilet
P_t= total number of people living in the household
I_u= number of defecation incidents per day in the toilet for a typical household user of the toilet
I_t= total number of defecation incidents per day for a typical household member
t_m=total days in the year when the toilet is not appealing for family members to use
los_{dist} = an index of distance where 1 is a facility in the house, reducing as distance increases
los_{access}= an index of accessibility where 1 is a facility in easy to access for all family members.
los_{share}= an index of the level of sharing where 1 is a facility usually used by a single household.

1.5.2 Sanitation facility perspective

From the perspective of the sanitation facility operational sustainability is measured by **operational sanitation service** which considers **how long the sanitation facility lasts**, the number of people that access and use the toilet over its operational life. This can be thought of as the availability of sanitation service provided by that facility over time (and is equivalent to the *output* level of the VFM framework), adjusted for level of service provided.

Operational service can be reported in terms of **adjusted sanitation person years (ASPY)** of service provided. In the context of programme design and monitoring ASPYs can be used to express **the change in effective service provided to the community at large because of the installation or rehabilitation or improved management of a toilet.**

Calculating operational sanitation service

In terms of operational service, if a toilet is usable and accessible for 24 hours a day and does not go out of service due to pits filling, flooding, or other periodic or seasonal factors and provides a secure private service to the household then its operational service will equal its lifecycle (in years of service) multiplied by the number of people in the household who use the toilet. A facility which cannot be used at night (for example due to issues of safety or distance), or which is not accessible for 6 months of the year due to flooding would have only half of the operational service. Operational service would also reduce where levels of sharing are high (i.e. where two households share then operational service would be reduced). These relationships are expressed mathematically below.

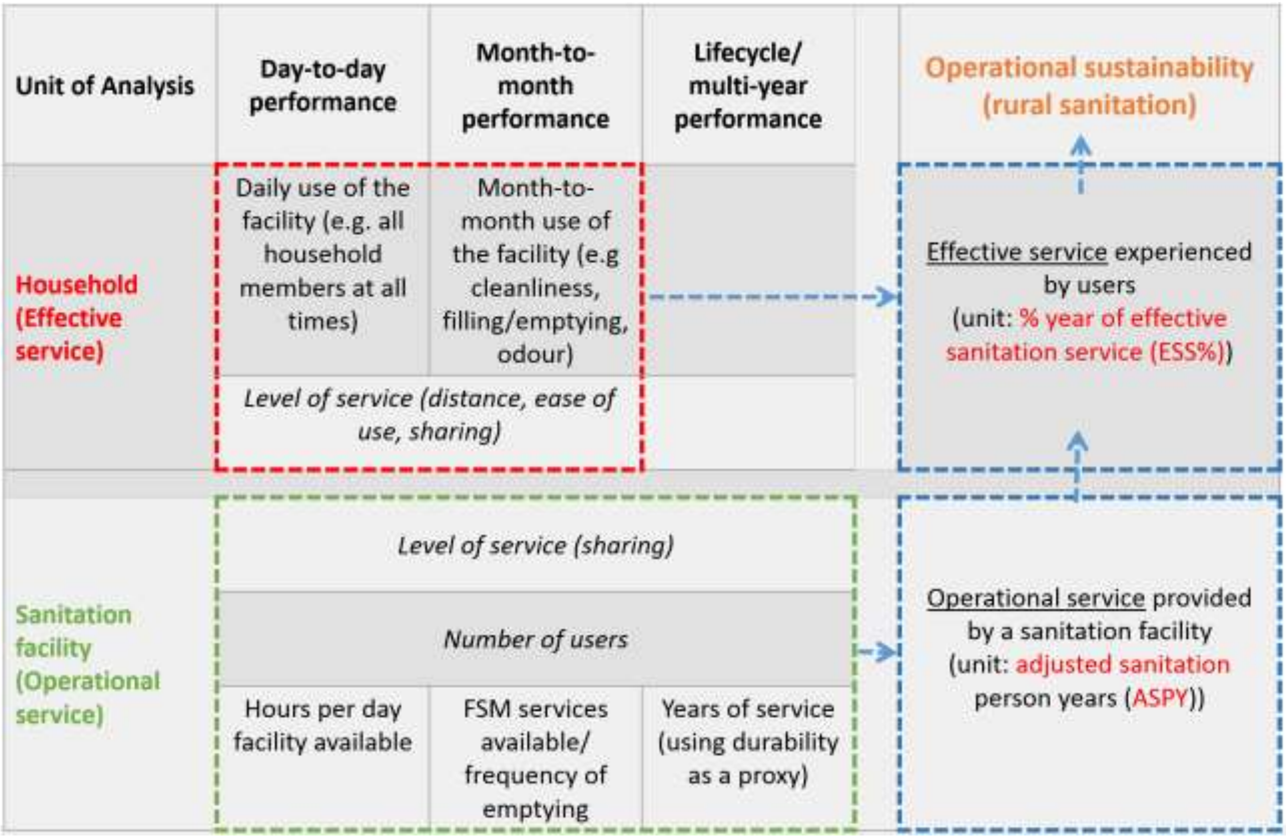
Equation 4:

$$Operational\ Sanitaton\ Service\ (adjusted\ sanitation - person - years)$$
$$= \left[\left(f_d \times \frac{t_d}{24}\right) + \left(f_m \times \frac{t_m}{365}\right)\right] \times L \times U \times los_{share}$$

Where:
f_d = weighting for daily hours when toilet/latrine is available (if periodically locked or not used)
t_d = typical daily hours when toilet/ latrine is available (if periodically locked or not used)
f_m = weighting for days per month and months per year typical service the toilet/ latrine (taking into account the availability, frequency and quality of pit-emptying services, septic tank emptying services or sewer maintenance)
t_m = typical days per year of service (combining days per month and months per year) taking into account the availability, frequency and quality of pit-emptying services, septic tank emptying services or sewer maintenance
L = years of operation of the toilet/ latrine before major infrastructure rehabilitation or replacement.
U = number of people who use the toilet/ latrine as one of their main/ preferred places of defecation
los_{share}= an index of the level of sharing where 1 is a facility usually used solely by members of the immediate family declining as levels of sharing rise.

Both the household and sanitation facility perspectives on operational sustainability are bought together in single conceptual framework (Figure 6). This framework is organised along three temporal dimensions relating to the day-to-day, month-to-month, and multi-year performance of the water service.

Figure 6 Conceptual framework for operational sustainability for rural sanitation



Day-to-day use reflects short-run measures of whether *all* family members use a sanitation facility or if any are excluded due to age, gender, ability or inclination to use the facility, and whether *all* defecation take place in the facility or whether some take place outside during, for example, working hours or time at school. So for example, in a family of five with a facility in the house, if one family member does not use the toilet but continues to defecate in the open for any reason, this would represent a reduction in day-to-day use of 20%. Similarly, if there are two children in the family who typically use the sanitation facility for only half of their defection episodes, and go outside the home for the other half, this would also result in a reduction in day-to-day use of 20%.

Month-to-month use reflects whether there are periods when overall sanitation facility use declines because, for example the pit becomes full, or odour levels rise due to weather conditions, or due to flooding, or due to characteristics of the facility or insect nuisance. Thus the month-to-month aspects of toilet use are more strongly related to the technical and managerial aspects of the facility whereas day-to-day use is more strongly related to issues of access, behaviour and social norms.

Multi-year performance reflects the years of service that may be expected from and individual sanitation facility before major infrastructure rehabilitation or replacement is required.

1.5.3 Using the conceptual framework for sanitation in this report

Effective sanitation service

The household surveys conducted in Bangladesh and Pakistan provided representative data on the household experience of sanitation services in terms of the cleanliness, ease of access and privacy offered by sanitation facilities, combined with disaggregated information on the access and use of facilities by different household members. This data provided a robust basis for the assessment of effective sanitation services in Bangladesh and Pakistan, and was complemented by comparable findings from sector literature. Nevertheless this understanding of effective sanitation services would further benefit from additional research into the ways in which household members latrine usage varies from day-to-day and month to month.

Operational sanitation services

In this report insights into the availability of sanitation facilities over time was generated through proxy indicators of latrine crowding, frequency of pit emptying, and durability. These indicators provided valuable information on the characteristics and quality of household sanitation facilities, but were unable to support a quantitative calculation of operational services in sanitation person years.

1.6 Scope and approach of this report

This report analyses two types of data sources: i) primary data collected from representative household surveys conducted in Bangladesh and Pakistan, and ii) available sector literature ('secondary data') relating to indicators of operational sustainability in all South Asian countries.

The criteria for including secondary data sources in this analysis have been designed to ensure that only robustly designed and large scale studies are included in this assessment. To help differentiate between the secondary data in this report we have indicated the **'scope'** and the **'representativeness of scope'** of each data source. The scope of a study refers to geographical areas from which the data sample has been drawn, differentiating between 'national', 'multi-regional' and studies covering only 'one region'. Scope always refers to data sample coverage of rural areas, unless expressly stated. Representativeness of scope indicates whether the data collected is representative of the areas where data has been collected. In this case each data source has been classified as either 'representative', 'not representative' or 'unknown'.

The primary and secondary data are presented in separate chapters. Each chapter reports on operational sustainability indicators related to the day to day, month to month and multi-year performance of water and sanitation services.

In the synthesis chapter we draw together the results of both primary and secondary analysis. The final part of the synthesis section looks across all three temporal dimensions to draw overall conclusions about operational sustainability.

2 Sources of data and methods

This chapter explains the main sources of data that are used to in this regional assessment of the operational sustainability of rural water and sanitation services in South Asia. We explain the approach to primary data collection through our surveys in Bangladesh and Pakistan, and then outline our approach to compiling and analysing secondary data sources.

2.1 Key indicators

The key operational sustainability indicators collected in our primary data surveys are shown in Table 3 and Table 4. These indicators were used as the starting point for the secondary data search. Unsurprisingly some of these indicators were not exactly replicated in the secondary data, but we sought data which was as comparable as possible.

Table 3 Key indicators collected from primary data on water

Time dimension	Indicators used in primary data collection
Day-to-day performance	• Mean hours per day during which water is available from the main household water point • Mean hours per day during which water is typically available from community water points
Month-to-month performance	• % public water points functional at time of enumerator inspection • % public water points usually functional (as reported by the community) • Months per year during which water is usually available from the main water point (as reported by households)
Multi-year performance - No primary data was collected on multi-year water point performance	
Water service levels	**Access** • % households using an improved water point as main water point • Minutes taken for round trip to fetch water • The number of households using each public water points **Quantity** • The quantity of water accessed by water point type • User perception of the sufficiency to water quantity accessed per person per day **Quality** • User perceptions of water taste and appearance • Enumerator perceptions of water taste and appearance • Chemical testing for salinity and the presence of arsenic

Table 4 Key indicators collected from primary data on sanitation

Time dimension	Indicators used in primary data collection
Day-to-day	• Daily use of the latrine when at home and away from home (as reported by households)
Month-to-month	• Satisfaction with the cleanliness of household sanitation facilities • Action taken when the latrine pit or septic tank has filled up
Multi-year	• Latrine durability / functionality (as reported by households)
Sanitation service levels	• % households using an improved or unimproved sanitation facility • Satisfaction with ease and access and privacy of sanitation facilities

The main gaps in primary data collection are for those indicators relating to the operational service provided by water points and sanitation facilities. Specifically these gaps include objective measurements of water point reliability, functionality, and the actual quality of water delivered over time; as well as evidence of the years of service (lifespan) of sanitation facilities. Secondary data collection has sought to fill some of these gaps, although it is acknowledged that the lack of data on these indicators is a sector-wide monitoring problem.

2.1 Primary data

We carried out primary data collection in two countries in South Asia: Bangladesh and Pakistan. These countries were selected for similar reasons. Firstly, they were both primary study areas under objective 1 of VFM-WASH and we saw significant synergies in carrying out Obj1 and Obj2 research in the same countries. Secondly, Pakistan and Bangladesh are recipients of significant DFID funding and being as they have the second and third largest populations in the region, they were thought to provide a good overview of services in the region. India was a candidate, but it would have been extremely complex and costly to implement a nationally-representative household survey in India and potentially we could only have covered a few states. Furthermore, DFID is no longer providing financial grant aid to India.

Data collection was carried out by local survey firms in each country, under the supervision OPM consultants. In Pakistan, OPM's Pakistan country office carried out the survey, while in Bangladesh, we partnered with Mitra and Associates for data collection.

There were three components of quantitative primary data collection, namely: household surveys, community surveys and water point inspections. The reason for having three different components for the quantitative surveys was that we required these different perspectives to get a full picture of operational sustainability and to triangulate results. We were interested to know about 'public' water points and their utilisation from the household perspective.[8] We were also interested in 'private' at-home supplies (meaning accessible only by that household, but could be from a public scheme). We were interested not only in collecting information associated with the physical characteristics of public water points, but also in water point utilisation, and access, availability and quality perceptions at the community and household levels.

[8] See the Glossary above for full definitions of key terms used in our survey

2.1.1 Survey components

Household surveys

The objective of the household survey was to build up a picture of the operational sustainability of services from the user perspective. The preferred respondent of the household survey was a senior woman from the household who was most knowledgeable about the household including the composition of the household and its use of WASH services. In absence of the senior most knowledgeable woman in the household at the time of the interview, we interviewed any adult woman (≥18 years) from the household with sufficient knowledge. All households in the community were listed a few weeks in advance of data collection (see sampling section below), in addition to all public WPs. This allowed us to allocate unique ID codes to all WPs and therefore triangulate data.

Data was collected from households on various WASH indicators. In addition, data on household characteristics and assets was also collected in order to understanding equity aspects of operational sustainability. Wealth quintiles were estimated through principal component analysis (PCA) using indicators consistent with the most recent Demographic Health Surveys in each country.

Community surveys

The objective of the community survey was to build a sample frame of all public WPs in the community, and to ascertain prevalent views about their functionality and accessibility. We ensured in the training of enumerators that they included non-functional WPs as well as functional ones. In the community surveys we interviewed a group of community members (8 to 12 people) within the same village where the household surveys were conducted. During the community interviews we also updated the list of public water points which has been collected previously as a part of the listing exercise. The primary objective of the community surveys were to gather community perspectives on the public water points on that community. After completing the community interviews and updating the list of public water points in the community, we visited the public water points in the communities for water-point inspection.

Water point inspections

The objective of the WP inspections was primarily to get short-term functionality data, specifically whether the enumerator was able to draw water at the time of visit. Using the public water point listing from the community questionnaire, we visited all improved public water-points and assessed their functionality, the salinity and arsenic[9] content of the water being delivered, and the risk factors for each source. We adapted the sanitary inspection tools prepared by World Health Organization (WHO) to assess and rate the condition of the water-points (WHO, 2005). We also recorded the geographical position of each water-point and took photograph to serve as a verification mechanism for water points recorded in the household questionnaire. Using these multiple instruments alongside unique ID codes for WPs allowed us to carry out data triangulation for key indicators, especially functionality, across the three survey instruments. This gives us very high confidence in our most important indicators.

[9] Arsenic concentrations were measured using the EZ Arsenic Reagent Set manufactured by HACH. Enumerators performed the testing according to operational procedure as laid out in the accompanying manual. These include the removal of sulphide from the water sample if concentrations of more than 15ppb are encountered.

2.1.2 Inclusion and exclusion criteria

Topography

We excluded areas of the country that are significantly different in terms of topography (and therefore predominant water supply technology) from where the majority of people in the country live. Mountainous areas and deserts, which are generally sparsely populated and employ atypical water supply technologies were excluded from the sampling frame.[10]

Locality

We have only included rural areas in this survey. The definition of rural areas varies across countries and we adopted the one that has been defined by the census authority in Pakistan and Bangladesh as outlined below (Table 5). This was necessary since we used census enumeration areas as our sampling units.

Table 5 Definition of rural areas in Pakistan and Bangladesh

Bangladesh	Pakistan
The areas which are not covered by "urban and other urban areas" are enumerated as rural areas. Urban areas are defined as: Area developed around a central place having 5,000 population with such amenities as metaled roads, electricity, gas, water supply, and comparatively higher density of population with the majority in non-agriculture occupations.	In Pakistan, local government department define the areas as urban areas and send the list to the Pakistan Bureau of Statistics (PBS). PBS consider the rest of the areas (which are not declared as urban areas) as rural areas.

Sampling frame

To estimate the sample size, we used the statistical software EpiInfo, developed by the US Centres for Disease Control and Prevention (CDC). For the household survey, we have a representative sample for all rural areas, of 1200 households in 60 communities. The sample size needed to generate representative estimates at a confidence level of 95% was predicted to be 960 households[11]. Hence, our survey increased the power of the estimations and allowed for a self-sufficient non-response rate.

For the community questionnaire and water point inspections, the sample size needed to obtain representative estimates at a confidence level of 80% was 300 water points[12]. We used a larger margin of error because we were unable to predict *ex ante* the number of public water points in each community. Since the sampling was designed for households and not water points, we were not able to guarantee a particular sample size for water points. Our water point sample is therefore not representative.

[10] In Pakistan, we have therefore included only the rural areas of Punjab and Sindh provinces. As a result approximately 21% of the total rural population from the sampling frame was excluded from this survey. In Bangladesh, we included all rural areas in Barisal, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet divisions, as well as in the remaining districts of Chittagong divisions (excluding districts comprising Chittagong Hill Tracts). Bangladesh harbours only a small mountainous area and no deserts, and as a result only 1% of the total rural population were excluded from the sampling frame.

[11] This is based on a households' use of public water points of 50% (our indicator of interest), a design effect of 2.5, a PSU/cluster size of 16, a total number of 60 PSUs, and a margin of error of 5%.

[12] This is based on a water functionality rate of 67% (following international evidence), a design effect of 1.5, a PSU/cluster size of 5, a total number of 60 PSUs, and a margin of error of 20%.

Sampling methodology

A Probability Proportionate to Size (PPS) method was used to sample the communities to be surveyed. These selections were based on the list of enumeration areas (EAs) and number of households provided by Pakistan Bureau of Statistics (PBS) the Bangladesh Bureau of Statistics (BBS). Any PSUs with more than 300 households were segmented into smaller clusters with no more than 300 households in each cluster. All the households in the sampled clusters were listed a few weeks in advance of data collection. Twenty households per cluster were subsequently sampled using systematic random sampling.

In the community interview, all public water points of the sampled communities were included and no sampling was carried out. All public water points in the sampled communities were inspected if the total number of public water points was less than seven. In those communities where the number of public water points exceeded this limit, we randomly sampled seven water points for inspection.

Data collection

The field teams collected the data from the 60 sampled clusters in six weeks in 2014 (comprising February-March in Pakistan and May-June in Bangladesh). On average, each team spent two days in each cluster.

2.2 Secondary data

This section outlines the inclusion criteria and method used to identify and evaluate secondary data sources. The overall approach to secondary data collection has been informed by standardised systematic review guidelines from the Cochrane Review style guides and the systematic review handbook of the Centre for Reviews and Dissemination (CRD) at York University, UK. In particular these guidelines informed the development of the inclusion criteria to evaluate the suitability of data sources, and also provided a helpful framework to track, categorise, and present secondary data drawn from multiple different sources.

2.2.1 Inclusion criteria

Defining the inclusion criteria for secondary data collection was complicated by two factors: 1) the desire to report robust and representative data on operational sustainability; and 2) the recognition that systematic data on the sustainability of rural water and sanitation systems are rare, and often reported inconsistently. Indeed preliminary literature searches revealed considerable variations in available data across operational sustainability indicators. Ultimately a pragmatic balance was struck where the inclusion criteria was defined separately for different indicators according to the quality and quantity of available data. Further details on the inclusion criteria are provided in Annex A.1.

2.2.2 Academic literature review (on water)

A review of available literature relating to the operational sustainability of water services was undertaken using the Scopus bibliographic database. This database was chosen because it covers a wide range of topic areas and provides over 20% more coverage than the Web of Science database, and is more accurate than Google Scholar (Falagas et al., 2008). Scopus was preferred over the PubMed as the latter was considered too focussed on biomedical research for the purposes of this analysis.

In alignment with both the indicators of interest and inclusion criteria stated above, five independent key word searches were undertaken of the study title, abstract and key words[13]. The returned items for each keyword search were compiled into a single excel database and screened according to their relevance to the outcomes of interest. The remaining studies were subject to more in depth screening and were included or excluded according to the criteria defined above. Overall just 4 academic data sources were found to meet the inclusion criteria from an initial returned list of 273.

2.2.3 Household survey search (on water)

We carried out a search of all available indicators related to household experience of water services using the International Household Survey Network database (http://www.ihsn.org/home/). The search was restricted to surveys conducted in each of the eight South Asian countries within the last 10 years and that contained any variable containing the keyword "water". These search terms returned a total of 86 sources which were then reviewed systematically to assess their relevance to operational sustainability.

2.2.4 Contacting WASH sector experts (on water)

Finally, a small number of WASH sector experts were contacted to seek guidance on availability of operational sustainability data for South Asian countries. This yielded useful additional data on water point mapping studies undertaken in Afghanistan, Bangladesh and Nepal. This version will be further shared within the sector to elicit further data which may be available and we have not yet come across.

Systematically drawing these data points together we have constructed a flowchart to demonstrate both our selection process current data universe for the examination of the operational sustainability of water systems (see Figure 27[14] in Annex A.2). An overview of each of these 23 data sources is provided Table 33 in Annex A.

2.2.5 Secondary data on sanitation

The search for secondary data on the operational sustainability of sanitation services consisted of a review of all nationally representative large or large scale surveys done since 2005. An initial search reviewed the JMP country files, the World Bank's micro data portal, and International Household Survey Network's data using the search term 'sanitation' for indicators. 52 surveys were reviewed in this initial search. However, none of these surveys had any indicators related to the use, cleanliness, functionality, or durability of sanitation facilities.

In light of the lack of data a second search was conducted including smaller studies, this search also included grey and peer-reviewed literature. This second search identified a small number of studies with relevant indicators. Many of these studies are however not representative at the national level and as such cannot be readily or reliably used in cross country comparisons. This is primarily due to a lack of consistent indicators, and that sustainability studies identified relate mainly to project implementation and as such are not nationally or regionally representative.

[13] Details of the advanced search terms are provided in Annex A.4

[14] This figure captures the number of selected studies used in the current version of this report. It is hoped that additional information will be provided over the coming months as this report is shared more widely.

2.3 Ethical considerations

The survey protocol was reviewed and approved by the Observational and Interventions Research Ethics Committee of the London School of Hygiene and Tropical Medicine (LSHTM). In Pakistan, we obtained from Pakistan Bureau of Statistics (PBS) which is the national agency responsible for approving all national surveys in Pakistan. In Bangladesh, we obtained ethical clearance from National Research Ethics Committee of Bangladesh Medical Research Council (BMRC). Informed consent was obtained from all participants before the interviews and all other ethical issues were duly complied.

3 Summary of rural water and sanitation services in South Asia

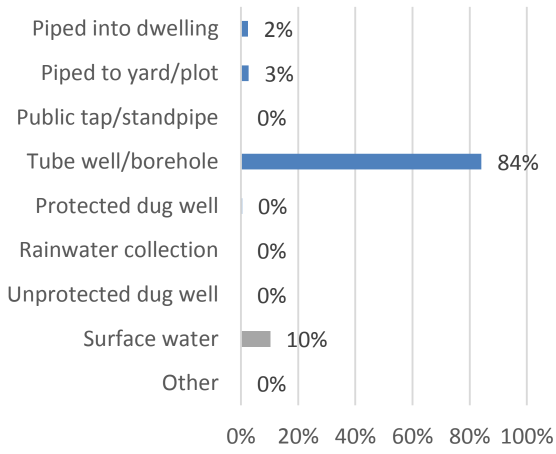
This section provides and an overview of the rural water and sanitation service context emerging from our household surveys in Bangladesh and Pakistan, as well as more broadly for secondary data in South Asia. This will set the scene for subsequent sections outlining the found operational sustainability of these services over time.

Rural water services

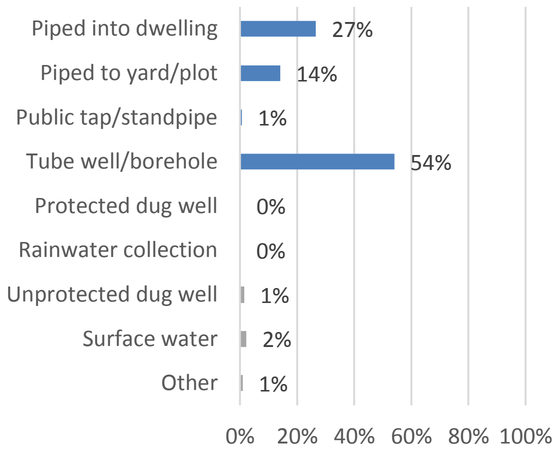
Primary data shows that in our household sample in Bangladesh and Pakistan the primary water point for nearly all is an "improved" water point,[15] (Figure 7). In Bangladesh, 90% of the households use an improved water point. The majority use tube-wells (84%), around5% have a piped water connection to the dwelling or yard/plot. Most of the remaining households use unimproved surface water sources.[16] In Pakistan 95% of households use an improved water point. The majority of these improved points were tube well's (54%), although a relatively high proportion (41%) have a piped water point in their dwelling or yard plot. In Pakistan, the use of public standpipes, or protected dug wells are very rare.

Figure 7 Use of rural water infrastructure

a. Bangladesh (n=1,158)



b. Pakistan (n=1,162)



Note: The figures include data for all public and private, improved (shaded in blue) and unimproved water points (shaded in grey). Estimations were derived from the household surveys[17]. Figures in Bangladesh do not total 100% due to rounding.

Joint Monitoring Programme (JMP) data shows across the whole South Asian region an estimated 91% of rural households access an improved water source. Around three-quarters (76%) of these

[15] Household respondents were asked to provide the type of water point they used. During design of the survey it was thought unlikely that the household would be able to accurately identify the water source. For the purpose of this analysis we therefore refer to "improved" and "unimproved" water points, this is premised on the general assumption that improved water points are supplied by an improved water source.

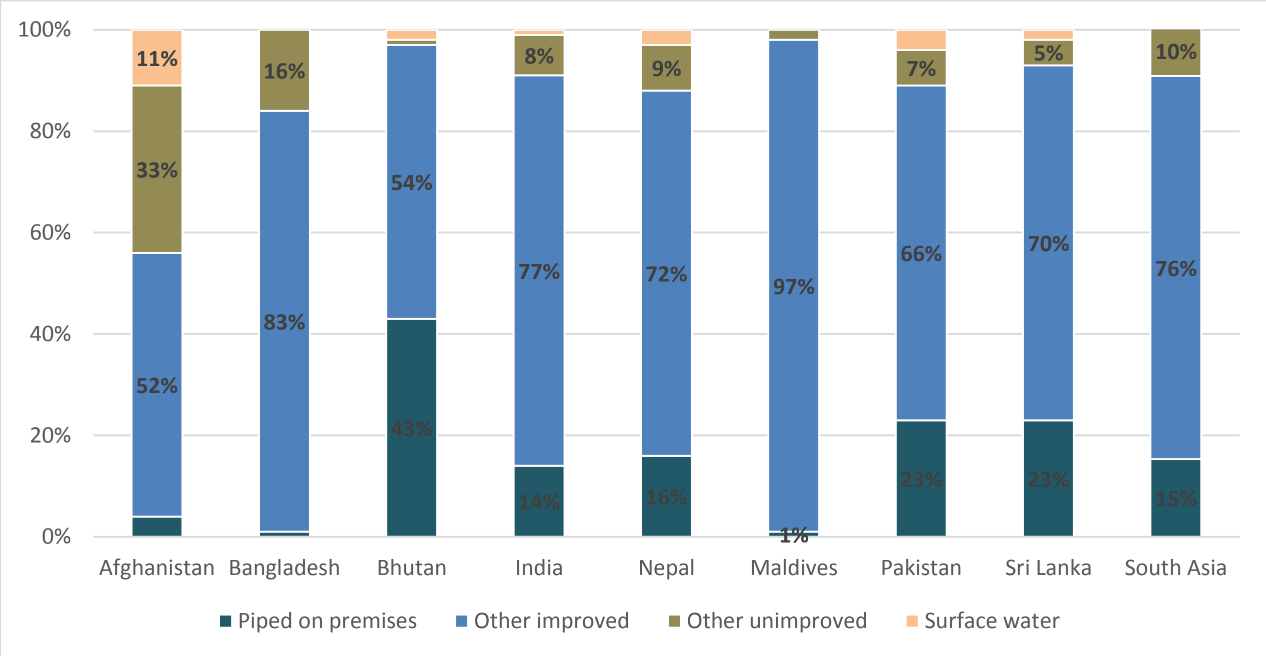
[16] The water use findings from Bangladesh differ from representative household survey findings from the DHS (2011) in two important ways; i) this study reports a higher proportion of households using a surface water source compared to the DHS (10% compared to 1.4% respectively); and ii) this study reported that virtually no households were accessing a rural traditional well, compared to 0.5% in the DHS survey. The small discrepancy between the traditional well usage may be because enumerators and respondents were unable to differentiate between tube-well and borewell systems and dug-wells with a handpump.

[17] Exact wording of survey question: "Please tell us about different water points that your household uses for any purpose, starting from the most frequently used water point". Only data from the main water point was included in the figure.

use 'other improved' water systems (e.g. tube-well and borehole systems) while an estimated 15% of households access piped water at their dwelling.

Comparing coverage between countries, JMP data shows that people living in the most populous countries in South Asia have similar level of access: India (91%); Nepal (88%); Pakistan (89%); and Sri Lanka (93%). Coverage in rural Bangladesh is slightly lower at 84% - although it should be borne in mind that figures in Bangladesh are unique in JMP reporting in that are revised downwards by between 10-15% to allow for the high prevalence of arsenic-contaminated wells in the country. In Afghanistan access is significantly more restricted than elsewhere in South Asia with just 56% of households accessing an improved sources. The two countries achieving near 100% rural use of improves sources are also those countries with the lowest population: Bhutan (97%) and the Maldives (98%).

Figure 8 Water coverage in South Asian countries



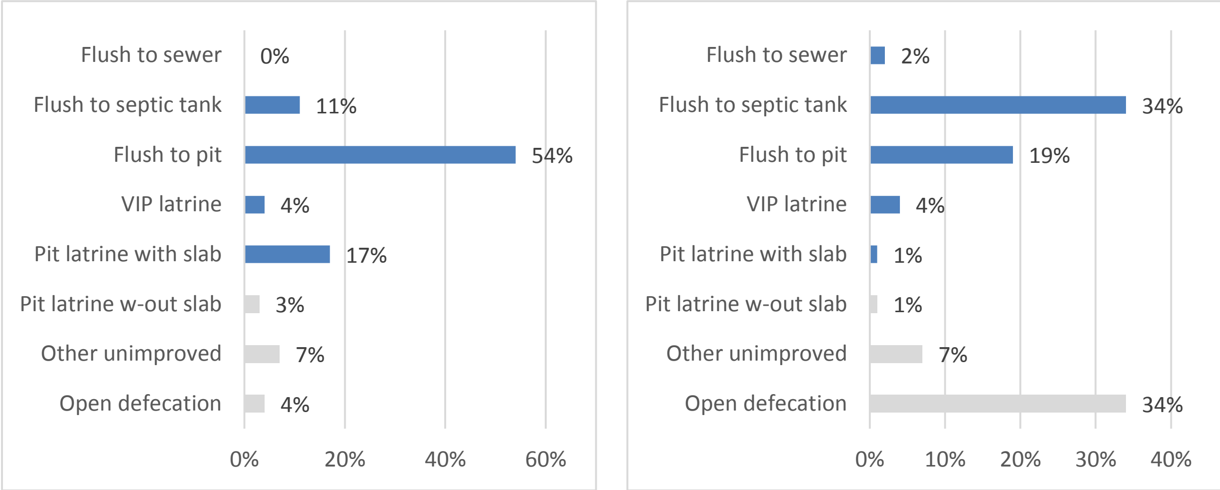
Source: WHO/UNICEF (2014)

Rural sanitation services

In the case of sanitation, our primary data shows that household access to improved sanitation facilities is much more common in Bangladesh than Pakistan (Figure 6). In rural Bangladesh, 86% of households use an improved sanitation facility, the majority of these are pour flush latrines with a pit and pit latrines with slab. Open defection is reported to be quite rare and practiced by only 4% of households. In Pakistan a smaller proportion of households (59%) used an improved facility, though the vast majority of those that did use a flush latrine connected to a septic tank or pit. Open defection is far more prevalent in Pakistan, and is practiced by over one third of households (34%).

Figure 9 Main type of sanitation facility used

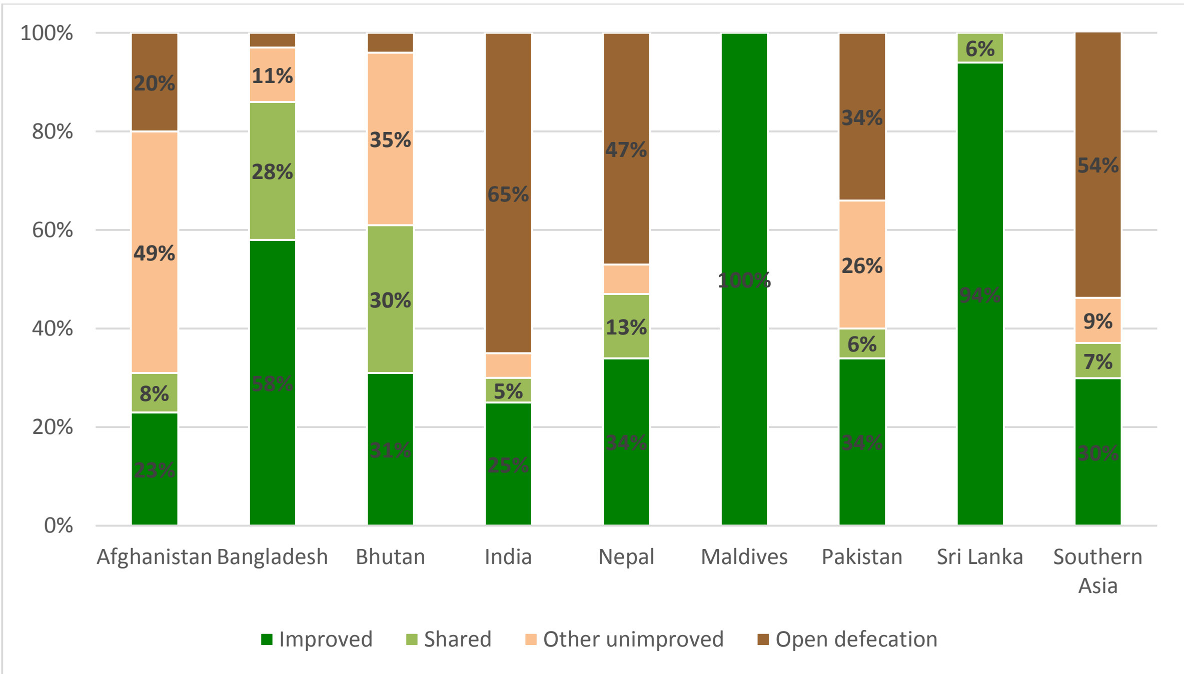
a. Bangladesh (n=1,158) **b. Pakistan (n=1,162)**



Note: The figures include data for all improved (shaded in blue) and unimproved latrine technologies (shaded in grey). Estimations were derived from the household surveys[18].

In South Asia improved sanitation coverage is estimated that at 30%– however significant regional differences exist. The highest percentage of sanitation facility usage was found in Maldives and Sri Lanka at close to 100%, with Bangladesh the next highest at 58%. The lowest levels of improved sanitation coverage were found in India and Nepal at 25% and 34% respectively.

Figure 10 Sanitation coverage in South Asian countries



Source: WHO/UNICEF (2014)

Water and sanitation services

Overall the primary data from Bangladesh and Pakistan on water and sanitation access follows similar trends to comparable data JMP estimates, yet some key differences do exist. In both

[18] Exact wording of the survey question: What kind of toilet facility do members of your household usually use?

countries our primary data shows that a marginally higher proportion of households use an improved water point, as compared to those using an improved water source according to JMP estimates: Bangladesh 89% vs 84%; Pakistan 95% vs 89%. Within Pakistan for example it is noticeable that primary data values show a much higher proportion of households accessing piped water supplies (42%) as compared to JMP estimates (23%), similarly in Bangladesh piped water sources represented the main water source for 5% of households compared to just 1% according to JMP values. It is likely that most of these discrepancies have the origin in our definition of a water point as opposed to a water source (see glossary). It is relatively common in rural Punjab and Sindh (in Pakistan) to have a protected well in the compound or nearby, from which an electric pump draws water to a tap. In our survey we have described this as “piped into dwelling” or “piped into yard/plot” (depending on the location of the tap). Our estimates of percentage of household with water piped into yard or house are therefore higher than those of the JMP who would classify these services according to the water source (protected well).

For a more detailed discussion on primary data collection see the full survey reports available at www.vfm-wash.org

4 Findings for primary data

4.1 Day to day performance of water systems

This section summarises primary data relating to the short term reliability of water systems in Bangladesh and Pakistan. Reliability is assessed according to two indicators collected from household and community respondents: hours of service per day and days of service per month.

4.1.1 Hours per day / days per month

Main water point (household experience)

In both Bangladesh and Pakistan, households experience remarkably reliable water supply in the short term (Table 6). The effective availability of water from the main household water point equates to a near 24/7 service, for all wealth quintiles. Water points in Bangladesh are found to be marginally more reliable than those in Pakistan providing on average an hour more service per day (24 hours compared to 23 hours) and just under half a day's more service per month.

Table 6 Hours per day and days per month by wealth quintile for main water point

Quintile	Hours per day of service (out of 24)		Days per month of service (out of 30)	
	Bangladesh	**Pakistan**	**Bangladesh**	**Pakistan**
Lowest	24.0 (n=224)	23.0 (n=223)	29.9 (n=224)	29.2 (n=223)
Second	23.9 (n=225)	23.3 (n=246)	30.0 (n=225)	29.6 (n=246)
Middle	23.9 (n=222)	22.7 (n=225)	30.0 (n=222)	29.8 (n=225)
Fourth	24.0 (n=227)	22.9 (n=245)	30.0 (n=227)	29.7 (n=245)
Highest	24.0 (n=241)	23.2 (n=241)	30.0 (n=241)	29.5 (n=241)
Total	**24.0**	**23.0**	**30.0**	**29.6**
No. of households	1158	1195	1158	1188

NOTE: This data measured the hourly/daily reliability of the primary water source only, regardless of whether it was improved or unimproved / public or private. Estimation of hours/days of service per day/month was derived from household's recall of "usual" service[19].

The histograms in Figure 11 indicate that is no difference in the day-to-day reliability of improved and unimproved water points in Bangladesh, and only marginal differences in Pakistan. In Bangladesh both types of water point are available for 24 hours per day and for 30 days per month. In Pakistan a greater proportion of unimproved water points provide full day services compared to improved equivalents, however over a month time-frame unimproved water points are found to provide households fewer days of service compared to improved sources (Figure 12).

As the days per month indicator was based on household recall of their "usual" experience of service this data suggest that unimproved water points in Pakistan are more susceptible to monthly variations in water levels, whereas unimproved water points in Bangladesh are not.

[19] Exact phrasing of survey questions: 1) How many hours in a day (24 hours) is water usually available from this WP? 2) How many days in a month (30 days) is water usually available from this WP?

Figure 11 Hours per day by service level for main water point

a. Bangladesh **b. Pakistan**

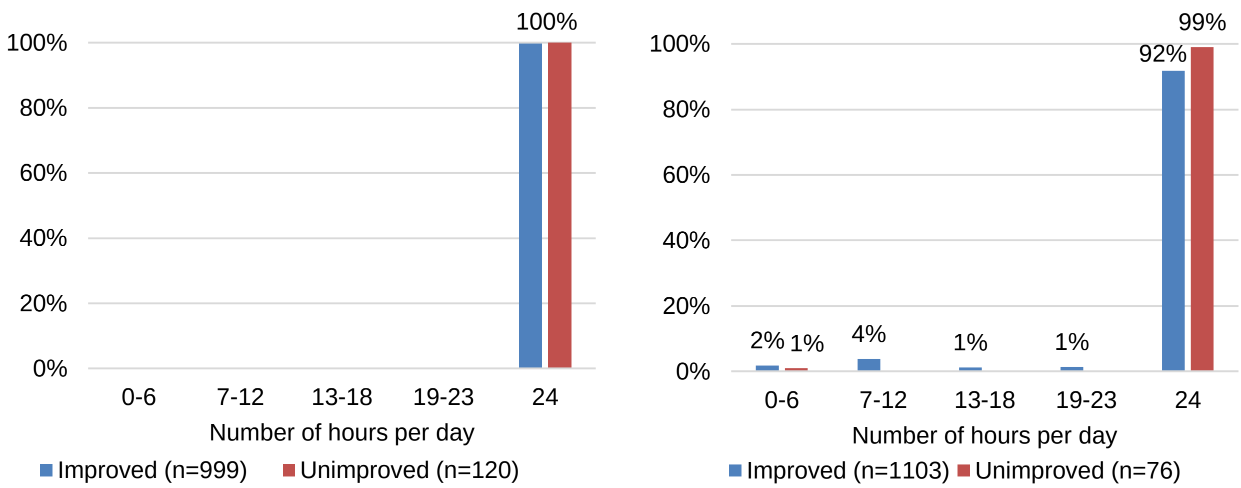
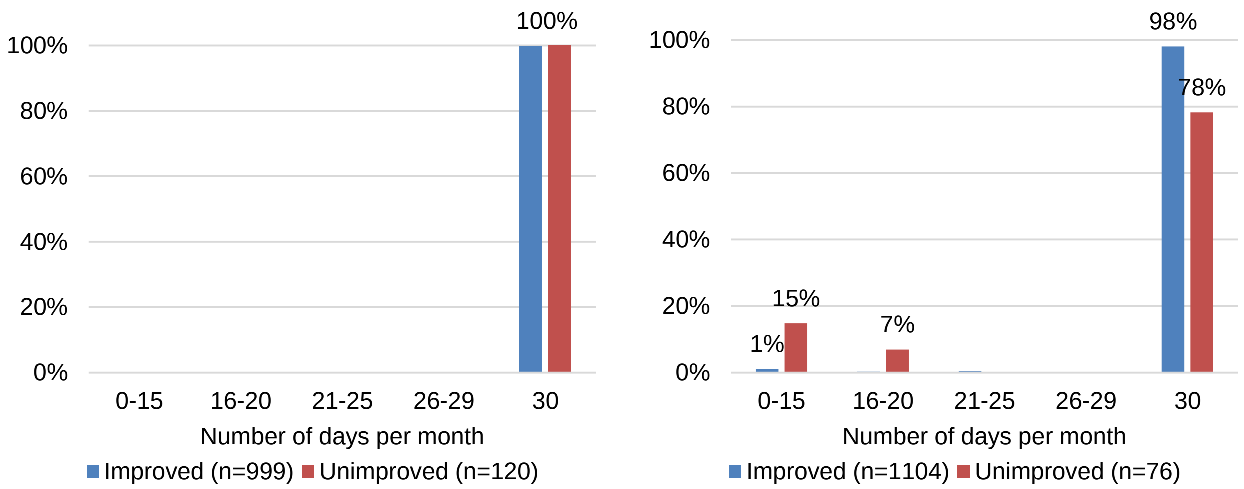


Figure 12 Days per month by service level for main water point

a. Bangladesh **b. Pakistan**



Public improved water point

The day-to-day performance of public improved water points were estimated through community focus group discussions. The findings from these are consistent with the findings above in that community systems were reported to provide users with 24 hours water services.

Summary of day-to-day performance

In both Bangladesh and Pakistan nearly all households reported that they were able to access water services from their main water point 24 hours per day and for every day in a month period. This demonstrates that in the short-term households in these two countries experience a very reliable water service.

4.2 Month-to-month performance of water systems

This section summarises primary data relating to the medium term functionality of water systems. Functionality is assessed according to a variety of indicators: *functionality of water points*; seasonal *continuity of service*; and *predictability of service*.

4.2.1 Functionality of public improved water points

Functionality of public improved water points was assessed according to the 1) community perception of the "usual"[20] functionality of specified water points; 2) water point inspection if water was available and 3) cross-comparison of household experience of functionality of that WP on their last visit and community perception of functionality using water point ID's.

Findings on the functionality of public water points based on community interviews are presented in Table 7. These show that communities in Bangladesh deem 89% of their public improved water points to be "usually functional", compared to 70% of systems in Pakistan. The remaining 30% of systems in Pakistan are fairly equally split between those that are non-functional (15%) and those that are "sometimes" functional (14%)[21]. In comparison, the Bangladesh sample shows that 4% of systems are non-functional, with 7% functioning some of the time.

These values are consistent with the reliability findings in the previous section which demonstrate that water systems in Bangladesh tend to provide greater continuity of service compared to those in Pakistan.

Table 7 Community perception of water point functionality

	Bangladesh	Pakistan
Not functional	4%	15%
Sometimes functional	7%	14%
Usually functional	89%	70%
Total	**100%**	**100%**
No. of water points	249	411

NOTE: This data here are reported only for public improved water points. Estimations were derived from the community survey, referring to their usual experience of functionality[22].

Table 8 disaggregates the community perceptions of functionality by type of system. In the case of Bangladesh all seven of the protected dug wells were considered to be "usually functional" compared to 89% of tube-wells. In Pakistan there is a marked difference between public taps where 72% of households receive an inconsistent service that is 'sometimes' functional, compared to households using a tube well which is usually functional 77% of the time. This difference likely reflects the intermittent electrical supplies affecting the reliability of public tap systems.

Table 8 Community perception of water point functionality - disaggregated

	Bangladesh		Pakistan	
	Tube well (n=237) well/borehole	Protected dug well (n=7)	Public tap (n=89)	Tube (n=318) well/borehole
Not functional	4%	0%	9%	16%
Sometimes	7%	0%	72%	7%

[20] Respondents were ask to identify whether each community water point was 'usually' functional. The possible responses were limited to three options (i) yes (ii) yes, some of the time, and (iii) no, never.
[21] Reporting percentages to one decimal place means that these figures do not appear to total 100%.
[22] Exact phrasing of survey question: Is this WP usually functional?

Usually	89%	100%	19%	77%
Total	**100%**	**100%**	**100%**	**100%**

The functionality of each public water point were assessed separately as part of public water point inspections. This was a simple binary assessment of whether or not the enumerator could draw any water at the time of inspection.[23] In Bangladesh enumerators found that 90% of improved public water points were functioning at the time of inspection. These values are consistent with findings on "usual functionality" presented in Table 7. For Pakistan, enumerators found that 92% of improved public water points were functioning, much higher the 70% usually functioning systems found in community surveys, and slightly higher than the 84% of systems deemed to be usually or sometimes functioning. This discrepancy may be explained by the fact that our enumerators visited at a fortuitous time when electricity supply was relatively reliable.[24]

The triangulation of household, community and water point inspection data demonstrated that the findings across each survey tool were consistent in 95% of cases. This strengthens our confidence in the functionality findings reported – across all survey tools[25].

4.2.2 Seasonality

Main water point (household experience)

Primary household survey data assessed the seasonality and continuity of water supply according to household perceptions of the number of month's that water is available per year, and of the predictability of water per year.

On the average number of months in which households can access their main water point are compiled in Table 9. This data shows that the vast majority of households in both Bangladesh and Pakistan receive year round access to water services from their main water point. Typically therefore households' access to water is not severely affected by seasonal variation in either country, although in some areas there will inevitably be better seasons in which to collect water.[26] The comparison of improved and unimproved water points in Figure 13 demonstrates that households using unimproved water points are more likely to face some seasonal problems in accessing their main water point. The seasonality of unimproved water points is most problematic in Pakistan where 50% of users reported that water was not available for the full 12 months per year.

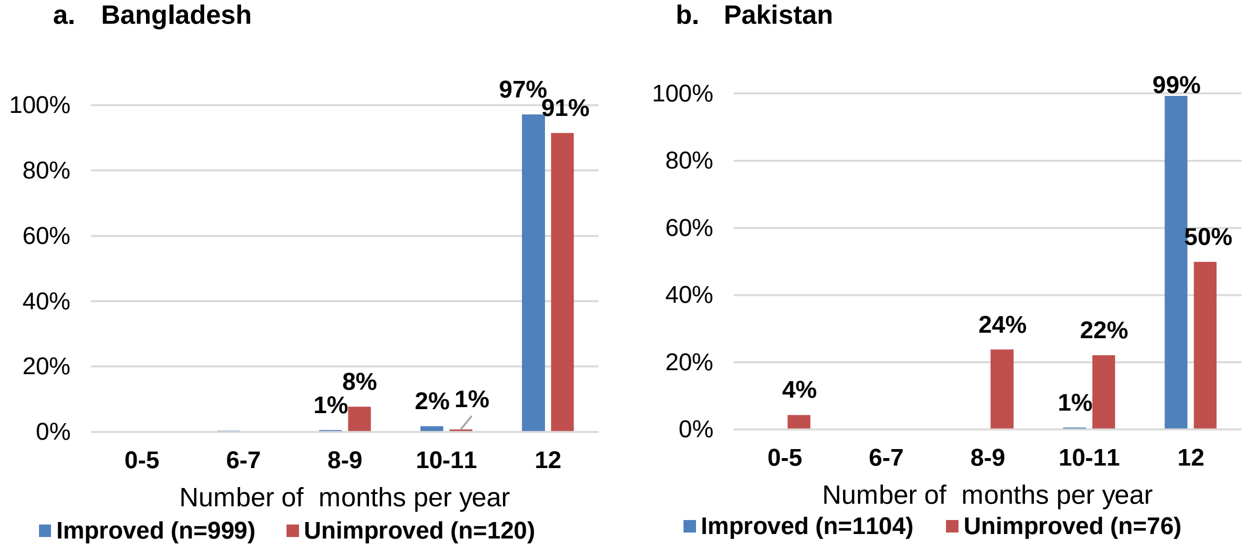
[23] Exact phrasing of survey question: Can you get water at the time of visit?
[24] When the indicators for "usually functional" and "sometimes functional" are added, we get 84%, which is slightly closer to 92% reported as part of the water point inspections. In addition, it is worth noting that, while 412 public improved water points were listed by the community, only 338 public improved water points were visited by our enumerators, due to the way the listing was conducted.
[25] Finally, we conducted a third data quality check by using the unique IDs which we associated with water points at the listing stage of data collection. When asked about which water points they used, enumerators cross-compared their answer with descriptions and photos taken at the listing stage. Using these unique IDs, which were used across all three instruments (household, community and inspection) we were able to compare the extent to which individual households using that WP agreed with the community group's consensus position. There was agreement for 95% of public water points. We can therefore have very strong confidence in our data quality on functionality.
[26] Primary data collection also found that generally two-thirds of households in Pakistan and one quarter of households in Bangladesh stated that there was no worst or best season for the collection of water.

Table 9 Average months per year of service by wealth quintile for main water point

Quintile	Months per year of service (out of 12)	
	Bangladesh	**Pakistan**
Lowest	11.8 (n=227)	11.7 (n=223)
Second	11.8 (n=225)	12.0 (n=246)
Middle	11.8 (n=222)	12.0 (n=225)
Fourth	11.9 (n=225)	12.0 (n=245)
Highest	11.9 (n=221)	12.0 (n=241)
Total	**11.9**	**11.9**
No. of households	1,158	1,195

Note: Includes data for all public and private, improved and unimproved water points.[27] Data comes from the household survey.

Figure 13 Months per year by service level for main water point

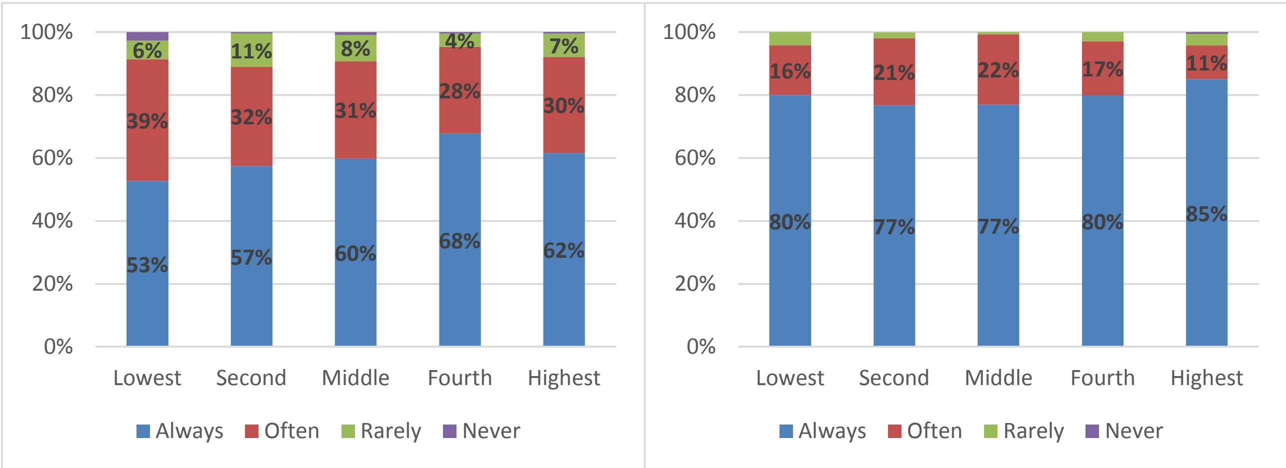


Households in Bangladesh and Pakistan were also asked whether they can usually predict whether water will be available from their main water point. In Pakistan 97% of households expressed that water availability is always or often predictable, with marginal differences, but no clear trend across quintiles. In Bangladesh, this figure was slightly lower with 93% of households stating that water services were always or often predictable (Figure 14).

[27] Exact phrasing of survey question: How many months in year (12 months) water is usually available from this WP?

Figure 14 Predictability of water availability by wealth quintiles for main water point

a. Bangladesh **b. Pakistan**



Note: Includes data for all public and private, improved and unimproved water points.[28] Data from household survey

Public improved water points

The month-to-month performance of public improved water points were estimated through community focus group discussions. These discussions indicate that in a similar manner to private water-point, community systems tend to provide users service virtually 12 months per year.

Summary of month-to-month performance

The month-to-month reliability was very high for households accessing an improved water point as their primary water source. This represents the vast majority of households in the sample. In both countries water was available for these water point virtually 12 months per year, with well over 90% of households stating that services from this water point were always or often predictable.

4.3 Multi-year performance

For a full understanding of the operational service provided by rural water points over time – and in particular the adjusted person years - it is important to have a measure of the years of service provided by water points in different contexts. Determining this 'service life' requires a clear definition of the boundaries of when a service starts and finishes. In the technical literature on asset management there are various methods to measure service life range from taking simple estimates of infrastructure 'design life', though to the application of evidenced-based probabilistic modelling to assess expected service life under different maintenance scenarios.

In the context of rural supplies, it is uneconomic to have a detailed technical assessment of large amounts of infrastructure but, equally, the presumed low levels of system maintenance means that estimates of system design lives are likely to be overoptimistic. For this study, the service life is understood as the interval in years between system construction and major failure (that is when major capital maintenance expenditure is required). The collection of primary data on this area was beyond the scope of the primary data collection in this research due primarily to the challenges of cross-checking reported service life of facilities. As a consequence, only general estimates could have been used to populate this element to generate an estimate of Adjusted Water Person Years.

[28] Exact phrasing of survey question: To what extent can you usually predict that water will be available from this WP?

A future research challenge is to re-analyse our primary data sets using estimated lifespans of typical infrastructure in the region using secondary water point mapping data reporting functionality by age.

4.4 Water service levels achieved

As outlined in the conceptual framework for water, the effective performance experienced by users, as well as the operational performance of the water point, can only be fully understood if indicators of water services (such as quality, quality, and accessibility) are also accounted for.

In primary data collection water service have been measured according to the: time taken to collect water; the number of users for each water point; water quantity accessed; and the household perception of water quality. Additional relevant data was not collected on the micro-biological and physical quality of the water and this limits a full understanding of the actual water quality and water safety.

4.4.1 Time to source and time taken to collect water

Data from the survey is presented as the both the average reported time taken for one round-trip (Table 10), and as the percentage of users within a certain time threshold (Table 11).

Among those households that had to leave their plot or compound to fetch water, the average time taken per round trip (including queuing time) was 4 minutes in Bangladesh. Households in the lowest quintile spend comparatively far more time to collect water than the wealthiest households (7 minutes versus 1 minute), although both values suggest that in Bangladesh public water points are in easy reach of most households. The findings from Pakistan follow a similar pattern. The average time for those that have to leave their plot or compound to fetch water was slightly higher than in Bangladesh at 5 minutes, and for the poorest households in rural Pakistan the time taken to collect water is at 15 minutes more than three times greater than any other quintile group.

Table 10 Average round trip time by wealth quintiles for main and improved water points

Quintile	Average (minutes)	
	Bangladesh	**Pakistan**
Lowest	7 (n=231)	15 (n=224)
Second	5 (n=232)	4 (n=248)
Middle	3 (n=232)	2 (n=226)
Fourth	4 (n=232)	1 (n=246)
Highest	1 (n=231)	0 (n=244)
Total	**4**	**5**
No. of households	1,158	1,188

Note. This table only includes data for the household's primary improved water point, and only for those households who left their plot or compound to fetch water. Estimations were derived from the household surveys, referring to their usual experience of time-to-source. Averages include water points where the round-trip took 0 minutes[29].

Table 11 disaggregates the time taken to collect water for improved and unimproved sources according to whether the sources are on premises and whether they are more or less than 30 minutes round trip from the household. In both countries, 96% of all households can fetch water within a 30 minute round trip. The main difference between the findings is that in Pakistan if you do not have access to an improved source then you are much more likely to have to travel more than

[29] Exact phrasing of survey questions were: 1) On average how long does it take to travel to this WP? And 2) On average how long do you/ the household member have to wait in the queue to get water?

30 minutes to your source to collect water. This is not found to be a major problem in Bangladesh where only 4% of unimproved sources are greater than 30 minutes from their household.

Table 11 Time to source by service level for main and improved water points

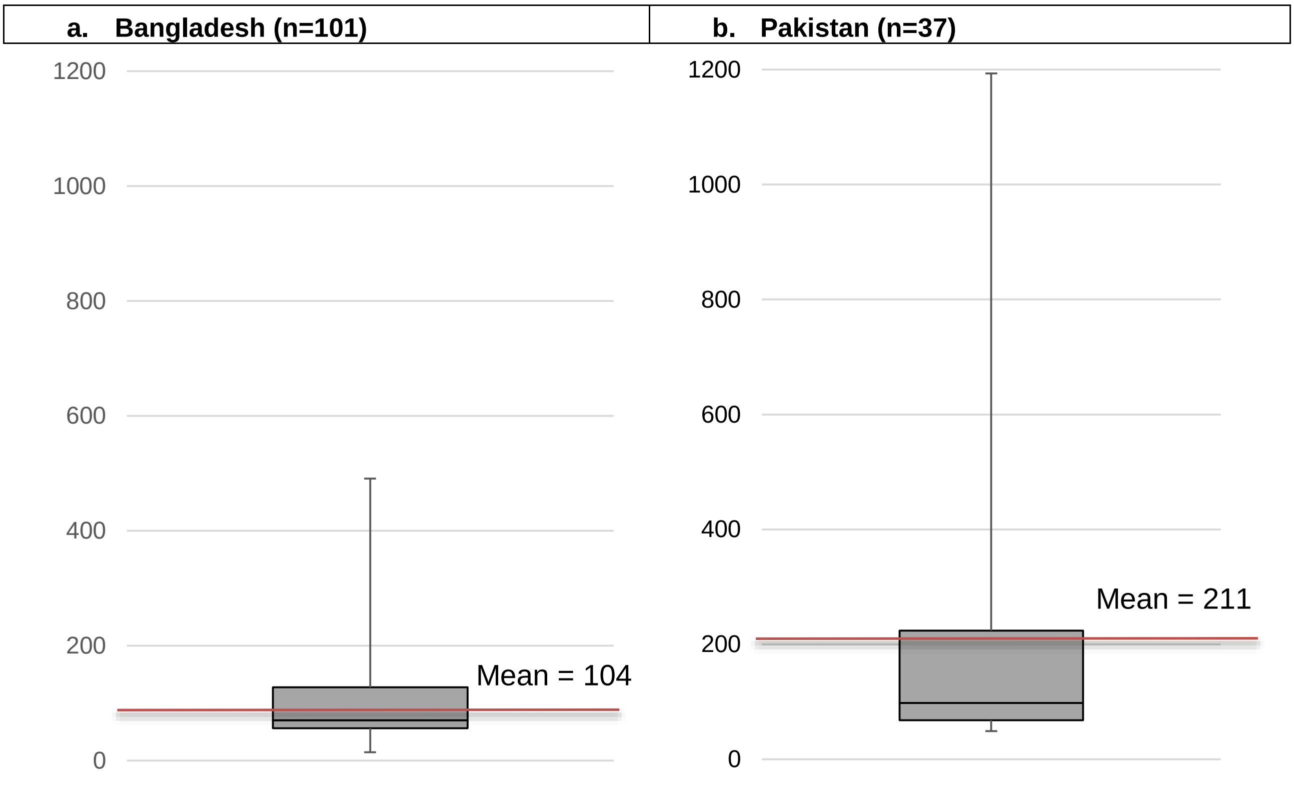
Time to source	Bangladesh			Pakistan		
	Improved	Unimproved	All	Improved	Unimproved	All
On premises	71%	38%	68%	89%	19%	86%
Less than 30 mins	26%	58%	29%	7%	33%	8%
30 mins or more	3%	4%	3%	4%	48%	6%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
No. of households	1,037	121	1158	1109	79	1,188

Note: This table includes data for all public and private, improved and unimproved water points. Estimations were derived from the household surveys, referring to their usual experience of time-to-source.

4.4.2 Number of users / crowding of public improved water points

We have analysed data on the number of people using each public improved water point based on extrapolation of household survey data which contained water point IDs. As can be seen in Figure 15, the median number of users of each water point are broadly similar, although variance in values is far greater in Pakistan. In Bangladesh estimates ranged from a minimum of 15 to 491 users per water point, in Pakistan estimates are even more dispersed ranging between 49 and 1,193. The median was taken as the most appropriate measure of the number of household users as mean values were skewed by a small number of water points with a very high number of users.

Figure 15 Box plots showing the number users of each improved public water point



Note: The box plot shows the median (horizontal line), the inter-quartile range (grey box) and the minimum and maximum values (vertical line).

4.4.3 Water quantity used

The internationally-recognised benchmark for water consumption per person per day is 20 litres per capita per day (LPCD). This figure has been adopted by the JMP and World Health Organisation (WHO); it is directly referenced in General comment 15 on the Human Right to Water (WHO, 2013). The figure is based in a review concluding that 'basic' level of water consumption of up to 20 LPCD is likely to be sufficient for basic health protection, with around 7.5 litres of this water typically being required for direct consumption, though concluding that 20 litres would still leave inadequate quantities of water for "effective use in hygiene practices" (Howard and Bartram, 2003).

Our primary data for Bangladesh and Pakistan estimated the average litres of water used per person per day for households leaving their house to collect water. To determine the amount of water accessed per person per day, enumerators first estimated total household usage according to the number of containers of a specified time filled and used per day, and then divided by the household size. Household's perceived satisfaction with the quantity of water they received was not assessed.

In Bangladesh water consumption varied between quintiles, specifically the lowest two quintiles consumed between 15-16 LPCD compared to between 19-25 LPCD for the three higher quintiles. The average consumption across all households using an off-site water point was 18 LPCD. In Pakistan water consumption increases between the lowest and the second quintiles. Households in the poorest quintile consumed on average 11 LPCD while those in the second quintile consumed 19 LPCD. Across all quintiles water consumption for non-household sources is 13 LPCD in Pakistan.

Table 12 Average litres of water used per person per day from off-site water points

Quintile	Average volume per capita (litres)	
	Bangladesh	**Pakistan**
Lowest	16.9 (n=119)	10.9 (n=58)
Second	15.0 (n=91)	18.5 (n=28)
Middle	20.0 (n=62)	14.4 (n=15)
Fourth	19.1 (n=54)	11.8 (n=9)
Highest	25.0 (n=26)	- (n=0)
Average	**18.8**	**12.9**
No. of households	352	110

Note: Water quantity consumed per person, this is estimated as the capacity of the container multiplied by the number of containers-full of water collected per day, , divided by the average household size by quintile[30]. This data was only calculated by for households leaving their house to collect water. The reason why we excluded households with on-site water points is that they either will not be able to provide an accurate estimate, and the assumption that on-site water points most likely represent a high level of service from a quantity perspective.

Looking across both countries these findings demonstrate that average water consumption across both countries is below the World Health Organisation (WHO) guideline amount of 20 LPCD for basic consumption and hygiene needs; with the lowest and most unsatisfactory consumption levels found in Pakistan and amongst poorer households in Bangladesh.

4.4.4 Perceptions of water quality

The perceived quality of water provided by public improved water points was assessed in two ways: i) by the enumerators as part of the water point inspection, and ii) by the community during

[30] Exact survey questions used: 1) What is the capacity of the container in litre do you usually use to obtain, carry or store water from this WP that would be best for estimating daily use? And 2) How many units of the container do you usually use per day for the entire household for drinking and other domestic use?

community interviews. Perceptions of users, while subjective, are important because they are one of the determinants of usage levels. Water quality testing was not undertaken.

We tested all water points in Bangladesh for Arsenic[31] contamination. The water quality testing results demonstrates that 40% of all samples tested has some form of arsenic contamination. 25% of these were higher than WHO guidelines for acceptable levels of arsenic in drinking water (10µg/l) and 14% were high than the less stringent Bangladesh national guideline of 50 µg/L The indicators collected in this study are not sufficient to provide a full understanding of actual safety and quality of water being delivered. To do this would require systematic testing of a range of chemical and micro-biological indicators, and this was beyond the scope and budget of this research.

Table 13 Drinking water quality assessed through enumerator perceptions and arsenic testing

	Bangladesh (n=196)	Pakistan (n=307)
Appearance and taste		
Clear appearance	99%	92%
Clear from visible particles	99%	64%
Colourless	96%	91%
Odourless	99%	87%
Not brackish water	94%	No data
Arsenic		
0 µg/L (in line WHO standards)	60%	No data
1-10 µg/L (in line WHO standards)	15%	
11-25 µg/L	8%	
25-50 µg/L	2%	
>50 µg/L	14%	

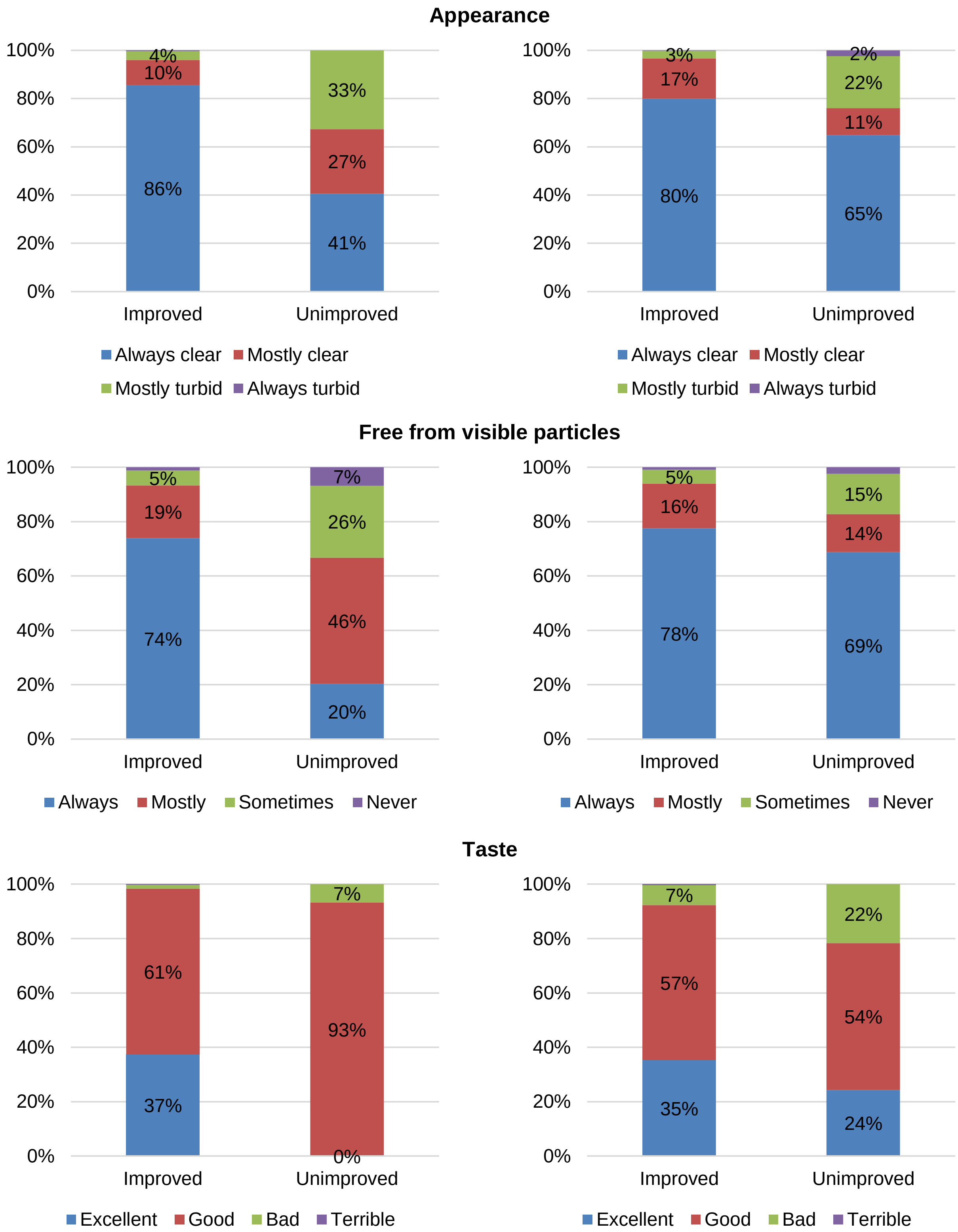
Our data collection also assessed the perceptions of water quality by users in Bangladesh and Pakistan according to indicators turbidity, presence of visible particles, taste and salinity. Perceptions of users, while subjective, are important because they are one of the determinants of usage levels. These results are also compared with enumerator inspections of the quality of water from public improved water points.

For both countries households generally have a better perception of the water quality of improved water sources compared to unimproved sources (Figure 16). In Bangladesh households using unimproved sources reported a higher proportion of turbidity (29%), prevalence of visible particles (28%), bad taste (6%) and salinity (16%). Across all Bangladeshi sources the most common perceived water quality problems are associated with visible particle and general appearance, whereas the issues with taste and salinity are only a problem in a small number of households. In Pakistan households using unimproved sources reported higher a proportion of turbidity (19%), prevalence of visible particles (11%), bad taste (15%) and salinity (6%). Overall perceptions of water quality and reports of water salinity are better in Pakistan compared to Bangladesh. However the perceptions of water taste – especially for those using unimproved sources – are markedly worse in Pakistan.

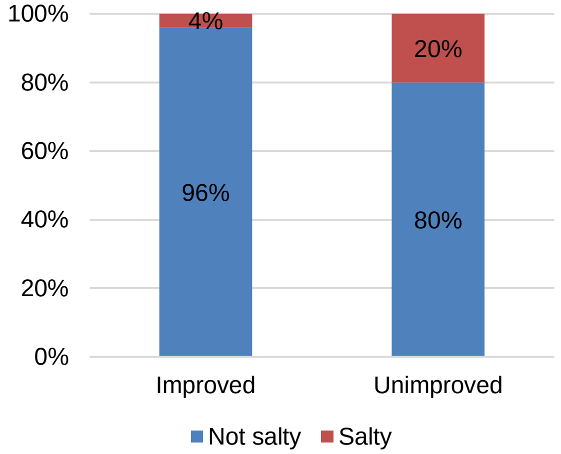
[31] Further details of arsenic testing procedure will be included in a later draft of this report.

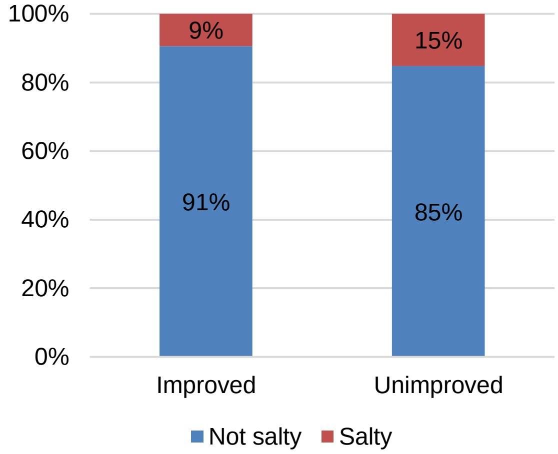
Figure 16 Perceived drinking water quality by service level for main water point

a. Bangladesh (n=1,014) **b. Pakistan (n=996)**



Salinity





Note: Includes data for all public and private water points[32]

Community perceptions of water quality were also cross-checked with enumerator's perceptions of the turbidity, taste, and colour of water from public improved water points. These findings demonstrate that for the public improved water points there are no major problems in terms of water appearance and taste in Bangladesh. In Pakistan the primary concern is the presence of visible particle in 36% of the samples.

Summary of service levels

In Bangladesh and Pakistan, service level data shows that the main water point accessed by household's' tends to be close by and convenient, and the perceived water quality is acceptable to most users of improved water points. The water quantity accessed from the main water point is slightly below guideline the guideline standard of 20 LPCD, although most households are expected to access additional water from alternative sources. On the negative side some water points were found to be excessively crowded and chemical water quality remains a key concern – especially in Bangladesh where 25% of the water points test were found to have unacceptable levels of arsenic.

[32] Exact phrasing of the survey questions: 1) What is the appearance of the water from this WP? 2) Is the water free from visible particles? 3) How would you rate the taste of the water from this WP? And 5) Is the water salty?

5 Findings from secondary data

In order to paint a more representative picture of water services across South Asia, relevant secondary data is compiled in this section. Further detail on the inclusion criteria for secondary data, and the sources identified, can be found in Annex A.

5.1 Day to day performance of water systems

Despite an extensive literature search no secondary data was collected on the short term reliability of rural water systems. Data relating to short term system performance are more often associated with a networked piped supplies.[33] JMP data shows that only 15% of the rural population in South Asia access these systems (WHO/UNICEF, 2014).

5.2 Month to month performance of water systems

5.2.1 Functionality

In South Asia a small number of data sources were identified that met the inclusion criteria of being large-scale (over 5,000 data points), and being nationally representative, or more commonly being national level in their scope of coverage[34]. The three main data sources identified (water point mapping studies in Afghanistan, Bangladesh, and Nepal) are examples of this type of administrative data and report on the functionality of water systems. Additional functionality data was drawn from two sample surveys undertaken in Bangladesh and Nepal.

Secondary evidence from across the five studies, spanning three countries, shows between 62% and 88% of water points were functional at the time of data collection (Table 14). The highest percentage of functioning rural water points are found in Bangladesh where 88% of systems are functional, compared to 77% of systems in Afghanistan. Extrapolating broader conclusions from these headline findings must be done with caution, mainly because the WPM survey in Bangladesh only collected data on systems constructed since 2006, whereas WPM in Afghanistan did not restrict sampling according to system age.

The nationwide data from Nepal indicates that only 62% of piped systems are operating to satisfactory level. However, as no distinction is drawn between rural and urban areas, and only 16% of the rural population access piped supplies, these findings cannot be generalised across the rural population. Specific information on the functionality of rural piped systems in Nepal are found in a study of 92 water systems over 5 years of age that have been supported by the Water Resources Management Programme (WARM-P) implemented by HELVETAS Swiss Inter-cooperation.[35] A total

[33] We did investigate the potential of IB-NET (the benchmarking network for urban utilities) to provide some of this data, but the results were not very detailed and it is not possible to tell utilities are operating in rural areas, in accordance with our methodology. Nonetheless, a small amount (n=20) of comparative data was collated from ib-net.org. This database was filtered for small piped systems (serving less than <50,000 consumers) across South Asia and shows that all users of these systems are receiving discontinuous supplies of between 2 and 12 hours of service per day. It is impossible to tell which of these small systems are in rural areas (or "small towns") by national definitions. Since the primary focus of this assessment is rural areas, we have not included a full analysis of this data.

[34] Inventories of WPs such as WPM initiatives would not be nationally representative in the sense of a sample survey. Here we use the term to mean surveys which attempt to catalogue many or most of the public water points in a country, rather than those of a specific programme or single sub-national area.

[35] As this study is only representative of systems related to a single programme it does not meet our inclusion criteria for water point mapping data. Its conclusion is justified as it provides directly comparable data on water point functionality to the nationwide survey.

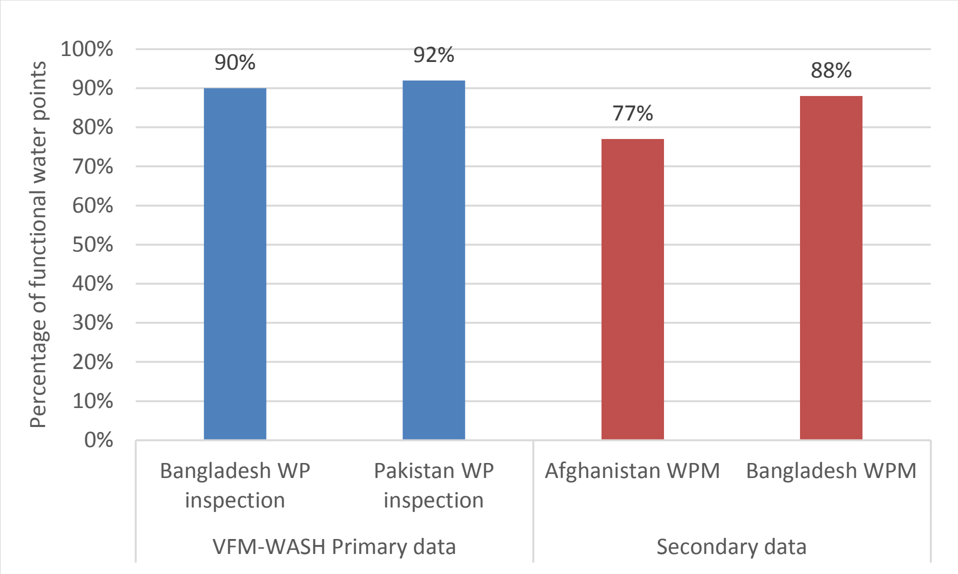
of 71% of these systems are found to be functional, approximately 9% higher than the systems reported nationwide.

Table 14 Percentage of water points functional at the time of data collection

	Data		Notes		
	Value	**Indicator definition**	**Data source**	**Scope / coverage**	**Representative of scope**
Administration data					
Afghanistan	77%	Functionality dichotomised into functional and non-functional water points but without clear definition of either status	DACAAR 2014	National (n=28,524)	Representative
Bangladesh	88%		SHEWA-B/DPHE 2014	National (n=151,534) Only covering systems constructed in the last 7 years	Representative
Nepal	62%	Defined as piped water supply systems that were well functioning or only required minor repairs	National Management Information Project 2014	National (n=41,205) Only covering piped systems. No distinction is made between rural and urban areas	Representative
Relevant functionality surveys – sample data					
Bangladesh	64%	A source was considered functional if either 1) the enumerator was able to draw water from the source or 2) community members stated that the source was functioning.	Kabir and Howard (2007)	Other: Arsenic affected communities (n=971)	Representative
Nepal	71%	Defined as piped water supply systems that were well functioning or only required minor repairs	Pant, 2013	Other: Programme areas of WARM-P (n=92) Rural piped systems between 5 and 10 years old	Representative

It is worth considering the data in the table above carefully, particularly the extent to which it is comparable. Arguably, none of the three large WPM datasets are comparable, since each has its idiosyncrasies (e.g. Bangladesh only WPs less than 7 years' old, Nepal only piped schemes, spanning urban and rural areas). The only comparable multi-country data is the primary data collected under the VFM-WASH project with cross functionality data in Afghanistan and Bangladesh (Figure 17). Systematic understanding of water point functionality is also complicated by the supposed "denominator problem" the fact that monitoring data often fails to take account of water points that have been abandoned. These issues are discussed further in section 5.3.1 discussing the expected years of service on a given water point, and in Annex B, which provides a detailed account of existing evidence of the denominator problem.

Figure 17 Comparison of primary and secondary WP functionality data



5.2.2 Seasonality/continuity of service

In South Asia a good number of large scale studies have been collected in Bangladesh, India, and Nepal which yield a range of indicators of medium-term seasonality and service continuity (Table 15). The secondary data collected can be broadly divided into two groups. The first group represents an extension of water point mapping studies where a technical assessment has been made of the capability of systems to provide year-round service. The second group tend to be drawn from household surveys, and are therefore more directly comparable with the VFM-WASH primary data.

As part of the water point mapping activities in Bangladesh, an additional study was undertaken assessing the vulnerability of 5,788 shallow and deep wells (specifically those fitted with the low cost “Nr. 6” suction pump) to falling water levels during dry seasons. This study found that 71% of these systems were going to be unable to draw water in the dry season[36]. In Nepal the national inventory of piped systems found that only 68% of systems spread between rural and urban areas were able to provide “whole-year”[37] supply to users.

In terms of household surveys; Kabir and Howard (2007)[38] assessed whether water systems within Arsenic affected communities were affected by seasonal or monthly breakdowns. This is conceptually similar, to if not directly comparable, to the approach taken by WASHCost India where households recalled the number of days the water point was not functional within the last months and years. In the case of Bangladesh only 45% of systems did not suffer seasonal or monthly breakdowns according to community interviews. In the WASHCost study the main water point for many rural households was found to be non-functional for extended periods, as only 58% of households accessed a primary water point that was functional for more than 350 days per year.

[36] We are checking with UNICEF Bangladesh the extent to which other water points, not equipped with the Nr. 6 handpump, experience seasonal water shortages

[37] The definition of ‘whole year’ supply are not provided in any of the secondary documentation from the NMIP programme.

[38] This study meets the stated inclusion criteria in terms of study design and was the only peer reviewed journal found dealing with the seasonality of rural water systems in South Asia. The study captures a statistically representative sample of water systems installed in Arsenic affected communities in Bangladesh, although this cannot be attributed to a defined region or geographic area.

Finally the state-wide ASHWAS in Karnataka, India, found that 78% of households reported year-round availability of drinking water from their main source.

Table 15 Seasonality/continuity of water supply

	Data		Notes		
	Value	**Indicator definition**	**Data source**	**Scope**	**Representativeness of scope**
Water point mapping indicators					
Bangladesh	71%	% of shallow and deep wells that maintain acceptable drawdown in the dry season	Ravens-croft et al., 2014	National (n=5,788) Only deep and shallow tube wells using a number 6 suction pump	Representative
Nepal	68%	% of piped systems that are delivering a whole year supply	NMIP 2014	National (n=41,205) Piped systems only	Representative
Household/Community data					
Bangladesh	45%	% of systems that do not suffer seasonal or monthly breakdowns as determined by community surveys	Kabir and Howard 2007	Other: Arsenic affected communities (n=621) Only examined functional water points at the time of survey	Representative
India	58%	% of households whose main improved water source is functional for more than 350 days per year	WASH Cost India	State/Region (n=5,232)	Representative
	78%	% households reporting an availability of drinking water from their main water source throughout the year	ASWAS 2009	State/Regional (n=17,200)	Representative
	55%	% of households that do not experience any water shortages throughout the year		State/Regional (n=17,200)	Representative

Summary of month-to-month performance

The secondary data relating to the seasonality and continuity of water services indicates that commonly around a third of water supply systems experience some form of discontinuity of service on a month to month basis. Sometime this proportion is as high as 50% or as low as 22%, although the different indicator definitions in the data sources may also account for some of this variation. The functionality data is interrogated in more detail in following section 5.3.1 on the number of years of service provided by a water point.

5.3 Multi-year performance

5.3.1 Number of years of service

Using water point mapping datasets in Afghanistan and Bangladesh, we are able to consider the functionality of many WPs of different ages in cross-section. However, it is important to remember that this is not the same thing as looking at the same WPs over time, which would be much more instructive in understanding the expected number of years of service of rural water points.

In Afghanistan the age of systems sampled range between 1 and 20 years giving an extended cross-sectional profile of age versus functionality data.[39] Although the absolute number of data points are much higher in Bangladesh, their ages are spread over a shorter time period and this means that direct comparison of functionality data over time can only be done for systems aged between 1 and 7 years (Figure 18 and Figure 19).

Over this time period the two data sets show similar rates of decline in water point functionality with age. For new systems that are less than two years old, the percentage of functional systems are at their highest at 89% in Afghanistan and 92% in Bangladesh. In each subsequent year the proportion that is functional tends to falls by a few percentage points per year. The rate of decline is most pronounced in Afghanistan where, after 7 years, the number of functional water points has dropped by around one fifth (19%), to 70% overall. In Bangladesh the after 7 years the percentage of functional water points has declined by a further 14%, to 77% overall.

The entire time series of data in Afghanistan appears to show water point functionality bottoming out at around 65% for 10 and 11 year old water points, and after this point the functionality rates increase for older systems, peaking at 89% for 20 year old systems (Figure 18). The most likely reason for this counter-intuitive trend is that non-functional older systems - that may have been lost, abandoned, or simply discounted - are not captured in WPM inventories, leading to erroneous positive skew of the reported functionality of older systems.

Given these uncertainties and without longitudinal data for each water point, it is not possible to provide evidence based estimation of the typical service life of rural water points in South Asia. This is topic area which has implications for service sustainability and long term financial planning. Initial approaches to better understand and model the “denominator problem” are presented in Annex B.

[39] The age (in years) of a water point was calculated by isolating the year at which the functional status of the water point was assessed minus the year of installation. The Bangladesh database does not record the year of collection – we have assumed that all systems were assessed in 2013 given that we know that data collection took place during 2012/3.

Figure 18 Functionality of water points in rural Afghanistan according to system age

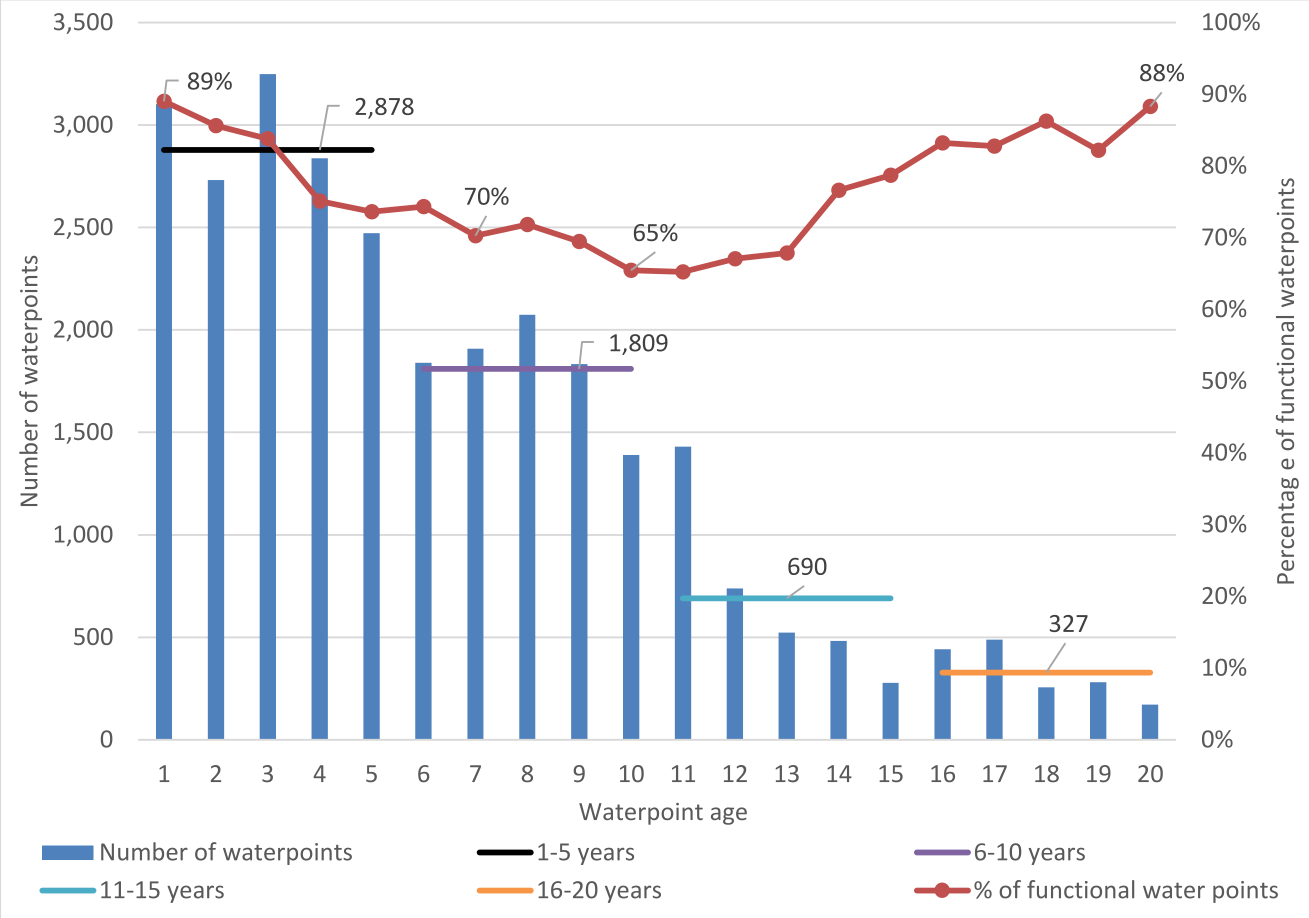
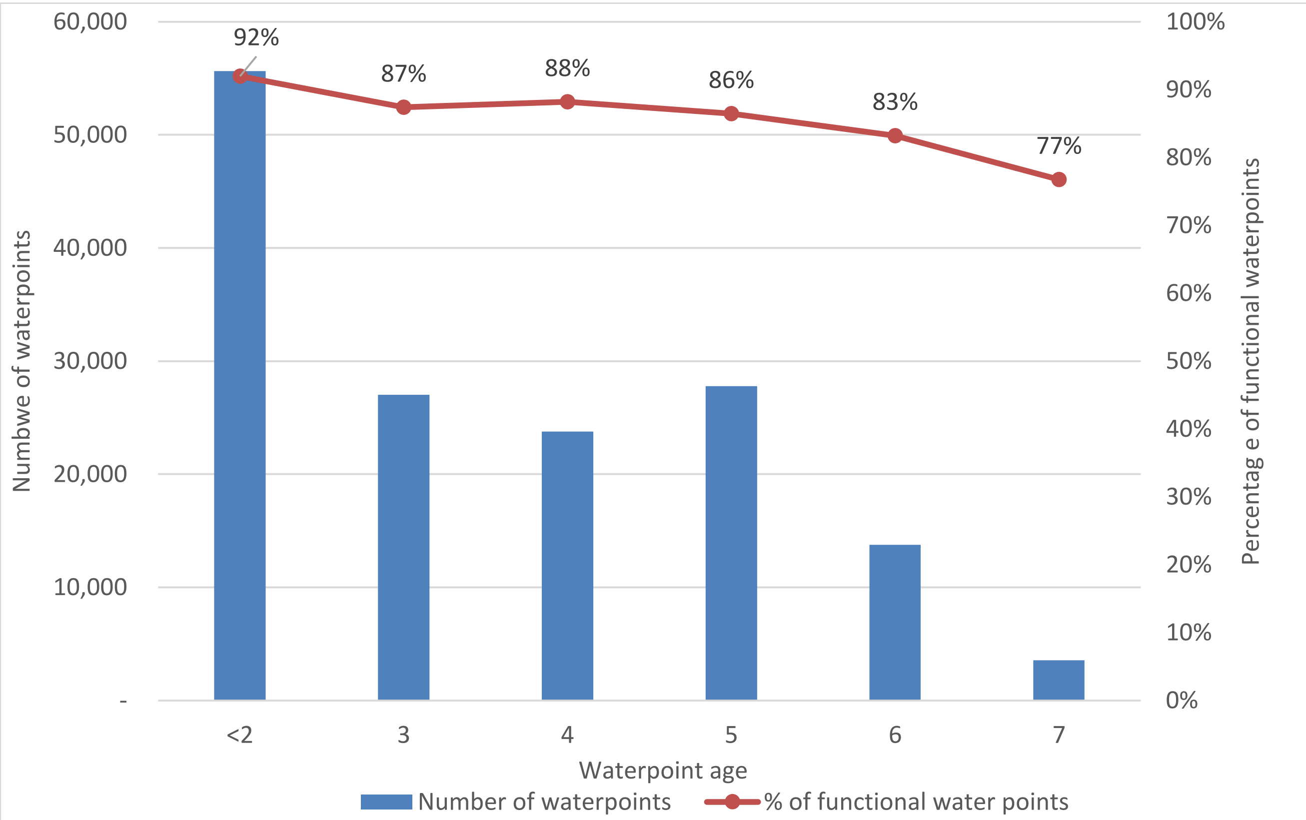


Figure 19 Functionality of water points in rural Bangladesh according to system age



Summary of multi-year performance

Country-wide administrative data from Afghanistan and Bangladesh indicates that rural water point functionality at the time of data collection were between 89% and 92%. However examining the proportion of functioning water point in age profile indicates that there is a considerable erroneous positive skew of the reported functionality of older systems. This is likely linked to a so-called 'denominator problem' where older non-functional systems are discounted from functionality assessments meaning that the percentage of functional water points are likely to have been over-estimated.

5.4 Water service levels achieved

This section explores secondary data on time to source, water quality used and water quality accessed. In the wider literature, and survey data, on service delivery there is more information available on these different dimensions of water services, than any others. Consequently the bar for inclusion of secondary data is somewhat higher, in comparison to the previous sections.

5.4.1 Time to source and time taken to collect water

Time taken to collect water can be reported in several ways. We have chosen to focus on either the average time taken to collect water, or the percentage of users under a certain time threshold (e.g. the percentage of users who access water off-plot, or the percentage taking under 30 minutes to collect water). It is important to note that this measure includes the time taken to walk to the water source, wait in line (if required), collect the water and return home. Some countries report distance to a water point instead, but this indicator is less relevant as it does not take into account time spent queuing, nor the fact that distance walked uphill is not equivalent to the same distance walked on flat ground.

In 7 of the 8 countries in South Asia nationally representative data was collected on percentage of households accessing their primary water point within a 30 minutes round trip[40]. The missing country is the Maldives where the most recent MICS study was carried out in 2001 and it did not meet our inclusion criteria for being finalised within the last 10 years.

For the remaining countries the two main sources of this data were MICS and DHS surveys, although data was also drawn for the Household Income and Expenditure survey in Sri Lanka, and the National Family Health survey in India.

Secondary findings summarised in Table 16 show that in four of seven countries over 90% of households access their primary water point within a 30 minute round trip. The highest percentage encountered in a representative sample was the 96% recorded in Bangladesh – exactly the same proportion as that found in primary data collection. Access to the primary water point is more problematic in Nepal where 81% of households meet the less than 30 minute criteria, and in the Mid and Far west regions this percentage falls as low as 71%. Once again the findings from Afghanistan, where only 45% of households can fetch water within 30 minutes, are the exception to prevailing trends elsewhere in South Asia. It is clear from the JMP estimates presented in section 3 that there is proportionally far less formal infrastructure in rural Afghanistan compared to other South Asian countries, and it seems that this necessitates households to travel for much longer to access either an improved or unimproved source.

[40] In Sri Lanka the indicator collected recorded the percentage of households with a water point on the premise or within 500m. Although not exactly analogous to the indicator elsewhere it was considered similar enough for direct comparison.

Table 16 Percentage of households accessing water point on premises or in less than 30 minute round trip

	Data		Notes		
	Value	Indicator definition	Data source	Scope	Representativeness of scope
Afghanistan	45%	Total time to obtain drinking water (travelling to and from source). Typically this has been reported according to four categories 'water on premises'; 'less than 30 minutes'; 'more than 30 minutes'; 'don't know/missing'.	MICS Afghanistan 2010/2011	National (n=9,571)	Representative
Bangladesh	96%		DHS Bangladesh 2011	National (n=11,273)	Representative
	96%		MICS Bangladesh 2006	National (n=44,797)	Representative
Bhutan	94%		MICS Bhutan 2010	National (n=11,534)	Representative
India	85%		National family health survey India 2005/6	National (n=58,805)	Representative
Nepal	81%		DHS Nepal 2011	National (n=7,678)	Representative
	71%		MICS Nepal 2010	Multi-regional (n=4,671) Mid and Far west regions	Representative
Pakistan	94%		DHS Pakistan 2012	National (n=6,608)	Representative
	90%		MICS Pakistan 2011	Regional (n=56,863) Punjab region	Representative
Sri Lanka	97%	Households with water source on premises or within 500m of the dwelling	Preliminary report - Household Income and Expenditure Survey Sri Lanka 2012	National (n=3,475)	Not Representative
	95%		Household Income and Expenditure Survey Sri Lanka 2009	National (n=12,949)	Representative

In addition to the systematic data collected above, sporadic data from Afghanistan, Bangladesh and India, were collected on the average time (minutes per roundtrip) for a households to fetch water (Table 17). In Afghanistan, on average households spend of 14 minutes to travel to and from the primary source (not including any waiting time). In comparison, secondary data from Bangladesh calculates round trip travel time at 13 minutes – over three times as long as the 4 minutes travel time found in primary data collection – and only one minute less than in Afghanistan.

Representative findings from Andhra Pradesh state in India calculate that on average households only take 6 minutes to fetch water from the source, considerably less that other secondary findings, but consistent with primary findings in Bangladesh and Pakistan.

Table 17 Average time to source round trip (minutes)

	Data		Notes		
	Value	**Indicator definition**	**Data source**	**Scope**	**Representative ness of scope**
Afghanistan	14	The mean time for rural household to reach and return from the water point. **Does not include waiting times**	National risk and vulnerability assessment Afghanistan 2012	National (n= not disaggregated for rural areas)	Representative
Bangladesh	13	The mean time for rural household to reach and return from the water point. **Including waiting times**	MICS Bangladesh 2006	National (n=44,797)	Representative
India	6		WASHCost (India)	State/Regional (n=5,242)	Representative

5.4.2 Water quantity used

In secondary literature, the quantity of water used by households is generally reported in one of two ways: either as an average of water quantity per capita per day; or some kind of measure of household satisfaction with the quantity of water they receive. Representative data on water quantity was available from household's surveys in India, Nepal and Sri Lanka – however there is limited opportunities for direct comparison between these studies.

WASHCost India was the only secondary data source identified which reports on the average water consumption per person per day. The average consumption of 45 LPCD in Andhra Pradesh state and was between two to four time higher than primary data values in Bangladesh and Pakistan - however is important to bear in mind that the Indian study included water sources at household level, whereas water quantity was only calculated for non-household sources in the primary analysis. Similarly an SNV study in three districts of rural Nepal reported that the vast majority (96%) of rural households achieved the 20 LPCD standard.

In Karnataka state in India 88% of households are fully or partially satisfied with the water quantity they are receiving, while in Sri Lanka 92% of household's state they have sufficient water for drinking, and 87% state they have sufficient water for bathing and washing.

Table 18 Secondary data on the quantity of water accessed by households

	Data		Notes		
	Value	**Indicator definition**	**Data source**	**Scope**	**Representativeness of scope**
Water quantity					

India	45	Mean water consumption (LPCD) from improved water source for all domestic purposes	WASHCost (India)	State/Regional (n=5,252)	Representative
Nepal	96%	% of households where users access 20 liters or more per capita per day	SNV Nepal 2014	District level	Not representative
Household satisfaction with water quantity					
India	88%	% of households that are fully satisfied with the quantity of water they are receiving	ASWAS 2009	State/Regional (n=17,200)	Representative
Sri Lanka	92%	% of households who have sufficient (not defined) access to drinking water	Household Income and Expenditure Survey Sri Lanka 2009	National (n=12,949)	Representative
	87%	% of households who have sufficient (not defined) access for bathing/washing			Representative

5.4.3 Water quality

Assessment of actual water quality is challenging due to both the technical constraints of sampling and managing tests in the field, and to the fact that the quality of water at a source may vary significantly on monthly, weekly, daily or even hourly basis due to variations in climate and usage. The perceptions of users can be used in tandem with water quality testing to give an indication of some aspects of water quality. The perceptions of users, while subjective, are important because they are one of the determinants of usage levels. Standards for water testing are usually based on national norms which can vary between countries.

Whereas primary data collection focussed on household perception of water quality, most available secondary data reported water quality testing results (Table 19), and only two studies, both from India, report household perceptions of water quality (Table 20). The data collected provides proxies for water taste and salinity; such as Total Dissolved Solids (TDS) and Electrical Conductivity (EC) as well as key indicators of water safety such as arsenic, fluoride and bacterial contamination (e.g. E-coli). Available indicators on Nitrate, Sulphate, Boron, Sulphur, and Manganese excluded.

Overall the picture emerging of water quality across South Asia demonstrates that a large proportion of water quality samples are not meeting standards associated with taste, salinity and most strikingly bacteriological contamination. Arsenic contamination (measured against various threshold values – most of which are less stringent than WHO guidelines) is found in all countries where it has been tested.

Starting with the proxies of taste and salinity as they are most comparable with the primary data collected. Testing in Afghanistan and Pakistan demonstrated that between a quarter to a third of water points are found to be failing quality standards for TDS and EC. Furthermore in Pakistan 14% of rural water points are found to have unacceptable levels of turbidity – which may negatively affect user's perception of water quality.

Turning to Arsenic contamination a recent study in Bangladesh found that 7% of water points do not meet the national standard of less than 50 µg/L. These proportions have fallen in recent years as deep tube-wells have begun to dominate in Arsenic affected areas. Results from Afghanistan suggest a more widespread problem with 58% of samples not meeting a more strict arsenic threshold of less than 20 µg/L – although this is drawn from a small sample. In Karnataka state in India 60% of water points exceeded the Bureau of India standard for permissible fluoride of 1 part per million, however this standard is stringent in comparison with WHO guidelines which state that fluoride concentration of up to 1.5 mg/l are acceptable and that serious health consequences are more likely beyond 10 mg/l (WHO, 2006).

The most consistently problematic water quality indicator identified in the secondary data was bacteriological contamination. Large scale testing results from Bangladesh, India, and Pakistan show that bacterial contamination, most likely measured in terms of the presence of e-coli coliforms although this is not always stated, affects around quarter of water points in Bangladesh (24%), rising to 38% in Karnataka state, and nearly two-thirds (64%) of rural water points in Pakistan.

Table 19 Percentage of water samples failing defined water quality standards

	Data		Notes		
Country	**% of samples not meeting standards**	**Indicator definition**	**Data source**	**Scope**	**Representativeness of scope**
Afghanistan	Arsenic - 58% EC - 30%	Arsenic - <20 µg/L Electrical conductivity - <1500 µS/cm	DACAAR 2013	National - Electrical conductivity (n=23,800) - Arsenic (n=348)	Administrative data – methodology not specified
Bangladesh	Arsenic - 7% E-coli - 24%	Arsenic - <50 µg/L E-coli threshold - >10 cfu	Ravenscroft et al., 2014	National - arsenic analysis (n=4,551) - E-coli analysis (n=1,032)	Representative with independent quality control for 10% of samples
India	Fluoride - 60% Bacteriological contamination - 38%	Fluoride threshold - <1000 µg/L Bacteriological contamination - not defined	ASWAS 2009	State/Regional (n= not stated[41])	Unknown
Nepal	Arsenic - 2%	Nepal standard for Arsenic (<50 µg/L)	Thakur et al., 2010	Multi-regional (n=737,009)	Representative
	Arsenic - 8%	WHO standard for Arsenic (<10 µg/L)			
Maldives	Faecal coliforms + sanitary safety - 58%	Water quality assessed according to presence of any faecal coliforms and a composite sanitary hazard score	Bathiban et al., 2012	Other: Samples drawn for 7 study islands with known water quality issues (n= 173)	Not Representative
Pakistan	Bacteriological contamination - 64% TDS - 25% Turbidity - 14% Fluoride - 7% Arsenic - 1%	Threshold standards not stated	Tahir et.al., 2014	National (n = 14,000)	Representative

[41] The sampling strategy states that between 10 and 40 water quality tests were conducted across 172 sites therefore range of possible data points are: min (n=1,720); max (n=6,880)

Two state-wide studies in India – using slightly different definitions - suggest that between 66% and 85% of households are satisfied with their water quality.

Table 20 Percentage of households that are satisfied with the perceived quality of water they receive

	Data		Notes		
	Value	Indicator definition	Data source	Scope	Representativeness of scope
India	66%	% of households satisfied with water quality according to a composite QIS score	WASHCost India	State/Regional (n=5,242)	Representative
	85%	% households that are fully or partially satisfied with the quality of water they are receiving	ASWAS 2009	State/Regional (n=17,200)	Representative

Summary of water service levels

The high density of water supply infrastructure in much of rural South Asia means that for most households water collection times are well below 30 mins per round trip and also that a high proportion of the population access an acceptable quantity of water according to WHO guideline standards. The exception to this summary is Afghanistan where household water services are much worse than elsewhere in South Asia.

6 Findings on sanitation – primary and secondary data

An additional evaluation has also been taken of indicators of operational sustainability in rural sanitation. Relevant indicators of operational sustainability have been explored in reference to the sanitation conceptual framework, as set out in section 1.5. Due to the scarcity of secondary data sources this section of the report presents the primary and secondary data related to sanitation together.

In terms of secondary data, information on usage, durability, cleanliness and functionality are all drawn from stand-alone pieces or research and project monitoring, meaning that there are currently no reliable cross-country datasets for comparing these indicators. This is in due – in part - to the costs of obtaining the data to the granularity required, a lack of agreed methodologies and the sensitivity of the results to the methodology used.

6.1 Day-to-day performance of sanitation facilities

From the household perspective the day-to-day effective service of a sanitation facility is assess according to household usage by different family members. Sanitation facility 'functionality' is assessed according to the number of hours the sanitation facility is available.

6.1.1 Primary data

Our household survey assessed household sanitation practices for different household members while they are at home, and while they're at their workplace or school.

Addressing home based practices first, in Bangladesh on average, around 52% of adults (men and women) were reported to be using the sanitation facility inside the household compound, while 42% reported using a facility outside the household compound. Open defecation (OD) is practiced by, on average, 5% of adults, primarily outside of the household compound. A similar trend is observed for children between 3 and 14 years to age. OD is highly common for children under 3 years of age: 70% practice OD inside the household compound and 16% practice OD outside the household compound. In contrast sanitary practices in Pakistan are much more polarised. Findings show that a higher proportion of female, male and child household members are using sanitation facilities inside the household as compared to Bangladesh. However almost all those that do not use a household facility revert to open defecation, whereas in Bangladesh the use of a neighbours/public facility is much more common.

Table 21 Sanitation practices while at home by population group

Population group	Sanitation facility inside the HH compound (%)	Sanitation facility outside the HH compound (%)	OD inside the HH compound (%)	OD outside the HH compound (%)	Total	N
Bangladesh						
Adult women (over 15 years of age)	53.5	41.3	0.3	4.9	**100**	1,150
Adult men (over 15 years of age)	51.4	43.4	0.1	5.2	**100**	1,052
Children (9-14 years of age)	53.1	41.4	0.2	5.2	**100**	557
Children (3-8 years of age)	53.7	35	4.4	6.9	**100**	547
Children under 3 years of age	11.8	2.1	69.9	16.1	**100**	260
Pakistan						
Adult women (over 15 years of age)	62.7	2.2	3.8	31.3	**100**	1,177
Adult men (over 15 years of age)	58.8	1.8	1.3	38.1	**100**	1,145
Children (9-14 years of age)	59.8	1.5	3.5	35.2	**100**	670
Children (3-8 years of age)	55.7	3.4	4.6	36.3	**100**	719
Children under 3 years of age	36.4	7.8	35.9	19.9	**100**	510

Away from the household pronounced differences can be seen between the actions of women, men, and children. In Bangladesh the majority of adult women who work, reported using a sanitation facility inside or outside their workplace (93%).Although the majority of adult man also reported using a facility outside or inside their workplace (71%), the remaining 29% practice OD, mainly outside of their workplace. The practice of OD among children aged between 3-14 years while at school is quite small (around 2%), with the majority of them using a sanitation facility inside the school (around 80%). In Pakistan open defecation is significantly more common, particularly amongst adult women and men, than in Bangladesh, for example whereas in Bangladesh only 7% of women openly defecate away from the home, in Pakistan this figure is well over 70%. This reason for such a difference does not seem to be due to any difference in the type of work done in Bangladesh and Pakistan as in both cases around 20% of adults work in agriculture, 30%-40% in domestic labour, and around 5%-20% in skilled and unskilled manual labour.

These data give the impression that community-led total sanitation interventions in Bangladesh have been effective at changing social norms and creating pressure for individuals *not* to practice OD at any time. Where possible both adults and children appear to prefer to use neighbours' toilets and toilets and schools and workplaces (whose quality is unknown) rather than defecate in the open. Having said that, working men clearly still practice open defecation in significant numbers, and may feel less social pressure, or they may more commonly be working in environments where toilets are not available (in farm fields for example). By contrast with Bangladesh, in Pakistan, the presence of a toilet in the house appears to be highly significant in reducing open defecation. This may in part be due to social norms which preclude the use of a neighbours' toilet and may also reflect geographical and demographic context; the social pressure not to practice open defecation may be less where there is less crowding and more space.

Table 22 Sanitation practices away from the home by population group

Population group	Sanitation facility inside the workplace/school (%)	Sanitation facility outside the workplace/school (%)	OD inside the workplace/school (%)	OD outside the workplace/school (%)	Total	N
Bangladesh						
Adult women (over 15 years of age)	79	13.9	n. d	7	**100**	137
Adult men (over 15 years of age)	28.4	42.6	5.3	23.6	**100**	990
Children (9-14 years of age)	82	16.9	n. d	1.1	**100**	535
Children (3-8 years of age)	79.2	18.3	1	1.5	**100**	398
Pakistan						
Adult women (over 15 years of age)	22.4	1.5	7.1	68.9	**100**	499
Adult men (over 15 years of age)	29	2.3	7	61.6	**100**	1,074
Children (9-14 years of age)	65.4	0.7	4.3	29.7	**100**	569
Children (3-8 years of age)	60.7	1.1	4.8	33.4	**100**	492

6.1.2 Secondary data

The status of sanitation facility use across South Asia are summarised in Table 23. Where there are data for sanitation facility usage the definitions used vary widely. In the only two national representative surveys (GoN (2011) and GoI (2011)) facility usage was self-reported. In both cases self-reported usage was high; 98% and 88% in Nepal and India respectively. These values seem out of step with findings from smaller studies, notably the Sanitation Quality, Access, Use, and Trends (SQUAT) survey in India which deployed a more robust methodology but was focused on a specific region of the country.

In surveying facility use, subtle variations in the phrasing of questions can lead to varying results. In the GoI (2011) survey, households were asked if everyone in the household used a sanitation facility, on this indicator 67% of households responded positively opposed to the 88% who responded positively when asked if the sanitation facility was regularly used. Though not nationally representative; the SQUAT survey provides representative state level data.

Table 23 Studies identified with survey data relating to sanitation facility usage

	Data		Notes		
Country	**Value**	**Indicator definition**	**Data source**	**Scope**	**Representative of scope**
Bangladesh	99%	Use of sanitation facility at any time (5 years after programme intervention)	Jacimovic et al. (2014)	Multi-regional (n=3,752) Restricted to BRAC WASH (I&II) programme areas	Representative
	93%	Use of sanitation facility at all times (including after heavy rain and flood) by household members 5 years after programme intervention			
	96%	Use of sanitation facility by some household members			
Nepal	97%	Use of sanitation facility (sampled from those HHs with toilet)	SNV Nepal (2015)	Baseline of project areas (n=2,979)	Representative
	98%	Self-reported use of sanitation facility (sampled from those HHs with toilet)	GoN (2011)	National (n= 532,916)	Representative
India	36%	HHs with a functional sanitation facility that has signs of use – end-line	Clasen et.al. (2014)	District (focussed on HHs in the intervention area)	Representative
	95%	Self-reported use of sanitation facility (sampled from those HHs with toilet)	Arghyam (2009) ASHWAS	Karnataka (n= 17,200)	Representative
	60%	All HH members use (sampled from those HHs with toilet)	SQUAT (2014)	Five states in Northern India (n=3,235)	Representative
	88%	Self-reported *regular* use of a sanitation facility	GoI (2011) NGP sustainability report	National (n=9,960)	Representative
	67%	HHs where everyone in the HH regularly uses the sanitation facility, self-reported			

Summary of day-to-day performance

Even amongst those households that do own a sanitation facility in India, credible studies have found that only between 36% and 60% of households are using the sanitation facilities. Moreover sanitation facility usage at different times seems to be a particular challenge. In Bangladesh and Pakistan for example facility usage by adults declines sharply when they are working away from the home, particularly in Pakistan. In contrast sanitation facility usage by children falls far less sharply when they are away from the home, likely reflecting the availability of School WASH facilities.

6.2 Month-to-month performance of sanitation facilities

The month-to-month performance of facilities is measured according to indicators of sanitation facility cleanliness, odour and ability and ease of emptying.

6.2.1 Primary data

Surveys in Bangladesh and Pakistan assessed sanitation facilities according to household ‘satisfaction’ with facility cleanliness. Findings show that a higher proportion of households in Pakistan are ‘satisfied’ or ‘very satisfied’ with their toilet cleanliness (83%) as compared to the 72% of household in Bangladesh. The proportion of ‘satisfied’ and ‘extremely dissatisfied’ households is very similar across both countries, the main divergence lies in the higher proportion of very ‘satisfied’ households in Pakistan, and the corresponding higher proportion of ‘dissatisfied’ households in Bangladesh.

Table 24 Satisfaction with the cleanliness of household sanitation facilities

	Bangladesh	Pakistan
Very satisfied	10%	21%
Satisfied	62%	62%
Dissatisfied	24%	12%
Extremely dissatisfied	4%	5%
Total	**100%**	**100%**

Note: Estimations were derived from the household surveys, referring to their usual perception of toilet cleanliness[42].

Primary data collection did not directly ask households or communities about the frequency or ease of pit emptying. Instead a number of proxy indicators provide insight into prevalence and requirements for pit emptying and faecal sludge management of facilities in rural Bangladesh and Pakistan. Table 25 Action taken when pit or tank filled up

	Bangladesh (n=542)	Pakistan (n=166)
Pit covered and dug new toilet	0%	5%
Pit covered and alternative pit	4%	2%
Pit emptied and waste removed	13%	38%
Pit emptied and waste buried	69%	7%
Pit emptied and waste dumped	7%	36%
Others	7%	12%

Figure 20 shows that most toilets in rural Bangladesh and Pakistan are connected to septic tanks, single or double pits. The data indicates that approximately 62% of these toilets have filled up at any time in Bangladesh, compared to 26% of onsite latrines in Pakistan (Table 25). In both countries the re-siting of latrines when the pit becomes full is relatively rare; rather it is common for the pit to be emptied with waste either buried nearby (most common in Bangladesh) or removed to a location away from the household (most common in Pakistan). This sub-sample suggests that issues with waste ‘dumping’ is more of a problem in Pakistan as compared to Bangladesh.

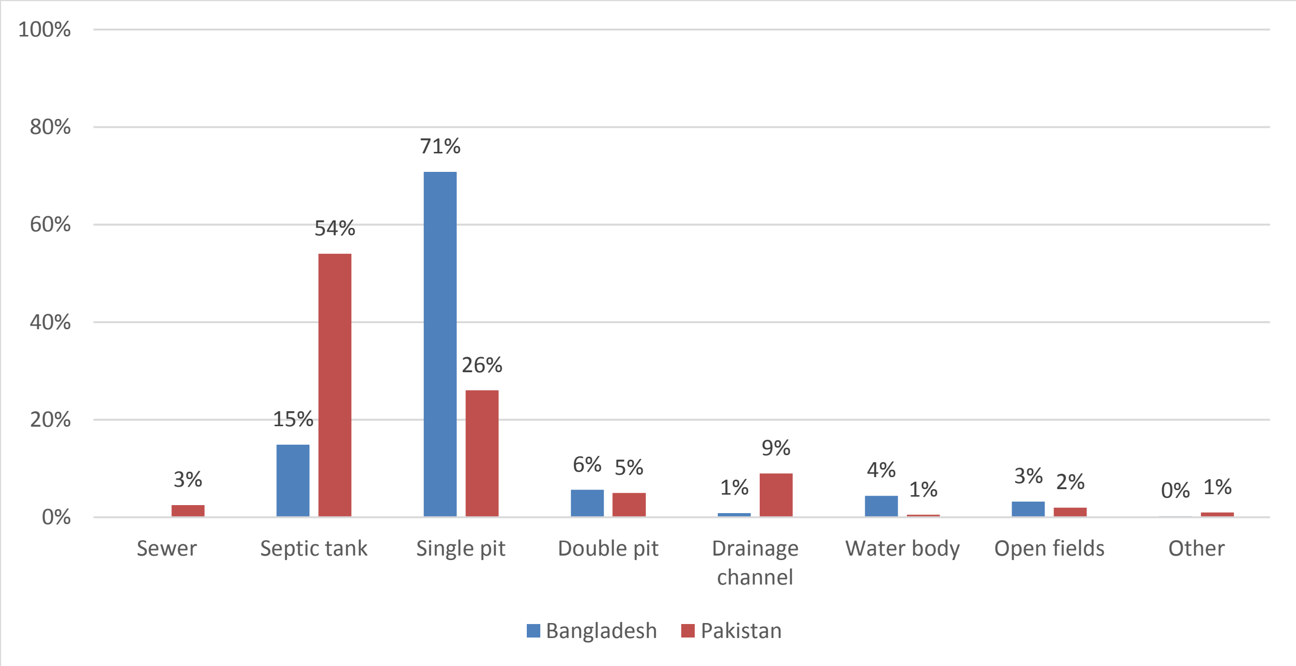
The recent upsurge in pit latrine construction in Bangladesh means that these results are likely to be relatively dynamic; as more household build facilities, an increasing number of toilets will require emptying and emptying practices are likely to be changing significantly. The practice of burying pit latrine waste beside the toilet may become less acceptable over time.

[42] Exact phrasing of the survey question: Please rate your satisfaction level with the cleanliness of your household latrine: Very satisfied / Satisfied / Dissatisfied/ Extremely dissatisfied / Don’t know.

Table 25 Action taken when pit or tank filled up

	Bangladesh (n=542)	Pakistan (n=166)
Pit covered and dug new toilet	0%	5%
Pit covered and alternative pit	4%	2%
Pit emptied and waste removed	13%	38%
Pit emptied and waste buried	69%	7%
Pit emptied and waste dumped	7%	36%
Others	7%	12%

Figure 20 Sanitation facility discharge



No of households: Bangladesh = 992; Pakistan = 756

6.2.2 Secondary data

As with use there is not a clear sector agreed measure of cleanliness. Most of the studies identified relied on observation of what the researchers defined as a measure of cleanliness. This is captured in the difference between 'hygienic sanitation facilities' and 'clean sanitation facilities' in the WSP (2011) study. Here the GoB's definition of a hygienic latrine is on based on the characteristics of the latrine and if it able to break faecal transition pathways, whereas the cleanliness was taken only to be the absences of faecal matter. For the purposes of this assessment cleanliness indicators were taken to be those which relate to the state of the sanitation facility at the time of observation and are predominantly linked to the presence of faecal matter.

On this measure there is some data with which to compare across countries though the data for Bangladesh is drawn from non-randomly sampled areas. In two nationally representative surveys in India and Nepal 12% of sanitation facilities were found to have visible faecal matter. This is in contrast to Bangladesh where 56% had visible faecal matter. The interpretation of these indicators is not immediately clear, especially with reference to the breaking of faecal disease transmission pathways. The presence of faecal matter is commonly used in checklists as an indicator of use, the indicators listed above give no indication of the quantity of faecal matter. In the Patil et al., (2014) and WSP (2009-2011) studies the indicator is expanded to cover the household and surrounding areas, with correspondingly higher reported rates of faecal contamination of; 40% and 60% respectively.

Table 26 Studies identified with indicators for cleanliness

	Data		Notes		
Country	**Value**	**Indicator definition**	**Data source**	**Scope**	**Representative of scope**
Bangladesh	83%	Number of Hygienic sanitation facilities (as per GoB's 2010 definition)	Hanchett et. al., (2011)	53 of 481 Union Parishads, Rural (only ODF areas surveyed)	Representative
	44%	Number of sanitation facilities found to be 'clean' (No visible faecal matter)			
	~75%	Number of Hygienic sanitation facilities (faecal separation, fly proof, and little smell)	Evans et al., (2009)	12 purposely sampled WaterAid intervention communities	Not representative
Nepal	88%	Clean toilets (sampled from those HHs with toilets)	GoN (2011)	National (n= 532,916)	Representative
	77%	Number of Hygienic sanitation facilities (faecal separation, fly proof, and little smell)	Evans et al., (2009)	4 purposely sampled WaterAid intervention communities	Not representative
India	40%	No visible faeces - human or animal -around the home	WSP (2009-2011)	Madhya Pradesh (n=2,000)	Unknown
	40%	No faeces in observed in living area around HH - 2011 endline	Patil et.al. (2014)	RCT in two district in Madhya Pradesh	Representative
	88%	No visible faecal matter in the sanitation facility (sample is HHs with a toilet)	GoI (2011) NGP sustainability report	National (n=9960)	Representative

Summary of month-to-month performance

Primary data on month-to-month performance from Bangladesh and Pakistan shows that household's satisfaction with sanitation facility privacy and cleanliness is quite high at around 70% to 80% – likely encouraging ongoing usage, maintenance and emptying of the toilets. In contrast secondary data from Bangladesh and India suggest that over half of toilets are not perceived to be clean. More secondary data is needed for other countries to better understand these medium- and long-term dimensions of sanitation facility functionality and how it interacts with the households' experience of service.

6.3 Multi-year performance

6.3.1 Primary data

Primary observation data was also collected on the specific toilet characteristics including the type of superstructure materials used, the presence of a roof, and whether the slab was cleanable. Together these indicators have been used to create a composite assessment of sanitation facility durability as laid out in Table 27 below. Findings show that only a small proportion of facilities – 12% for Bangladesh and 10% for Pakistan – were built to a standard which does not meet the JMP 'improved' criteria (Table 27). This is not surprising given our data on sanitation facility types shown earlier in Section 3. However, there is a big difference between sanitation facility durability at the "high" end. 75% of toilets in Pakistan are "strong" improved, defined as per the table below, whereas only 20% of those in Bangladesh are. In short, many toilets in Bangladesh which are "improved" by the JMP definition have a non-durable superstructure (or are missing certain key characteristics such as a roof or privacy, but this was only the case for a small proportion). In summary, not all improved facilities are equal – improved facilities in Pakistan are most likely to be higher quality than those in Bangladesh.

Table 27 Sanitation facility durability

	Definition	Bangladesh	Pakistan
Very basic	Non-durable superstructure without water seal / cleanable slab	10%	2%
Basic	Durable superstructure without water seal / cleanable slab	2%	8%
Weak improved	Non-durable superstructure with cleanable slab / cleanable slab & water seal	68%	15%
Strong improved	Durable superstructure with cleanable slab, roof & privacy / same + water seal	20%	75%
Total		**100%**	**100%**

Note: This table only includes data for functioning toilets. Estimations were based on observation by enumerators[43]

6.3.2 Secondary data

To date no large scale assessments of the years of sanitation facility service, or appropriate proxies, have been identified in South Asia.

[43] The enumerator asked to see the functioning toilet of the household. The enumerator then recorded the answers to the following questions, based on observations: (i) Does it have a water seal? (ii) Does it have a cleanable slab? (iii) What is the material of the superstructure? (iv) Does the toilet have a roof? (v) Does it have a curtain, door or other materials that provides privacy? (vi) Are anal cleansing materials present in the toilet (e.g. water/ sponge/ toilet roll)?

6.4 Sanitation service levels

The primary data collected on the sanitation service levels is limited to user perceptions of the ease of access they have to their sanitation facility, and the level of privacy it provides (Table 28). In Pakistan, the vast majority of households are satisfied or very satisfied with the ease of access they have to facilities (90%) as well as the privacy the facility provides (84%). The corresponding values in Bangladesh are markedly lower with 73% satisfied with sanitation facility access and 69% satisfied with privacy.

Table 28 Satisfaction with ease and access and privacy of sanitation facilities

	Bangladesh	Pakistan
Ease of access		
Very satisfied	10%	25%
Satisfied	63%	65%
Dissatisfied	25%	8%
Extremely dissatisfied	3%	2%
Privacy		
Very satisfied	11%	26%
Satisfied	58%	58%
Dissatisfied	25%	14%
Extremely dissatisfied	5%	3%

Note: Estimations were derived from household surveys referring to usual perception of the ease and privacy of access[44]

[44] Exact phrasing of the survey question: Please rate your satisfaction level with the ease of access and privacy of your household latrine: Very satisfied / Satisfied / Dissatisfied/ Extremely dissatisfied / Don't know

7 Synthesis

7.1 The operational sustainability of rural water services

7.1.1 Bangladesh and Pakistan

VFM-WASH primary research collected detailed, but not comprehensive, information on operational sustainability indicators in both Bangladesh and Pakistan. This data informs our understanding of household's experience of 'effective' water services over time, alongside the 'operational' service (in terms of the functionality) provided by individual community water points. For definitions of these terms, refer back to the conceptual framework in section 1.3.

The synthesis of both these elements of operational sustainability are presented in Figure 21 and Figure 22. These show a synthesis of primary data for Bangladesh and Pakistan respectively, laid out as per the conceptual framework for operational sustainability. In this primary analysis the 'effective service' findings only refer to the household experience of using the *main* household water point. Findings for 'operational service' in this case reflect all public improved water points listed by the community. The analysis of secondary data includes indicators for all rural water points unless expressly stated.

Figure 21 Operational sustainability of rural water services in Bangladesh (primary data)

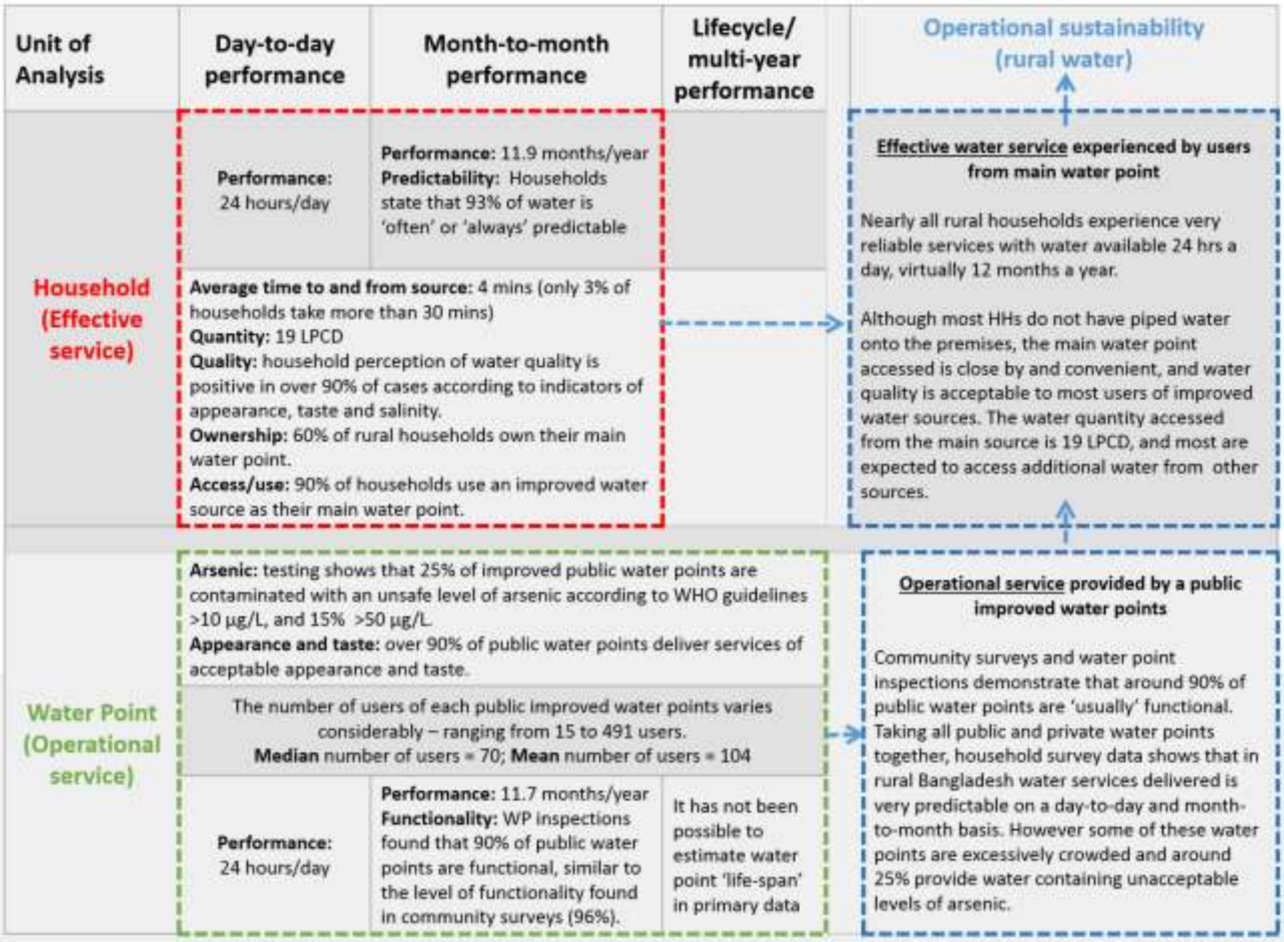
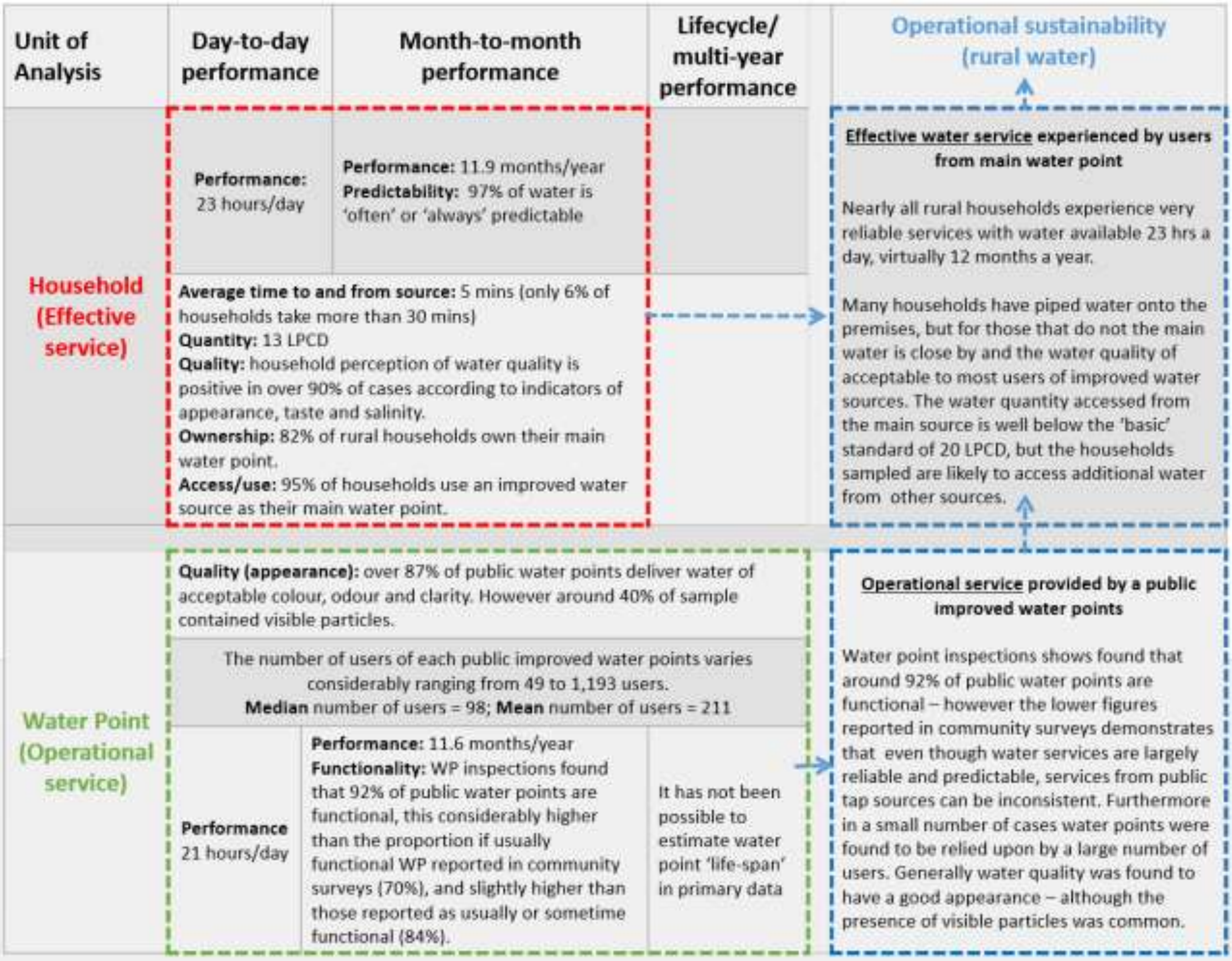


Figure 22 Operational sustainability of rural water services in Pakistan (primary data)



Effective service

Across both countries nearly all rural households are receiving a reliable service from their main water point, with water services usually available between 23 and 24 hours a days, virtually 12 months a year. These positive household experiences are found to be broadly similar across all wealth quintiles, although the seasonal and monthly performance are shown to be more varied for the small number of households using unimproved sources.

It is also striking to note that the high levels of reliability are also being achieved by the 41% of households in rural Pakistan accessing a piped water point in their dwelling or compound. What should be emphasised here is that we considered the water point not the water source (see glossary). It is relatively common in some parts of rural Pakistan to have a protected well (on or off-plot), from which water is pumped to a tank or tap using an electric pump. For the purposes of our survey, this would be "piped into yard/plot", since the water is available on demand from a tap right next to the dwelling. Nevertheless this data is particularly surprising given the regular power cuts common to rural Pakistan.

The water services which households receive is also shown to be acceptable to users. In both countries the majority of rural households can access water from sources which are inside are very close to the dwelling, from a source that they own, and receive water that they perceive to be of an acceptable quality. However, it is worth noting that microbial water quality at the point of use in rural South Asia is often lower than households perceive it to be.

In both Bangladesh and Pakistan, most households are not able to access an acceptable quantity of water with recorded consumptions levels at or just above half the World Health Organisation (WHO) guideline amount of 20 LPCD for basic consumption hygiene needs. In both cases it is probable that per capita water consumption will be much higher than the values quoted here if consumption from all rural water points was accounted for. We are also not overly confident in the water volume data, and it is also worth noting that this data is only for households who left their plot to fetch water, thus represents only a small percentage of the sampled households in South Asian countries.

The high rates of water point ownership in both Bangladesh and Pakistan means that there is less reliance of community owned and managed water points compared to some other countries in South Asia. In this analysis insights into the 'operational service' of water points have come from the assessment of these community sources, as oppose to private household sources. 5% of households in Bangladesh and 7% of households in Pakistan use a public improved water point as their main water point; and only between 15% and 20% of households ever use public water points. This means that these findings are only indicative of overall operational service. In other words, private water points (not captured by our community survey) represent an important dimension of operational service in South Asia.

Operational service

Findings from community interviews indicate that public improved water points tend to provide fairly reliable water services. In Bangladesh 89% of these water points are usually functional, compared to the 70% found in Pakistan, if systems which are sometime functional are included these values rise to 96% and 84% respectively.

In both countries the number of users of each of these water points varies significantly, but it is clear that in some areas the demand on a single source may be excessively high resulting in increased queuing time and a reduction in per capita water consumption, and therefore increased likelihood of component failure. Assessments of the appearance and taste of water from these sources were generally acceptable. However in Bangladesh where arsenic testing was undertaken around one quarter of samples exceeded WHO safety standards.

Overall operational sustainability

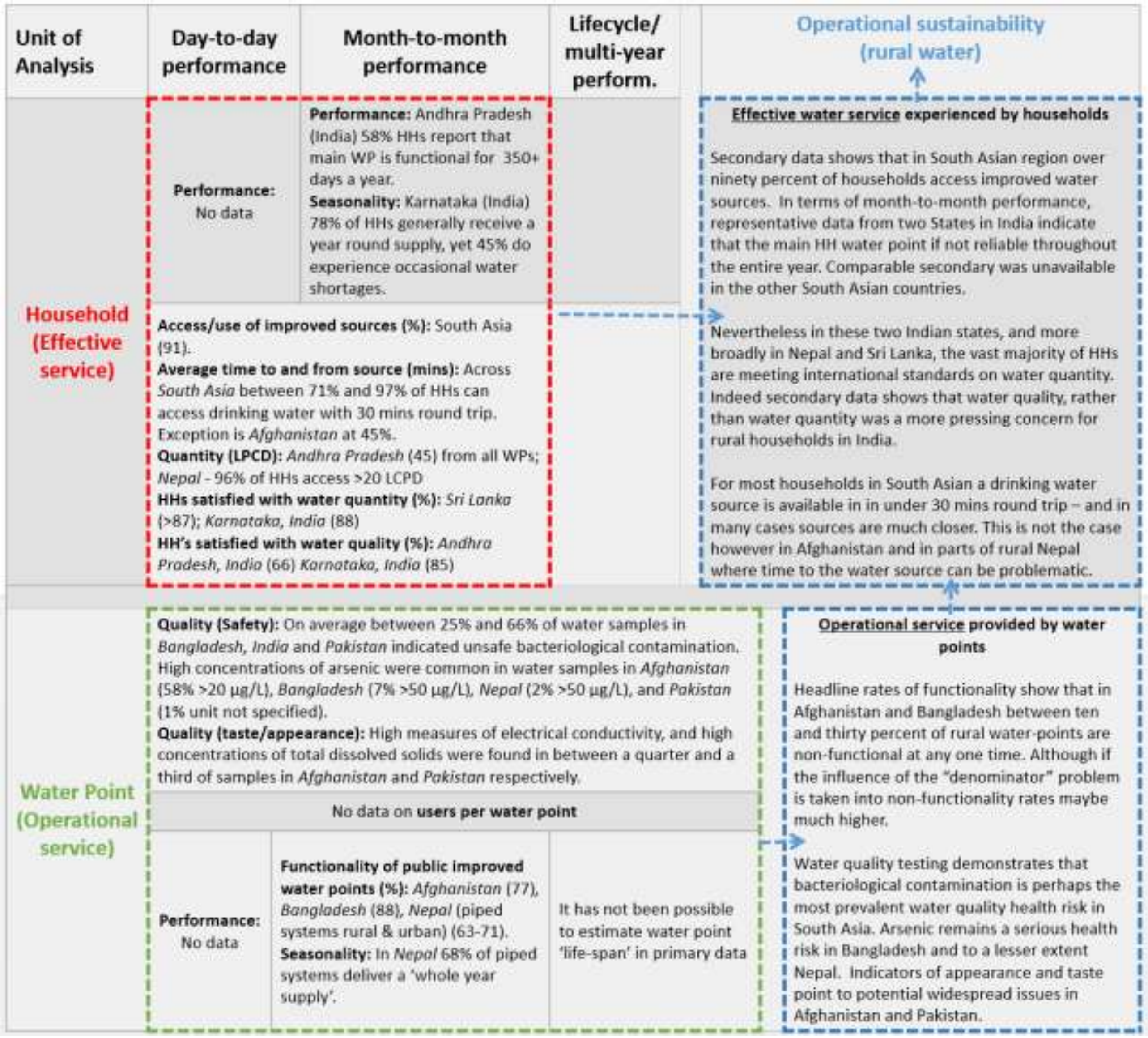
Taking all primary data together relative high operational and effective service suggesting that current prospects for ongoing operational sustainability are good, notwithstanding qualifications around microbial water quality which was not covered in primary data collection.

Nevertheless it is also important to acknowledge that there remains small pockets in both countries where effective water services remain stubbornly low, with household access water containing high concentrations of arsenic; or where they are accessing a very crowded source.

7.1.2 South Asian region

The regional findings on operational sustainability in South Asia are presented in Figure 23. This is for secondary data only – primary data is incorporated in a later figure.

Figure 23 Operational sustainability of rural water services in South Asia (secondary data)



Effective and operational service

At present, no secondary data has been found on the day-to day performance of rural water points from either a household or technical perspective. There are some understandable reasons for this. Firstly, day-to-day performance is generally more of an issue with networked schemes, which are not particularly common in rural areas of South Asia. Secondly, the focus of rural water policy for point sources such as wells or boreholes has generally been on binary functionality, rather than any ongoing assessment of performance.

On issues of month-to-month and seasonal performance secondary data is patchy and many different indicators have been used. The large Bangladesh dataset suggests that 71% of wells are still functional in the dry season (Ravenscroft et al., 2014). The WASHCost India data suggests that there might be a bigger problem in those Andhra Pradesh, with only 58% of households reporting that their WP is functional more than 350 days per year. The difficulty with these datasets is separating out trends related to seasonal water availability and groundwater levels from outages related to mechanical or financial issues.

Focussing on functionality – the interrogation of secondary sources indicates that there are many uncertainties inherent in estimating mean functionality (in terms of definitions, data collection frame and the “denominator problem"). Certainly it is not possible to come up with a point estimate for South Asia in the absence of data for so many large countries. What we can say is that functionality in the four most comparable datasets tends to be between 77-90%. To some extent, this tallies with prevailing theories in the sector, and the results may not be that surprising (as would be the case with mean functionality of 50% or 95%).

Considering the data from Bangladesh and Afghanistan comparing functionality by age, the main conclusion to be drawn is that functionality declines over time, up to 5-10 years. After that, the "denominator problem" appears to intervene, and the trend is blurred. This is mirrored in the data we have for Africa. In Afghanistan we have the arguably perverse result that water points over 12 years old are more likely to be functional than those between 8-10 years old. There are a number of factors at play here, and it would be unwise to place too much weight on a dataset where the key turning points intercede with periods of war, regime change and increased aid-backed investment in the sector. Nonetheless, the fact that we see the perceived "denominator problem" across so many different countries means that it is an issue which requires further scrutiny.

Service levels

The overall picture of long-term operational sustainability from the household experience perspective is that service levels are largely acceptable. Secondary data from Nepal, India and Sri Lanka, shows that around 90% of households report that they are satisfied with the quantity or “sufficiency” of water they receive. It seems clear that in general are not facing water quantity problems, since such a high proportion in the region have on-plot supply or have a short round-trip to collect water. Similarly from the household perspective water quality seems to acceptable, although water quality issues show that bacteriological contamination may pose a serious threat to health across South Asia, localised issues with Arsenic are clearly still a major concern in parts of Bangladesh and Nepal.

Collating primary and secondary data

The primary and secondary data is summarised together in Figure 24, and presented in table form in Table 29. From the data available we can see that data for service delivery in the sector stems predominantly from household surveys, which usually focus on the degree of access to and usage of water points, rather than incorporating the perspective of service users and aspects of day-to-day and longer-term performance.

Figure 24 Operational sustainability of rural water services in South Asia (primary and secondary data)

Unit of Analysis	Day-to-day performance	Month-to-month performance	Lifecycle/ multi-year perform.	Operational sustainability (rural water)
Household (Effective service)	**Performance (hours/day):** *Bangladesh* (24) *Pakistan* (23)	**Performance (months/year)**: *Bangladesh (*11.9), *Pakistan* (11.9) *Andhra Pradesh (India)* – 58% of HHs' main WP is functional for 350+ days a year. **Seasonality:** *Bangladesh/Pakistan* – Water is 'often' or 'always' predictable for between 93% and 97% of HHs. *Karnataka state, India* – 78% of HHs generally receive a year round supply.		**Effective water service experienced by households** In South Asia over ninety percent of rural households access and use improved water sources. Moreover this infrastructure tends to provide households with very reliable water services on a day to day and month to month basis (according to primary data from Bangladesh and Pakistan), although issues with seasonality are found in India. The high density of water supply infrastructure in rural areas means that for most households in South Asian water collection times are well below 30 mins per round trip; and that a high proportion of the population access an acceptable quantity of water. The exception to this summary is Afghanistan where HH water services are the worst, by far, in S. Asia.
	Access/use of improved sources (%): South Asia (91). **Average time to and from source (mins):** Bangladesh (4), Pakistan (5). Across *South Asia* between 71% and 97% of HHs can access drinking water with 30 mins round trip. Exception is *Afghanistan* at 45%. **Quantity (LPCD):** *Bangladesh* (19), *Pakistan* (13) from main WP; *Andhra Pradesh* (45) from all WPs; *Nepal* - 96% of HHs access >20 LCPD **HHs satisfied with water quantity (%):** *Sri Lanka* (>87); *Karnataka, India* (88) **HH's satisfied with water quality (%):** *Bangladesh* (>90); *Pakistan* (>90), *Andhra Pradesh, India* (66) *Karnataka, India* (85) **Private WP ownership (%):** *Bangladesh* (60); *Pakistan* (82)			
Water Point (Operational service)	**Quality (Safety):** On average between 25% and 66% of water samples in *Bangladesh, India* and *Pakistan* indicated unsafe bacteriological contamination. High concentrations of arsenic were common in water samples in *Afghanistan* (58% >20 µg/L), *Bangladesh* (7% >50 µg/L), *Nepal* (2% >50 µg/L), and *Pakistan* (1% unit not specified). **Quality (taste/appearance):** High measures of electrical conductivity, and high concentrations of total dissolved solids were found in between a quarter and a third of samples in *Afghanistan* and *Pakistan* respectively.			**Operational service provided by water points** From the water point perspective, headline rates show that between 77% and 90% of rural point source systems are functional at any one time. Although the day-to-day and month to month reliability found in *Bangladesh and Pakistan* suggests that at least in some countries this down-time is short-lived. The main message of this data is that across most of S. Asia the most pressing concern should not be on infrastructure functionality but rather the safety of water being supplied, particularly in the face of high level of bacteriological and arsenic contamination.
	Users per improved public water point: *Bangladesh* (median 70; mean 104); *Pakistan* (median 98, mean 211)			
	Performance (hours/day): *Bangladesh* (24) *Pakistan* (21)	**Performance of public improved water points (months/year)**: *Bangladesh (*11.7), *Pakistan* (11.6) **Functionality of public improved water points (%):** *Afghanistan* (77), *Bangladesh* (88-96), *and Pakistan* (84). *Nepal* (piped systems rural & urban) (63-71). **Seasonality:** In *Nepal* 68% of piped systems deliver a 'whole year supply'.	It has not been possible to estimate water point 'life-span' in primary data	

Table 29 Summary of primary and secondary date on rural water services in South Asia

Period	Indicators used to guide primary and secondary data collection	Primary data		Secondary data*	
		Ban	Pak	*Other South Asian countries*	JMP regional average
Day-to-day performance	**Household experience:** Mean hours per day during which water is available from the main household water point	24	23	-	
	Water point perspective: Mean hours per day during which water is typically available from public improved water points	24	21	-	
Month –to-month performance	**Household experience:** Mean months per year during which water is usually available from the main water point	11.9	11.9	-	
	Household experience: % of households who state that water flows are "always" or "often" predictable from the main water point / do not experience significant seasonal water shortages throughout the year	93	97	Bangladesh: 45 Karnataka state, India: 55 Andhra Pradesh state, India: 58	
	Water point perspective: % public improved water points functional at time of inspection	90	92	Afghanistan: 77 Bangladesh: 88 Nepal: 62	
	Water point perspective: % public improved water points always of sometimes functional as reported by the community	96	84	-	
Water services levels	**Access - household perspective**				
	% households using an improved water point	-	-	-	91
	% households using an improved water point as main water point	90	95	-	
	% households that own their main water point	60	82	-	
	Mean time per round trip to fetch water from their main water point (mins)	4	5	Afghanistan: 14 Bangladesh: 13 Andhra Pradesh state, India: 6	
	% of households that access their main water point in less than a 30 minute round trip	-	-	Afghanistan: 45 Bangladesh: 96 India: 85 Nepal: 71 - 81 Pakistan: 90 - 94	
	Access – water point perspective				
	Median number of households using each public improved water point	70	98	-	
	Mean number of households using each public improved water point	104	211	-	
	Quantity - household perspective				
	The quantity of water accessed by water point type (LPCD)	19	13	Andhra Pradesh state, India: 45	
	Quality - household perspective				
	% of users satisfied with all perceptions of water taste and appearance	>90	>64	Andhra Pradesh state, India: 66 Karnataka state, India: 85	
	Quality – water point perspective				
	% of water samples failing water quality standards for:				
	Arsenic (%)	25	-	Afghanistan (>20 µg/L): 58 Bangladesh (>50 µg/L): 7 Nepal (>50 µg/L): 2 Pakistan (not specified): 1	
	Bacteriological contamination (%)	-	-	Bangladesh: 24 Karnataka state, India: 38 Pakistan: 64	
	Electrical conductivity (%)	-	-	Bangladesh: 30	
	Fluoride (%)	-	-	Karnataka state, India: 60 Pakistan: 7	
	Total dissolved solids (%)	-	-	Pakistan: 25	
	Turbidity (%)	-	-	Pakistan: 14	

(*) Note that the secondary data is not directly comparable amongst different countries, nor directly comparable with the primary data, as secondary studies used different methodologies and definitions for their indicators.

7.2 The operational sustainability of rural sanitation services

The primary and secondary findings relating to effective sanitation service indicate considerable regional differences within South Asia (Figure 25 summarises the primary data and Figure 26 combines it with the secondary data).

Together this data shows that effective sanitation services across South Asia are hampered by a lack of access – largely driven by high levels of open defecation in India. Even amongst those households that do own a sanitation facility in India, credible studies have found that only between 36% and 60% of households are using the toilet. Moreover sanitation facility usage at different times seems to be a particular challenge. In Bangladesh and Pakistan for example the sanitation facility usage by adults declines sharply when they are working away from the home, particularly in Pakistan. In contrast facility usage by children fall far less sharply when they are away from the home, likely reflecting the availability of School WASH facilities. These values suggest that sanitation and hygiene promotion initiatives in Pakistan have created sufficient pressure for individuals not to practice OD when a sanitation facility is present nearby, whereas the interventions in Bangladesh have been effective at changing social norms and creating pressure for individuals *not* to practice OD *at any time.*

Nonetheless usage is not only driven by the availability of sanitation facility infrastructure. The primary data highlights that household's satisfaction with facility privacy and cleanliness is quite high at around 70% to 80% – likely encouraging ongoing usage, maintenance and emptying of the sanitation facilities. In contrast secondary data from Bangladesh and India suggest that over half of facilities are unclean. More secondary data is needed for other countries to better understand these medium- and long-term dimensions of sanitation facility functionality and how it interacts with the households' experience of service.

Figure 25 Operational sustainability of rural sanitation services in Bangladesh and Pakistan (primary)

Unit of Analysis	Day-to-day performance	Month-to-month performance	Lifecycle/ multi-year perform.	Operational sustainability (rural sanitation)
Household (Effective service)	**Frequency of use by HH members (% men, % women, % children(9-14)):** Inside the home *Bangladesh* (95, 95, 95), *Pakistan* (61,65,61) Away from the home *Bangladesh* (71, 92, 99), *Pakistan* (31, 24, 66)	**Satisfaction with facility cleanliness (%):** *Bangladesh* (72), *Pakistan* (83)		**Effective sanitation service experienced by users)** Due to the much higher rates of open defection in Pakistan, the overall effective service experienced by households will be higher in Bangladesh. However of the households using a sanitation facility the effective service indicators of cleanliness, and ease of access are higher in Pakistan as compared to Bangladesh.
	Access/use of improved sanitation facilities (%): *Bangladesh* (89), *Pakistan* (59). **HH satisfied with access to their facility (%):** *Bangladesh* (72), *Pakistan* (83) **HH satisfied with the privacy of their facility (%):** *Bangladesh* (60), *Pakistan* (82)			
Sanitation facility (Operational service)	**Sanitation facility sharing:** The extent of facility sharing has yet to be quantified			**Operational service provided by the sanitation facility** Primary data on the operational service provided by sanitation facilities are weak. Indicative findings suggest that pit emptying and re-siting is more common in Bangladesh than Pakistan, conversely the facilities in tend to be more durable and maybe expected to have a longer operational life.
	Household size: *Bangladesh* (4.5), *Pakistan* (7.5). (based on household size across the entire sample).			
	Facility availability: No data	**Emptying (proxy of frequency of emptying):** 62% of HHs in Bangladesh and 26% of HHs in Pakistan with a pit or septic tank latrine have taken steps to empty it.	**Durability (proxy for service life):** 75% of faciliteis in Pakistan are 'strong improved' facilities compared to 20% in Bangladesh.	

Figure 26 Operational sustainability of rural sanitation services in South Asia (primary and secondary)

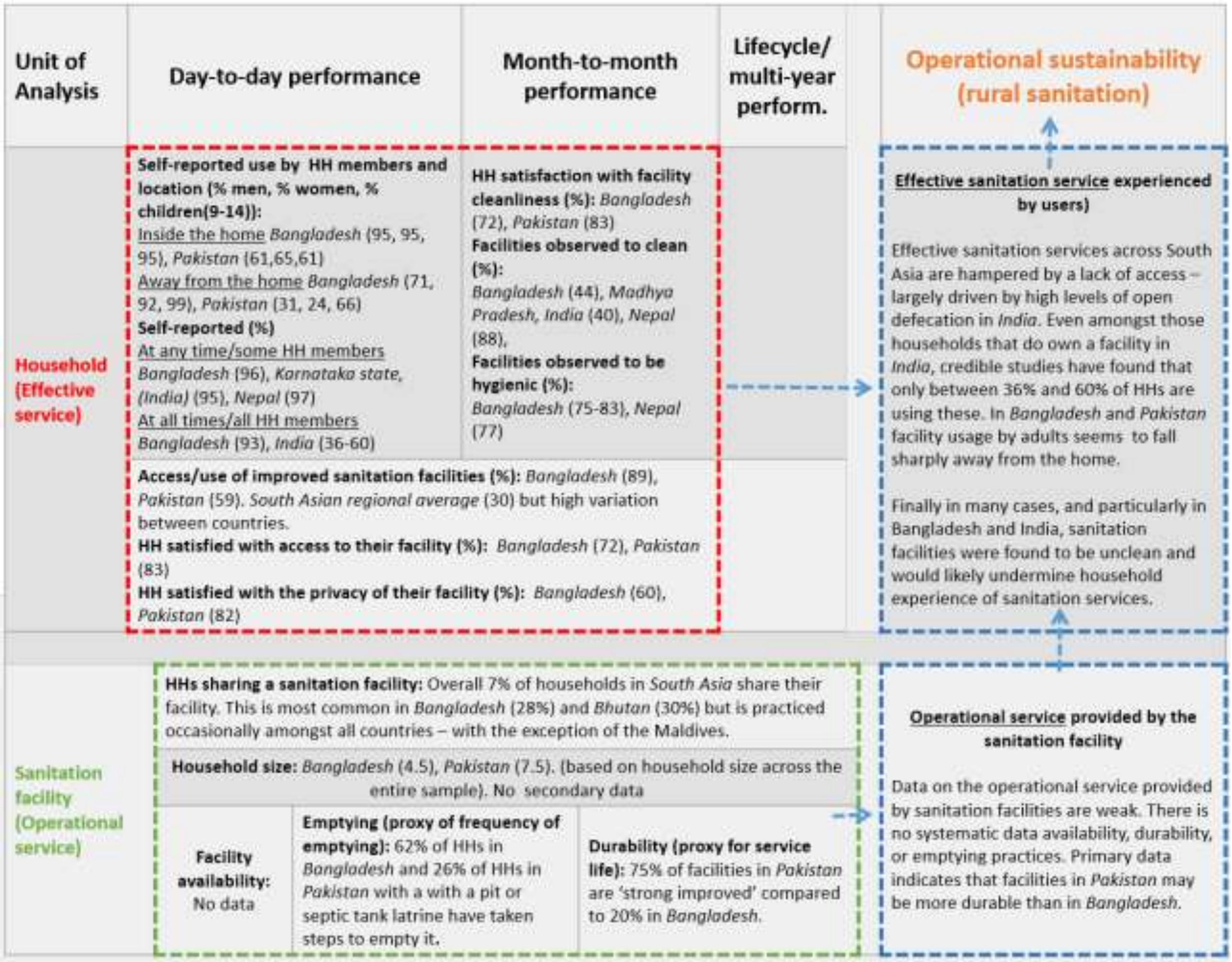


Table 30 Summary of primary and secondary data on rural sanitation services in South Asia

Period	Indicators used to guide primary and secondary data collection	Primary data		Secondary data*	
		Ban	Pak	*Other South Asian countries*	JMP regional average
Day-to-day performance	**Household perspective on sanitation use**				
	% of household members using a sanitation facility when at home (sample of all households)				
	Adult men	95	61	-	-
	Adult women	95	65	-	-
	Children (9-14 years of age)	95	61	-	-
	Children (3-8 years of age)	89	59	-	-
	% of all household members using a sanitation facility when away from the home (i.e. at work/school)				
	Adult men	71	31	-	-
	Adult women	92	24	-	-
	Children (9-14 years of age)	99	66	-	-
	Children (3-8 years of age)	97	62	-	-
	% of all households that are using their household sanitation facility (sampled from those households with a sanitation facility)	-	-	Bangladesh: 93-99 India: 60-95 Nepal: 97-98	-
Month-to-month performance	**Household experience:** % of households who state that they are "satisfied" or "very satisfied" with the cleanliness of their sanitation facility; secondary data is based on observations of cleanliness	72	83	Bangladesh: 44-83 India: 40-88 Nepal: 77-88	-
	Sanitation facility perspective: % of functioning sanitation facilities that are have a durable superstructure with cleanable slab, roof, privacy and a water seal	20	75	-	-
Sanitation service levels	% of households using an improved sanitation facility	86	59	-	30
	% of households using a shared or unimproved sanitation facility	10	8	-	16
	Household experience: % of households who state that they are "satisfied" or "very satisfied" with the ease of access they have to their sanitation facility	90	95	-	-
	Household experience: % of households who state that they are "satisfied" or "very satisfied" with the privacy of their sanitation facility	60	82	-	-

(*) Note that the secondary data is not directly comparable amongst different countries, nor directly comparable with the primary data, as secondary studies used different methodologies and definitions for their indicators.

8 Conclusions

This report reflects the **current 'state of knowledge'** operational sustainability of rural water and sanitation services in South Asia. It is based on primary data from our household surveys in two countries funded under this project (Bangladesh and Pakistan), and secondary data from a variety of sources. Rural water is the main focus of the analysis, although results findings have also been collated for rural sanitation.

Indicators of operational sustainability are organised around two key perspectives: the level of **effective water/sanitation service** understood as the household experience of service over time; and **operational service**, understood of as the functionality of water and sanitation systems over time. These functions represent the *outcome* of the financial, institutional, environmental; technical and social dimensions of a water or sanitation service. As such **operational sustainability will falter if any of these dimensions are not sustained.**

Findings across primary and secondary research demonstrated that overall household experiences of water and sanitation services were generally very positive. In terms of water - most households were able to access sufficient water, of an acceptable quality (from the household's perspective, rather than microbial quality), from a nearby water point. This water was available nearly 24 hours a day, for 12 months of the year. The notable exception from this Afghanistan where households access to water points is often very limited. This has important implications for policy. Since many households already experience a relatively high effective water service in some South Asian countries, investments and support to communities in those countries will need increasingly to focus on specific aspects of level of service; particularly water quality. In addition local government will need increasingly to focus investments in new water supplies on pockets of poor effective services (for example those areas where large numbers of households are still reliant on public shared facilities with consequent impact on the time taken to collect water, the reliability and quantity of water available.)

For sanitation data from across primary and secondary research has shown that household satisfaction with sanitation facilities is generally high, and is matched by seemingly high levels of sanitation facility usage over time. The key exception to this trend is India – where despite considerable advances in sanitation facility construction and coverage in the last 15 years there is increasing evidence of that demand for these services are not being maintained.

From the 'operational service' perspective, primary and secondary data is patchier – and consequently there remains a number key areas of uncertainty. This report has discussed the complexities of comparing cross-section functionality data at length and this remains a priority are for further research. Similar examination is also required of the functionality, emptying requirement, durability and expected service life of rural sanitation across South Asia.

The data on sanitation broadly indicate that targeted support would be needed in specific locations; for example in Bangladesh there is clearly a need to address open defecation of adult males when away from the home, and the issue of long term management of on-site sanitation is increasingly coming to the fore. In Pakistan, access to a private toilet inside the compound appears to have a strong effect on overall sanitation behaviours, suggesting that programming needs to be adapted to make this a focus of behaviour change interventions and sanitation marketing.

Overall this report highlights the need at both project and national level to examine the multiple dimensions of both water and sanitation services as they are experienced by households, in order to tailor interventions to generate real gains in effective service levels. The collection of reliable baseline data can usefully be shaped to populate the conceptual frameworks of operational sustainability of both water and sanitation, enabling the delivery and monitoring of real improvements in effective service experienced by households and communities.

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Annex A Overview of approach to secondary data collection

A.1 Inclusion criteria

The inclusion criteria for each indicator are reported under three headings (described below) and collated in Table 31 (for water), and Table 32 (for sanitation).

- **Study characteristics –** including features of research design; indicators collected; and type of publication.
- **Year of publication** – evidence belonging to which time period will be deemed fit for review; for instance are we looking at studies from the last 5 or 10 years, depending on the indicator.
- **Level of representativeness** – robustness of the sampling approach, whether data was collected to be representative at the district, state of national level, and whether the study has generalised applicability.

Alongside indicator-specific criteria, all studies include must have direct relevance to rural water and sanitation systems in relation to the following countries in South Asia: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka[45].

[45] There is a high degree of variation as to which countries are included in the South Asia region, with extended definitions variously including Iran and/or Tibet. We defined the boundaries of South Asia to the eight countries listed above, in line with the United Nations Statistics Division and the South Asia Association for Regional Cooperation (SAARC).

Table 31 Inclusion criteria per sustainability indicator (water)

Time -scale	Sustainability indicator	Inclusion criteria
Day-to-day (inter-day reliability))	Hours per day Days per month	*Study characteristics:* Any published or unpublished report dealing with any short-term indicators of rural system performance. *Time period:* Within last 10 years. *Level of representativeness:* Representative samples not required.
Month-to-month (inter-month functionality)	Functionality	*Study characteristics:* Water point mapping data, peer reviewed journal, or published grey literature report which including a technical assessment of system functionality. *Time period:* Updated within last 5 years. *Level of representativeness:* Nationally representative sample or large datasets defined as > 5,000 water points.
	Seasonality / continuity of service Predictability of service	*Characteristics:* Peer reviewed academic studies, or published grey literature reports assessing the seasonality or predictability of water services over a 12 month period. *Time period:* Within last 10 years *Level of representativeness:* Representative sample at national or regional/state level
Multi-year (sustainability of outcomes)	Outcomes (use of services) Time to source	*Characteristics:* Household survey data, or reports, recording the use and access to services according to JMP definitions *Time period:* Within last 10 years *Level of representativeness:* Representative data at national or regional/state level.
	Distance / mean time to source to source	*Characteristics:* Household survey data, peer reviewed academic studies, or published grey literature reports related to user distance (m) or mean time to source (minutes) *Time period:* Within last 10 years *Level of representativeness:* Representative data at national, regional, district, or programme level
	Water quantity	*Characteristics:* Household survey data, peer reviewed academic studies, or published grey literature reports related to drinking water quantity per person. *Time period:* Within last 10 years *Level of representativeness:* Representative data at national, regional, district, or programme level
	Water Quality (user perception)	*Characteristics:* Household survey data, peer reviewed academic studies, or published grey literature reports related to perceptions of water quality *Time period:* Within last 10 years *Level of representativeness:* Representative data at national, regional, district, or programme level.
	Water Quality (chemical/physical parameters)	*Characteristics:* Water quality testing data, or peer review journal articles recording water quality according to defined parameters[46] *Time period:* Within last 5 years *Level of representativeness:* Representative data at national or regional/state level.

[46] To align with the data collected as part of primary data collection, our water quality indicators of interest focus on those that will influence household perception water quality (such as salinity, total dissolved solids, electrical Conductivity, and turbidity); as well indicators of water safety such as arsenic and fluoride. Other indicators on Nitrate, Sulphate, Boron, Sulphur, E-coli, and Manganese excluded.

Table 32 Inclusion criteria per sustainability indicator (sanitation)

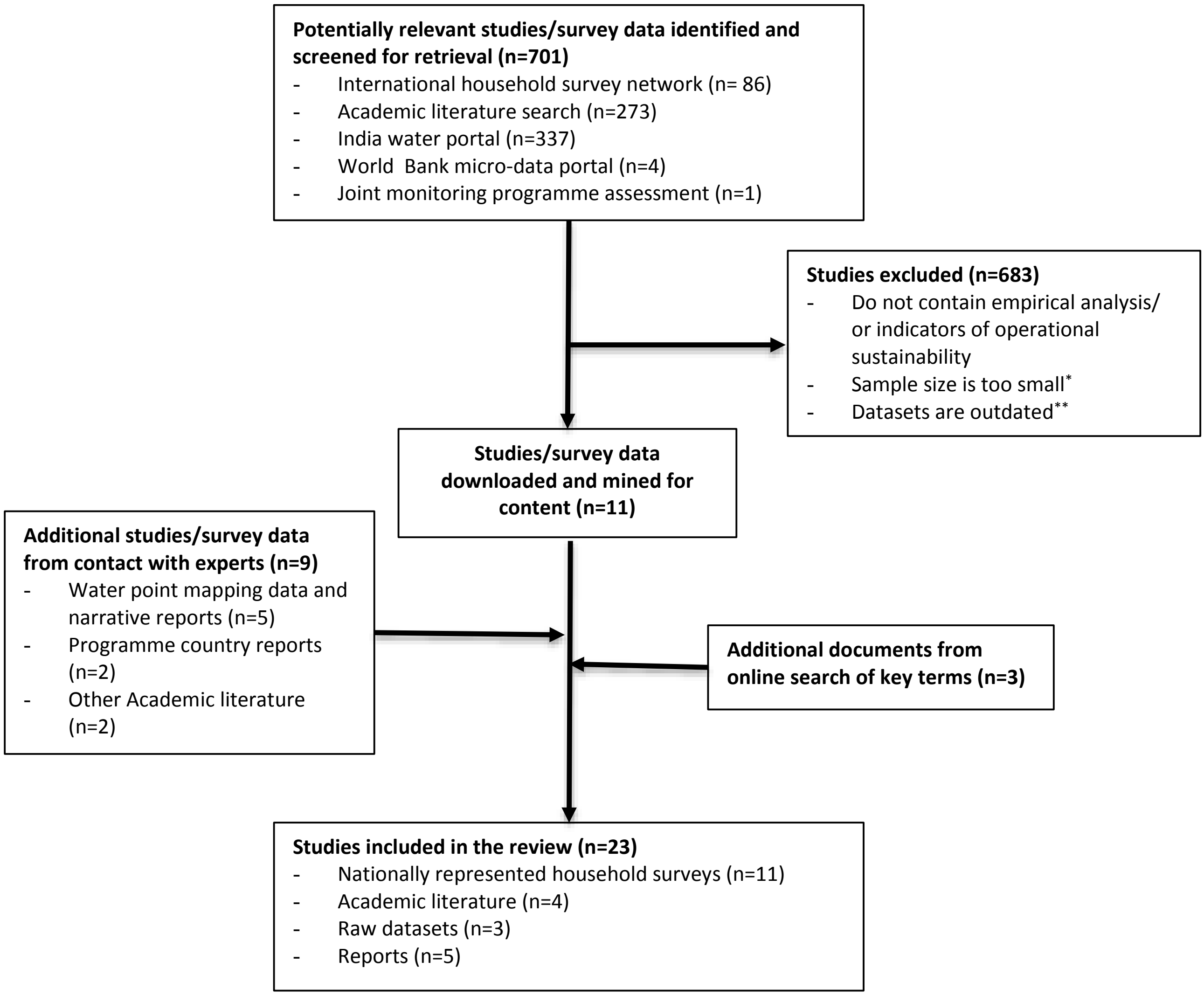
Time dimension	Key indicators of interest	Inclusion Criteria
Day-to-day (inter-day reliability)	Daily use of the sanitation facility (as reported by households)	*Study characteristics:* Published Household survey data, peer reviewed academic studies, published grey literature, and published programme monitoring data *Time period:* Within last 10 years. *Level of representativeness:* Representative data at national, regional, district, or programme level.
Month-to-month (inter-month functionality)	Sanitation facility durability and functionality (as reported by households)	
	Sanitation facility cleanliness (as reported by households)	
Multi-year (sustainability of outcomes)	% households using an improved or unimproved sanitation facilities (use as reported by households)	

Occasionally some studies have been included because of their particular relevance to our understanding of operational sustainability even if they fell outside the stated inclusion criteria. In these cases the studies will be highlighted and their inclusion justified.

Inevitably, different secondary data studies have defined operational sustainability indicators in different often making direct comparison of findings difficult; especially when these definitions were not clearly stated. In this report we have ensured that any differences and uncertainties are made clear to readers in two ways; 1) by providing a summary of the sampling design and data collection methodologies of the most important data sources for secondary analysis; and 2) by providing short descriptions of indicator definitions in each of the secondary data tables. Explanatory footnotes are also provided if definitions or interpretations are particularly complex or nuanced.

A.2 Data sources for regional assessment (water)

Figure 27 Flow chart of data selection process (water)



* Studies were considered too small if that did not meet the defined inclusion criteria for representativeness

** Studies have been excluded of there is a more recent iteration of the research from the same source with the same level of representativeness

Table 33 Summary of secondary data sources relating to water sources

Nº	Data source	Description	Country	Relevant operational sustainability indicators
1	Joint Monitoring Programme	Reports providing estimates of country level progress in accessing improved water and sanitation facilities.	All South Asian countries	**Use:** Classifies improved and un-improved water sources according to standardised definitions
2-4	Demographic Health Survey (DHS)	Nationally representative household surveys collecting data wide range of health and nutrition indicators (DHS) or to monitor the situation for women and children (MICS)	Bangladesh, Nepal, Pakistan	**Access (time/distance):** Total time to obtain drinking water (travelling to and from the source – including waiting times)
5-9	Multi-indicator Cluster Survey (MICS)		Afghanistan, Bangladesh, Bhutan, Nepal, Pakistan	
10-11	DACAAR database related to their 'National Study on Water Point Functionality' report (2013)	Inventory of approximately 25% of rural water points from 31 out of 34 provinces in Afghanistan	Afghanistan	**Functionality:** Each water point classified as functional or non-functional [47] **Water Quality:** Laboratory samples tested for electrical conductivity and Arsenic
12	National risk and vulnerability assessment [Afghanistan]	Only nation-wide household survey in Afghanistan	Afghanistan	**Access (time/distance):** Reports average time to obtain drinking water (travelling to and from the source – not including waiting times)
13-14	SHEWA-B project & DPHE [Bangladesh] database related to Ravenscroft et al. (2014)	Inventory of more than 150,000 rural water points constructed in Bangladesh between 2007-2013	Bangladesh	**Functionality:** Each water point classified as functional or non-functional **Seasonality:** Quantitative measure hand pump functionality in the dry season ['Nr.6 hand pumps' only] **Water Quality:** Laboratory samples tested for arsenic
15	Kabir and Howard (2007)	Functionality survey of a statistically representative sample of water systems in Arsenic affected communities	Bangladesh	**Seasonality:** Number of systems that do not suffer seasonal or monthly breakdowns as determined by community surveys

[47] In source excel database each water point were classified into four functionality categories: 'dry'; 'not delivering water', 'problem but not delivering water', 'problem but delivering water', and 'OK'. In this analysis only systems categorised as 'OK' are considered functional.

16	A Survey of Household Water and Sanitation (ASHWAS)	Survey of over 17,000 households in rural areas of Karnataka state, India	India (Karnataka state)	**Seasonality:** Number of households reporting an availability of drinking water from their main water source throughout the year **Water quantity:** Reports the number of households that are fully satisfied with the quantity of water they are receiving
17	WASHCost India database (2013)	Survey of over 5,000 households in rural areas of Andhra Pradesh state, India	India (Andhra Pradesh state)	**Access (time/distance):** Reports average time to obtain drinking water (travelling to and from the source – including waiting times) **Seasonality:** Number of households whose primary improved water source is functional for more than 350 days per year **Water quantity:** Reports average water consumption (LPCD) from improved water source for all domestic purposes **Water quality:** Reports of households satisfied with water quality according to a composite qualitative score
18	National Management Information Project (NMIP), (2014)	A monitoring report on the functionality of over 40,000 piped water systems nationwide. No distinction is drawn between systems in rural or urban areas.	Nepal	**Functionality:** Assessment of the physical condition of each piped water system (not individual water points). For this study each water system has been re-classified as either functional or non-functional[48].
19	Pant (2013)	Functionality study of 92 rural piped systems	Nepal	
20	SNV Nepal (2014)	Review of rural water services in three districts of mid-west Nepal	Nepal	**Water quantity:** Reports the number of households where users access 20 liters or more per capita per day
21	Thakur et al. (2010)	Nationwide water quality testing	Nepal	**Water quality:** Samples tested for Arsenic
22	Tahir et.al., (2014)	Nationwide water quality testing	Pakistan	**Water quality:** Samples tested for total dissolved solids, turbidity, and fluoride.
23	Household Income and Expenditure survey [Sri Lanka] (2009)	Nationally representative household survey	Sri Lanka	**Access (time/distance):** Households with a water point within 500m of the dwelling **Water quantity:** Reports number of households who have 'sufficient' access to drinking water

[48] In the NMIP each piped system was originally classified into one of five functionality categories. For the purposes of this analysis those systems that were classified as "well-functioning" and "need minor repair" were considered functional, and all other categories considered non-functional.

A.3 Description of data sources

Water point mapping data

Water Point Mapping (WPM) is increasingly been carried out at large or national scale in various countries globally. Typically WPM initiatives will provide cross-sectional data of the functionality of community water systems without necessarily capturing indicators of sufficiency of effectiveness of the water point in providing a service. Nevertheless as evidenced by the ongoing and vibrant discussions on the Rural Water Supply Network (RWSN) water point mapping forum[49] and in the development of open source sector tools such as *m-water*[50] there is great deal of scope for more advanced real time monitoring of water point performance, breakdowns and repairs.

In South Asia three sources of large scale water point mapping data were identified from studies conducted in Afghanistan, Bangladesh and Nepal. The largest of these was an Excel database of all rural water points constructed in Bangladesh since 2007. In Afghanistan a WPM database containing details of estimated 25% of rural systems in the country was shared with the team. For Nepal, the team analysed an inventory and functionality assessment of over 40,000 piped water schemes spanning urban and rural areas. Details of each of these data sources are provided below:

Bangladesh

The Bangladesh WPM database provides functionality information for all rural water points constructed between 2007 and 2013. The data set shared with the team combines two data sources. Initially the Government of Bangladesh-UNICEF project, 'Sanitation, Hygiene Education and Water in Bangladesh' (SHEWA-B) surveyed 22,000 rural water points in 2012/3. Subsequently UNICEF supported the Department of Public Health Engineering (DPHE) to expand this survey nationwide. This resulting database contains 151,534 unique data-points each representing a single water-point and includes information on water-point location, technology, construction date, and functionality status.

The SHEWA-B survey recorded water points simply as functional or non-functional; whereas nationwide survey also further differentiated between temporarily non-functional and permanently non-functional; depending on whether they expected them to be fixed or they were permanently abandoned.[51]

As part of DPHE monitoring, additional analyses were conducted on groundwater quality and seasonality of a sample of water points. The database of this information were not shared with the team, however a comprehensive analysis has been published in Ravenscroft et al., (2014). A brief overview of these datasets are given below.

Water quality: Five percent of water well's visited as part of WPM (n=3,110) were tested for arsenic contamination at DPHE laboratories. In addition approximately 50% of samples were tested for iron and manganese contamination (n=1,565), and in southern Bangladesh chloride analysis was undertaken on 631 samples. For greater quality assurance 10% of these samples were also sent for independent quality control checks at an external laboratory.

Seasonality of tube well's: A sub-study was undertaken on the capability of tube-well's attached with the Nr, 6 handpump to operate during the dry season. This type of hand pumps is the most commonly used in Bangladesh and cam operated to depth up to an around 7.6m, but by 9m depth it becomes inoperable. Seasonality was determined by measuring the depth to water during the dry season.

[49] https://dgroups.org/rwsn/mapping (members only)
[50] http://mwater.co/about/
[51] We have asked for a more detailed explanation of how functionality was defined and will continue to follow up.

Those encountering depths of greater than 7.6 were consider likely to face considerable issues with seasonality of water supplies.

Afghanistan

During 2012 and 2013, the Danish Committee for Aid to Afghan Refugees (DACAAR) conducted a functionality survey of 34,776 rural water points across 31 of the 34 provinces in Afghanistan. This represents approximately 25% of the estimated 138,000 rural water points nationwide. The Excel database was shared with the team for analysis as well as the accompanying narrative report 'National Study on Water Point Functionality'.

In source excel database each water point were classified into four functionality categories: 'dry'; 'not delivering water', 'problem but not delivering water', 'problem but delivering water', and 'OK'. In this analysis only systems categorised as 'OK' are considered functional. Alongside functionality assessment, DACAAR also conducted detailed physical and chemical water quality testing for 12% of water points (n=3,491). Although the DACAAR research covers large areas of rural Afghanistan the sampling strategy, the extent to which these studies are representative at national or regional level has not been made clear[52].

Nepal

As part of periodic national monitoring of water and sanitation coverage and functionality the Department of Water Supply and Sewerage periodically collects performance and functionality of piped water systems. The 2014 iteration of this survey reported on the functionality of 41,215 separate piped systems nationwide. The status of each piped system was determined according to the classifications laid out in Table 34 and have been published in the national report (NMIP, 2014). For the purposes of this analysis those systems that were classified as "well-functioning" and "need minor repair" were considered functional, and all other categories considered non-functional.

Table 34 Functionality classification of piped systems

Functionality classification	System description
Well-functioning	Need no repair
Need minor repair	Functioning - but system requires minor repairs that system managers/users can undertake
Need major repair	Functioning - but system requires major repairs with external inputs
Need rehabilitation	Functioning - but are unable to meet demand
Need reconstruction	Providing a minimal amount of water and need major technical and financial inputs from external sources
Non-refunctionable	Schemes that cannot be made operable again even with rehabilitation/reconstruction

For the purposes of this report, one major limitation of this data is that it does not disaggregate the functionality of rural and urban systems, instead these values are presented nationally and per region. To augment our understanding of the functionality of rural piped systems in Nepal, an additional smaller scale study of 92 rural piped systems (Pant, 2013) has been included in the analysis.

[52] We will continue to follow up to clarify remaining sampling uncertainties.

Nationally-representative household surveys

Joint Monitoring Programme

The Joint Monitoring Programme for Water Supply and Sanitation (JMP) was launched by the WHO and UNICEF in 1990 to report on country level progress in access to water and sanitation services. The focus of JMP monitoring is on outcomes, in other words the number and proportion of people using improved water and sanitation facilities, and these are measured according to standardised definitions that are applied across all country contexts[53].

The JMP estimates are based on a range of national data sets – such as large scale national surveys and censuses. For each country, the data sets from all years are plotted on a timescale from 1980 to the present and annual estimates are derived from constructing a linear trend line, based on the least square method, through these data points (WHO/UNICEF, 2014).This linear trend line approach was adopted in 1990 when very few datasets were available and the application of complex statistical procedures couldn't be justified. However in recent years as data has become more widespread there is an expectation that future estimates may employ more sophisticated modelling techniques.

Despite current limitations, the growing influence of JMP reporting over the last 25 years has led to many countries aligning national definitions of access with international standards such as the JMP. As the consequence the terminology of 'improved' and 'unimproved' facilities have become widespread and standardised, and we consider JMP estimates as the most robust means to make comparison between service delivery outcomes between different countries and regions.

Demographic and Health Surveys

Demographic and Health Surveys (DHS) are usually nationally-representative household surveys of usually between 5,000 and 30,000 households which provide data for a wide range of population, health and nutrition indicators. DHS surveys normally involve stratified two-stage cluster sampling. In the first stage the country is divided into small administrative units usually in-line with census enumeration areas. From this sampling frame list between 300-500 enumeration areas are selected using probability according to size so that larger clusters have a greater probability of being sampled. The second stage of sampling a fixed number of households are selected by equal probability in the selected enumeration areas (ICF International, 2012).

For the purposes of our secondary analysis, the DHS generally provided nationally representative data on the total time to obtain drinking water (travelling to and from source). Typically this has been reported according to four categories 'water on premises'; 'less than 30 minutes'; 'more than 30 minutes'; ' don't know/missing'.

Multiple Indicator Cluster Surveys

The Multiple Indicator Cluster Surveys (MICS) is an international household survey programme developed by UNICEF in the 1990s. Typically MICS are designed to be national representative but regardless of the scope of the survey, all MICS are based on representative samples. MICS surveys report the total time to obtain drinking water in the same manner as DHS. Occasionally,

[53] JMP consider the following as improved sources of water: piped water into dwelling, piped water into yard/plot, public tap or standpipe, tube well or borehole, protected dug well, protected spring, and rainwater. All remaining water sources are considered unimproved. Improved sanitation facilities include flush toilet, piped sewer system, septic tank, flush/pour flush to pit latrine, VIP latrine, pit latrine with slab, and composting toilet. Shared facilities are classified as unimproved if shared by more than two households.

MICS reports also provide the mean time (in minutes per roundtrip) of those households that do not have water on the premises.

Both DHS and MICS also report on improved access to water and sanitation infrastructure. These values are not however presented in this study as the JMP estimates are considered the definitive estimates because they are compile data from a range of comparable nationally representative surveys, including DHS and MICS.

Regional/state level household surveys

A Survey of Household Water and Sanitation (ASHWAS)

In 2009 the Arghyam charitable foundation conducted the representative ASHWAS survey of over 17,000 households in rural areas Karnataka state in South West India. This survey aimed to analyse household perceptions and understandings of the water and sanitation situation. In doing so they collected a number of indicators of interest on water use, availability, seasonality and quality.

WASHCost India

From 2008 – 2013 the WASHCost project undertook action research on the cost and quality of water services in Andhra Pradesh state. A representative survey of over 5,000 households was conducted across the nine agro-climatic zones of Andhra Pradesh providing indicators of water system functionality and reliability, as well as the quantity and quality of water used.

A.4 Search terms for literature review

Key words	Search syntax used in SCOPUS
Water quality	(TITLE-ABS-KEY("drinking water quality") AND TITLE-ABS-KEY(Pakistan) OR TITLE-ABS-KEY(Afghanistan) OR TITLE-ABS-KEY(Nepal) OR TITLE-ABS-KEY(Maldives) OR TITLE-ABS-KEY(Sri Lanka) OR TITLE-ABS-KEY(Bangladesh) OR TITLE-ABS-KEY(India) OR TITLE-ABS-KEY(nepal) OR TITLE-ABS-KEY(south asia)) AND PUBYEAR > 2009
Seasonality	(TITLE-ABS-KEY("seasonality") AND TITLE-ABS-KEY("drinking water") AND TITLE-ABS-KEY(Pakistan) OR TITLE-ABS-KEY(Afghanistan) OR TITLE-ABS-KEY(Nepal) OR TITLE-ABS-KEY(Maldives) OR TITLE-ABS-KEY(Sri Lanka) OR TITLE-ABS-KEY(Bangladesh) OR TITLE-ABS-KEY(India) OR TITLE-ABS-KEY(nepal) OR TITLE-ABS-KEY(south asia)) AND PUBYEAR > 2005
Reliability/ Continuity	(TITLE-ABS-KEY("reliability") OR TITLE-ABS-KEY("continuity") AND TITLE-ABS-KEY("drinking water") AND TITLE-ABS-KEY(Pakistan) OR TITLE-ABS-KEY(Afghanistan) OR TITLE-ABS-KEY(Nepal) OR TITLE-ABS-KEY(Maldives) OR TITLE-ABS-KEY(Sri Lanka) OR TITLE-ABS-KEY(Bangladesh) OR TITLE-ABS-KEY(India) OR TITLE-ABS-KEY(nepal) OR TITLE-ABS-KEY(south asia)) AND PUBYEAR > 2005
Quantity	(TITLE-ABS-KEY("quantity") AND TITLE-ABS-KEY("drinking water") AND TITLE-ABS-KEY(Pakistan) OR TITLE-ABS-KEY(Afghanistan) OR TITLE-ABS-KEY(Nepal) OR TITLE-ABS-KEY(Maldives) OR TITLE-ABS-KEY(Sri Lanka) OR TITLE-ABS-KEY(Bangladesh) OR TITLE-ABS-KEY(India) OR TITLE-ABS-KEY(nepal) OR TITLE-ABS-KEY(south asia)) AND PUBYEAR > 2005
Functionality	(TITLE-ABS-KEY("functionality") AND TITLE-ABS-KEY("drinking water") AND TITLE-ABS-KEY(Pakistan) OR TITLE-ABS-KEY(Afghanistan) OR TITLE-ABS-KEY(Nepal) OR TITLE-ABS-KEY(Maldives) OR TITLE-ABS-KEY(Sri Lanka) OR TITLE-ABS-KEY(Bangladesh) OR TITLE-ABS-

	KEY(India) OR TITLE-ABS-KEY(nepal) OR TITLE-ABS-KEY(south asia)) AND PUBYEAR > 2005

Annex B The denominator problem

B.1 Definition

The denominator problem is the fact that monitoring data often fails to take account of water points that have been abandoned. In other words, some water points which were constructed in year *x* are dropping out of the denominator in Equation 1 below.

Equation 1 Functionality for all water points constructed in year x

$$\%\, WPs\ constructed\ in\ year\ x\ now\ functional = \frac{no.of\ WPs\ constructed\ in\ year\ x\ now\ functional}{no.of\ WPs\ constructed\ in\ year\ x}$$

Consider now Equation 2 below. The key distinction is that Equation 1 focuses on all WPs constructed in a particular year, whereas Equation 2 focuses on WPs of a certain age in a given dataset. Equation 1 is more theoretical (it is unlikely we would ever know how many WPs were constructed in a given year), whereas equation 2 provides the kind of data we see in Figure 18 and Figure 19 (in section 0 of the main report).

Equation 2 Functionality for water points of age y in a given dataset

$$\%\, WPs\ in\ dataset\ of\ age\ y\ now\ functional = \frac{no.of\ WPs\ in\ dataset\ of\ age\ y\ now\ functional}{no.of\ WPs\ in\ dataset\ of\ age\ y}$$

Finally, Equation 3 produces the kind of indicators we commonly see reported, that is, average functionality in a dataset containing WPs of various different ages.

Equation 3 Average functionality across water points of all ages

$$\%\, total\ WPs\ now\ functional\ = \frac{number\ of\ functional\ water\ points\ of\ all\ ages}{total\ number\ of\ water\ points\ of\ all\ ages}$$

The "denominator problem" has been shown to cut across the secondary WPM data collected that we have collected in Sub-Saharan Africa and South Asia.

In South Asia data, the under-reporting of older non-functional systems appears to be borne out in Afghanistan. While there was an average of 2,878 water points collected for water points aged between 1 and 5 years, there were over 1,000 fewer data points (1,809) collected for systems aged between 6 and 10 years. An average of only 690 data points were collected each year systems with ages between 11 and 15 years, falling to 327 per year for systems between 16-20 years old.

This extent of difference is unlikely to be wholly explained by increases in financing for rural water and rural coverage rates. We would suggest that, in addition, a considerable number of systems constructed more than 5 or 10 years ago are missing from the analysis. Afghanistan is a particular case given its recent history, but the 'denominator problem' is a cross-cutting issue that has also been identified across WPM data in a number of countries (see, for example, the Sub-Saharan Africa regional assessment under this project). Across the board, fewer older WPs are found than one would expect. We are considering various options for modelling the possible number of "missing" water points using different approaches outlined below; the conceptualisation of the denominator problem is further explored in a forthcoming paper in the context of a model for functionality (Carter & Ross, forthcoming).