WASHCost

Briefing Note 1a
Life-cycle costs approach

Costing sustainable services

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On enumerator's shirt: "Quantifying the costs of water and sanitation"

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Photo
Enumerator from WASHCost Mozambique team collects costs data from community.
(taken by Jeske Verhoeven)

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

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Abbreviations

AMP	Asset management plan
CapEx	Capital expenditure
CapManEx	Capital maintenance expenditure
CBO	Community-based organisation
CoC	Cost of capital
CLTS	Community-led total sanitation
DST	Decision support tool
ExpDS	Expenditure on direct support
ExpIDS	Expenditure on indirect support
GDP	Gross domestic product
HIC	High income countries
JMP	Joint Monitoring Programme
LCC	Life-cycle costs
LCCA	Life-cycle costs approach
LIC	Low income countries
Lpcd	Litres per capita per day
MIS	Management information system
MDG	Millennium Development Goal
Mpcd	Minutes per capita per day
MUS	Multiple-use services
NGO	Non-governmental organisation
OpEx	Operating and minor maintenance expenditure
O&M	Operation and maintenance
WACC	Weighted average cost of capital
WASH	Water, sanitation, and hygiene

Summary

This briefing note describes the life-cycle costs approach and why it was developed. It explains the main cost components for water and sanitation in rural and peri-urban areas. Detailed cost breakdowns are presented in the annexes. Different types of analysis can be made with disaggregated cost information: comparing costs of infrastructure components, comparing the cost of services delivered or comparing the costs of difference service delivery models. The briefing note explains the building blocks used in the life-cycle costs approach for all these types of analysis and explores how these fit with different accounting practices. It explains why the WASHCost Project has adopted a regulatory accounting approach to calculate aggregated total expenditure costs and provides a step-by-step approach to comparing and reporting costs.

Introduction

Why do you need to understand the costs of water and sanitation services? The answer depends on the task, but most probably you need to plan what needs to be spent to develop and sustain improved services, or to monitor what you are really achieving with your money, or you would like to compare your spending with others. You need to understand costs because you would like to improve the way you are spending your own money, either directly or through tariffs to service providers, or as a tax-payer, and to ensure that money transferred internationally (through grants and loans) is not wasted. What you really want is to achieve the most while spending the least.

Water, sanitation and hygiene (WASH) services are central to addressing poverty, economic development, livelihoods and health. Lack of accurate information, especially on and in rural and peri-urban areas in the developing world, makes it impossible to estimate the true cost of extending sustainable and good quality water and sanitation services to the poorest.

To address some of these challenges, the WASHCost team has developed and tested the life-cycle costs approach (LCCA), which provides a framework for analysis of cost data from water, sanitation and hygiene in rural and peri-urban areas in developing countries. The framework was developed to support the comparison of costs of services consistent with contemporary accounting and financing practices. To investigate unit costs, different types of analysis can be made:

- A breakdown of cost components: capital expenditure, operational expenditure, capital maintenance expenditure, cost of capital, etc.
- Costs by source of expenditure: household, local government, central administration, service provider, etc.
- Costs by infrastructure component: cost per system/ borewell/ pump/ standpost/ metre or pipe/ latrine
- Costs by volume: litre/ cubic metre
- Costs by people served: cost per person/ household/ poor community/ village/ population density
- Costs by service level: services accessed and used for a specific defined quantity, quality standard, hours of service
- Costs by service delivery model: combination of technologies and institutions providing a specific service in one area

Although the different costs are all expressed in an apparently similar way, the different nature of investments and payments to which those costs refer means that it is not helpful simply to add everything together, particularly because of the timing and regularity of some costs. Government officials, donors, civil society, even some consumers, want a convenient way of understanding the total cost of providing good WASH services and, in some situations, of developing mechanisms to charge tariffs relative to those costs.

The life-cycle costs approach seeks to raise awareness of the importance of life-cycle costs (LCC) in achieving adequate, equitable and sustainable WASH services, to make reliable cost information readily available and to mainstream the use of LCC in WASH governance processes at every level. A significant element of the LCCA is understanding that costs can only be compared and properly assessed against particular levels of service.

The first section of the briefing note explains the life-cycle costs approach and why it was developed, and describes the main cost components. The second section explores different ways to compare costs: per infrastructure component, per service level and per service delivery model. The third section discusses how the cost analysis relates with accounting practices and their purposes and lastly the authors propose a step-by-step approach explaining how costs can be aggregated and reported.

1 The life-cycle costs approach

Life-cycle costs refer to the costs of ensuring delivery of adequate water, sanitation, and hygiene (WASH) services to a specific population in a determined geographical area, not just for a few years, but indefinitely. They include not only the costs of constructing systems but also what it costs to maintain them in the short and long term, to replace, extend and enhance them as well as the indirect support costs of the enabling environment; that is capacity-building, planning and monitoring at both district and national level.

1.1 What are life-cycle costs and what is the life-cycle costs approach?

Life-cycle costs (LCC) represent the aggregate costs of ensuring delivery of adequate, equitable and sustainable WASH services to a population in a specified area. These costs include the construction and maintenance of systems in the short and longer term, taking into account the need for hardware and software, operation and maintenance, capital maintenance, any cost of capital, and the need for direct and indirect support, including source protection, training and capacity development, planning and institutional pro-poor support.

The delivery of sustainable services requires that financial systems are in place to ensure that infrastructure can be renewed and replaced at the end of its useful life, and to deliver timely breakdown repairs, along with the capacity to extend delivery systems and improve service delivery in response to changes in demand. This is the 'life-cycle' at the heart of this approach – what is needed to build, sustain, repair and renew a water (or sanitation) system through the whole of its cycle of use.

The term 'life-cycle' in this context does not refer to conventional 'cradle-to-grave' system analysis, but indicates that in a sustainable system, the costs follow a cycle, from initial capital investment, to operation and minor maintenance, to capital maintenance and replacement of infrastructure that has come to the end of its useful life (which may well be extended or renewed with additional capital expenditure). The life cycle refers both to the life of the individual system components and to the overall costs required to develop and run a service indefinitely.

The life-cycle costs approach (LCCA) goes beyond achieving the technical ability to quantify and make costs readily available. It seeks to improve understanding about life-cycle costs and the ability to analyse them in relation to service delivery. The aim is to change the behaviour of sector stakeholders, so that life-cycle unit costs are mainstreamed into WASH governance processes at all institutional levels from local to national and international. The LCCA is recommended to increase the ability and willingness of decision-makers (those involved in service planning, budgeting and delivery) and users to make informed and relevant choices between different types, levels and models of WASH services. Not only will they understand costs better, but they will budget for all the elements required to have a sustainable service.

Short definitions

Life-cycle costs (LCC) represent the aggregate costs of ensuring delivery of adequate, equitable and sustainable WASH services to a population in a specified area.

The life-cycle costs approach (LCCA) seeks to raise awareness of the importance of life-cycle costs in achieving adequate, equitable and sustainable WASH services, to make reliable cost information readily available and to mainstream the use of LCC in WASH governance processes at every level.

1.2 Why do we need this framework?

There are many cost comparisons for budgeting and reporting on rural and peri-urban water and sanitation services in developing countries. However, there are also many limitations in the way that costs are reported at country level and in international reports.

The first limitation is the lack of a consistent accounting framework for rural and peri-urban water and sanitation services. Unit costs used in the sector literature refer to how much a specific technology costs and to the amounts paid by households for the use of those same technologies. In this and other ways, prices are confused with costs. The costs paid by households for a water connection are not the same as the costs of producing and distributing water. In a privatised water system the cost to the household may be more, while in a subsidised or underfunded service the price to the household may be a small fraction of the real costs. Furthermore costs are considered only from the perspective of the implementing organisation or service provider, not from the perspective of the overall costs to society. A subsidy to a family to buy a slab is still a cost. A household contribution to capital expenditure to make their system work is still a cost. Confusion also derives from the terms used to disaggregate the unit costs. For expenditures with direct and indirect support to communities there are different terminologies in use: software, administration costs, costs of running a programme, sector costs, etc. For rural and peri-urban water supply and sanitation there is not yet a consistent accounting framework comparable to the one used by (urban) utilities and service providers. Below, we explain the terms used in the life-cycle costs approach.

For cost comparisons between technologies and service levels it can be helpful for capital expenditures and other costs to be annualised. In theory, the most straightforward way would be to divide capital expenditure (and other investment costs) over the lifespan of the infrastructure. The longer the lifespan, the lower the annual cost. However, actual lifespans are usually much shorter than estimated or 'ideal' lifespans, making an annualised capital cost look too low. In reality many handpumps only last three to five years, instead of the 20 years design lifespan. Below we describe a 'building block' approach to costs that overcomes these problems.

A significant element of the LCCA is an understanding that costs can only be compared and properly assessed when they are related to particular levels of service. WASHCost specifically aims to draw attention to the costs of pro-poor WASH services delivery, including water for small-scale productive uses. WASHCost aims to help national and decentralised sector bodies to embed an understanding and use of life-cycle costs so that this approach becomes institutionalised, owned and actively used within countries as well as internationally, and that national bodies develop and maintain their own cost databases and incorporate them into management information systems (MIS) and decision-support tools (DST).

1.3 Which cost components are considered in the life-cycle costs approach?

It is necessary to understand six definitions used in discussing or thinking about life-cycle costs (Fonseca, 2007; Franceys, Perry and Fonseca, 2010a and 2010b):

Capital expenditure – hardware and software (CapEx)

Capital expenditure (CapEx) is the capital invested in constructing or purchasing fixed assets such as concrete structures, pumps, pipes and latrines to develop or extend a service. Investments in fixed assets are occasional and 'lumpy' and include the costs of initial construction and system extension, enhancement and augmentation. They include essential ancillary equipment, such as vehicles or even building offices to support the operation of water and sanitation systems. CapEx does not only cover hardware. CapEx 'software' includes the costs of one-off work with stakeholders prior to construction or implementation, extension, enhancement and augmentation (including costs of one-off capacity building). An example of CapEx software would be the cost of holding a meeting to explain alternative systems to users. Investment costs also include 'household coping costs' by which households spend their

own money on, for example, storage tanks or water filters to achieve a satisfactory level of service.
See Franceys & Pezon, 2010, WASHCost Briefing Note 1b – Services are forever – for further details.

Operating and minor maintenance expenditure (OpEx)

There is a requirement for recurrent (regular, ongoing) expenditure on labour, fuel, chemicals, materials, and purchases of any bulk water. Most cost estimates assume OpEx runs at between 5% and 20% of capital investments. Minor maintenance is routine. It is maintenance needed to keep systems running at design performance, but does not include major repairs or renewals which are recognised as not recurrent. Sometimes the distinction between these categories is less than clear. OpEx also includes 'household coping costs' by which households spend money to achieve a satisfactory level of service; i.e. cleaning products for sanitary facilities, energy costs, etc.

Capital maintenance expenditure (CapManEx)

Expenditure on asset renewal, replacement and rehabilitation (CapManEx) covers the work that goes beyond routine maintenance to repair and replace equipment, in order to keep systems running. The costs may be estimated based upon serviceability and risk criteria related to service degradation and failure. Accounting rules may guide or govern what is included under capital maintenance and the extent to which 'broad equivalence' is achieved between accounting charges for depreciation (designed to build up a reserve for renewal) and actual expenditure on capital maintenance. Capital maintenance expenditures and potential revenue streams to pay those costs are critical to avoid the failures represented by haphazard, and almost always late, system rehabilitation.
See Franceys & Pezon, 2010, WASHCost Briefing Note 1b – Services are forever – for further details.

Cost of capital (CoC)

The cost of capital is the cost of financing a programme or project; i.e. the cost of accessing the funds needed to construct a system. CoC is made up of interest on any loans and – in the case of a commercialised public or private sector provider, including small scale private providers – the return required (including the dividend) on the CapEx investment by government as owner, or the shareholders in the case of a private company. Where the capital has been provided as a grant it is sometimes appropriate to consider an indirect (estimated) cost of capital.
See Franceys, Naafs, Pezon & Fonseca, 2011, Briefing Note 1c – The cost of capital – for further details.

Expenditure on direct support (ExpDS)

ExpDS includes expenditure on both pre- and post-construction support activities directed to local-level stakeholders, users or user groups. In utility management, expenditure on direct support – such as user satisfaction surveys or handling complaints – is usually considered to be an overhead and included in OpEx. However, these costs are rarely included in rural water and sanitation estimates. They include the costs of ensuring that local governments have the capacities and resources to plan and implement, manage contracts or emergency situations when systems break down, and to monitor private or public service providers' performance.
See Smits et al., 2011. Working Paper 5 – Arrangement and costs of support to rural water service providers – for further details.

Expenditure on indirect support (ExpIDS)

ExpIDS includes macro-level support, capacity-building, policy, planning, and monitoring that contribute to the sector working capacity and regulation but are not particular to any programme or project. Indirect support costs include government macro-level development and maintenance frameworks and institutional arrangements and capacity-building for professionals and technicians.
See Smits et al., 2011. Working Paper 5 – Arrangement and costs of support to rural water service providers – for further details.

Total Expenditure (TotEx)

TotEx is determined using fixed asset accounting to aggregate the costs components described above. Because cost components are not directly comparable they cannot simply be added up. As explained in the next section, different questions will require different methods to calculate total expenditure.

Note: Detailed elements for each of the cost components are listed in the Annexes.

1.4 Further cost breakdown: making use of the RIDA framework

The cost data collection process can be very extensive if all the elements listed in the annexes are taken into account. The WASHCost team, and specifically the India team, has found it useful to use and build upon the RIDA framework (Moriarty, Batchelor, Laban and Fahmy, 2010) for further disaggregation and structuring of cost components described in the previous section and detailed in the Annexes. This framework has been used to structure information, analysis and discussions that related to the planning and management of water delivery systems.

WASHCost has found this framework useful because it identifies costs incurred by different levels of service providers (those involved in exploiting and protecting water resources, and those involved in providing infrastructure and responsible for service delivery) as well as by users (identified as demand and access costs). The RIDA concept is based on the understanding that water resources are linked to users by infrastructure, and that each of these elements (resources, infrastructure, demand/access) has its own set of institutions and boundaries which make it easier to collect and analyse the different cost components (Table 1). In other words, there may be three sets of largely independent physical/institutional boundaries that need to be considered systematically when looking at the respective cost components. The detailed cost annexes have been organised using the RIDA framework.

Table 1. Costs and the RIDA framework

	Resources	Infrastructure – service delivery	Demand/Access – user coping costs
Water and hygiene	Costs involved in sustainable provision of water resources of required quantity and quality.	Costs incurred by service providers when constructing, operating and maintaining water supply infrastructure.	Costs incurred by users who routinely access formal, informal and private water supply systems to meet demands (domestic, municipal, commercial, industrial, MUS, livestock etc.). These costs include any costs that are not met by the service providers.
Sanitation and hygiene	Costs involved in protecting water resources from disposal of black and grey wastewater and storm water.	Cost incurred by service providers when constructing, operating and maintaining sanitation, environmental sanitation and grey and black wastewater and stormwater infrastructure. Also other costs incurred by service provides that relate to CLTS and/or creating and maintaining demand for and ownership of improved sanitation, environmental sanitation and hygiene practices.	Costs incurred by users who routinely access formal, informal and private grey and black wastewater and stormwater systems to meet demands. These costs include any costs that are not met by the service providers.

2 Building blocks: aggregating and estimating costs in WASH services

One of the purposes of collecting information using a life-cycle costs approach is to understand the relative magnitude of different costs over a period of time, with a goal towards setting policy and policy-informed planning and budgets and any direct cost recovery in the form of charges for users. It is expected to give international and national policy-makers a better perspective on for example:

- the range of costs for different types of infrastructure. For example, handpump and shallow borehole-based services versus gravity-fed spring systems.
- the relative weight of different cost components (e.g. capital versus operation and maintenance costs for different types of systems and services over a period of time).
- the range of costs for different service levels. This question lies at the heart of WASHCost (i.e. how much would it cost for a basic service where people access a minimum of 20 litres per person per day of acceptable quality water from an improved source spending no more than 30 minutes per day)
- the cost of going from one service level to another (enhancement).

Answers to these questions can help with planning by providing an expected range of such costs. Alternatively, the information can be used in reverse, i.e. if the budget is set, what can be delivered in terms of population served and level of services?

It is true to say that there is no 'right' way to analyse accurately all these elements of service provision because every approach to costing has to make estimations and approximations somewhere in the analysis, and has specific strengths and weaknesses. However it can be said that fixed asset accounting, which has been developed over centuries by traders and manufacturers to give a best estimate of the total costs of any activity, has become generally accepted as the most suitable approach to costing asset intensive sectors – where it is often referred to as 'regulatory accounting' (described further in the next section). This approach recognises that fixed assets and other long-term financial requirements have to be approached in a different way from short-term expenditures. Fixed asset accounting separates out 'lumpy' capital investment costs from ongoing recurrent costs. What government and donors in the sector want to know is how to combine the different cost components (capital expenditure, operational expenditure, capital maintenance expenditure, costs of capital, and expenditure on direct and indirect support) in a manner which indicates how much is required to be budgeted or charged for each year to ensure sustainable services. These costs have to be aggregated, but as suggested earlier, it is not simply a matter of adding them all up. WASHCost has found the 'building block approach', regulatory accounting, to be the most useful approximation to understanding total costs.

A second major use for the life-cycle costs methodology is to compare services designed for and received by different socio-economic groups in specific districts or communities. This is a fundamental issue for WASHCost, as almost all existing cost data refer to the 'as designed' service with almost no exploration of the costs that people pay for actual, real services received. From our research findings, even in areas that are nominally covered by improved services, closer disaggregation at the level of households and individuals identifies pockets of reduced access to services that, when taken together, can represent a substantial part of the population. Lack of accurate information, especially on and in rural and peri-urban areas in the developing world, makes it impossible to estimate the true cost of extending sustainable and good quality water and sanitation services to the poorest.

The next section explores different ways to compare costs, answering questions about the cost per infrastructure component, per service level and per service delivery model.

2.1 Costs – 'the building blocks'

The life-cycle costs approach uses an adaptation of the regulatory accounting approach to aggregate costs, separating investment costs (capital expenditure) from recurrent costs. These recurrent costs are derived from the 'building blocks' of operational expenditure, capital maintenance expenditure and the cost of capital along with the direct and indirect support costs described above. These costs make up the best approximation of the total annual costs of operating any system.

The building blocks approach indicates the total funding required to keep systems functioning permanently. The funding can come from tariffs[1], other charges, taxes, transfers (international taxes), as well as household expenditure. However, most service providers defer capital maintenance and do not fully take into account the real cost of capital when assessing total costs. The main reason for investigating these issues is to ensure the availability of necessary capital maintenance funding before systems fail and are abandoned. It is the poorest who suffer most from lack of capital maintenance and subsequent failure of their service – higher-income consumers can invest in coping strategies to bypass this failure.

Figures 1 and 2 illustrate the building block approach for two scenarios. Shugart and Alexander (2009) suggest for urban utilities (Figure 1) that a relative proportion of operational expenditure can be 30-70%, capital maintenance expenditure 10-40% and cost of capital between 10-35%. Figure 2 may be more typical of a rural area, with no return to equity owners, lower operating costs but a bigger proportion of costs on direct support to communities. These are speculative examples: LCCA seeks to determine actual values for these building blocks with a particular focus on services in rural and peri-urban areas which are usually not provided by a utility. There are no current good estimates of the overall relative proportions applicable to rural and peri-urban water and sanitation services. Note that capital costs (CapEx) do not have to be included in the stack as they are not recurrent costs.

Figure 1: Building blocks for urban utility costs

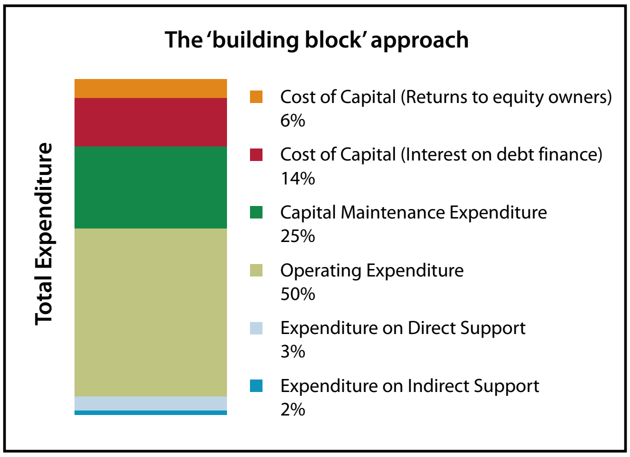
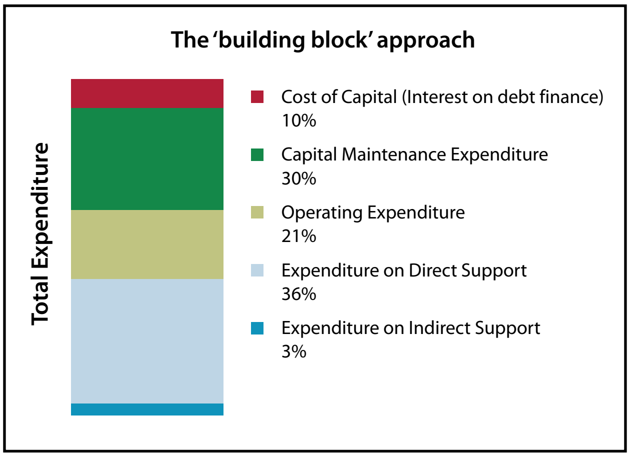


Figure 2: Building blocks for rural services

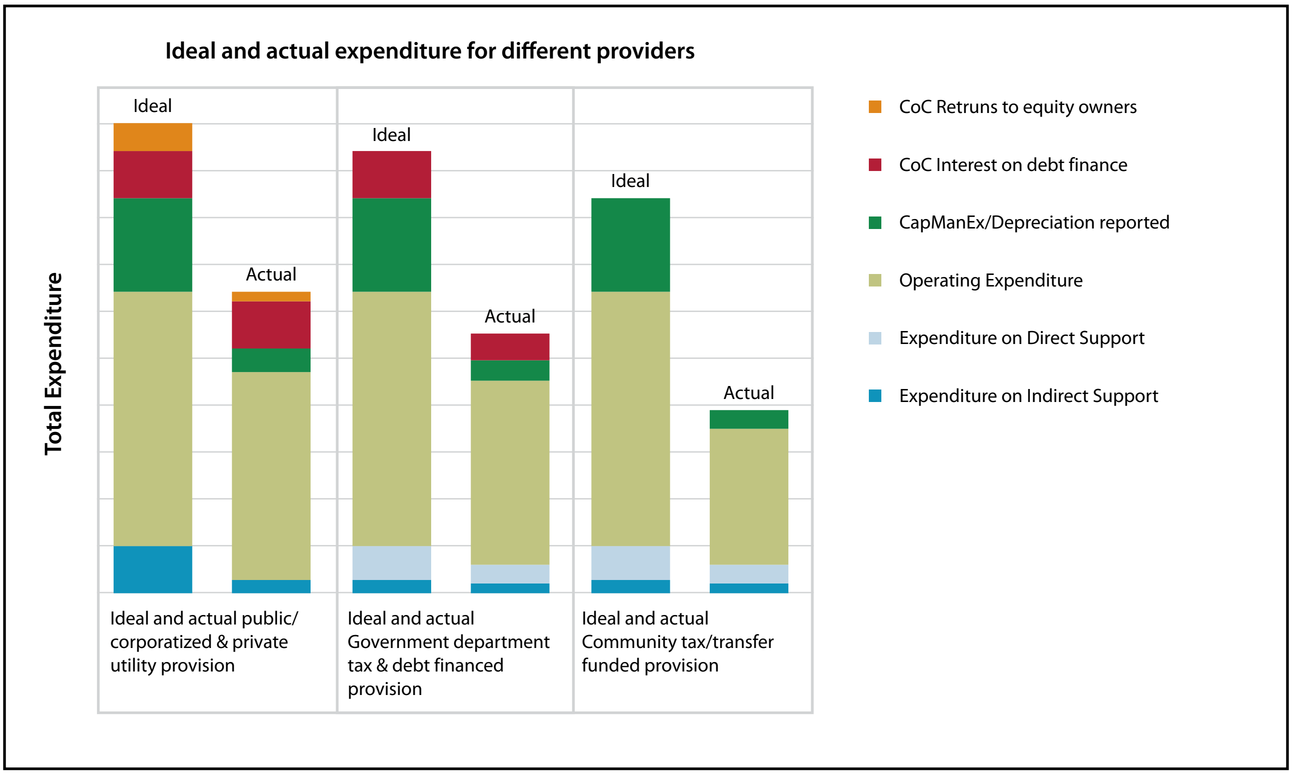


The building blocks and proportion of cost components will probably be different for different types of service providers, as shown in Figure 3. For many rural schemes managed by a rural NGO or CBO and directly funded through national taxation or from international transfers (in the form of aid or soft loans to government) there will be no cost of capital, but in our experience there are significant direct support costs, and these are often not fully reported. The actual capital maintenance expenditure reported is usually well below what is required for long term functionality. Figure 3 makes the distinction, for each main service delivery model, between the costs which would be incurred to

1 Tariffs which charge consumers the full amount of operational expenditure, capital maintenance expenditure and costs of capital are described as being 'cost reflective'. In reality, very few water and sanitation services, even in high-income countries, are actually cost reflective, as they do not include the true costs of capital maintenance or the cost of capital.

deliver an effective and sustainable service ('ideal') and the actual expenditure we often find in reality. A local government provider that makes use of direct loans must pay the interest (cost of capital) but it is likely that operating expenditure will be less than needed to function effectively, while capital maintenance expenditure may be almost absent. For a public or private utility provider, 'direct support costs' will be absorbed in operating expenditure but indirect support costs of economic and environmental regulation may be higher as a result of the need for oversight of monopoly providers. Capital maintenance expenditure should reflect the required depreciation charges and repayment of interest is likely. Where a utility is privately owned or where government (as owner) wants to ensure careful use of capital, a return to equity owners will also be included. This is part of the cost of capital.

Figure 3: The 'building block' approach for different providers: ideal costs and actual expenditure



We anticipate that 'ideal' capital maintenance expenditure (what is actually required to keep the infrastructure operational) and expenditure on direct support will be a higher percentage than is generally recognised. It is also likely that the costs recorded from data collection of actual expenditures will not be sufficient to maintain services in the long-term at an appropriate level. The ideal costs are likely to be somewhere between what is presently reported (too low) and the normative assumptions for depreciation which are likely to be too generous for networked systems, as the life of piped systems can often be extended beyond the assumed lifespan of the assets. In the case of rural non-networked systems, ideal costs are likely to be higher than what is reported and higher than the normative costs (based on 'expected life span'). This is because the life of point systems such as handpumps is in practice rather shorter than manufacturers claim.

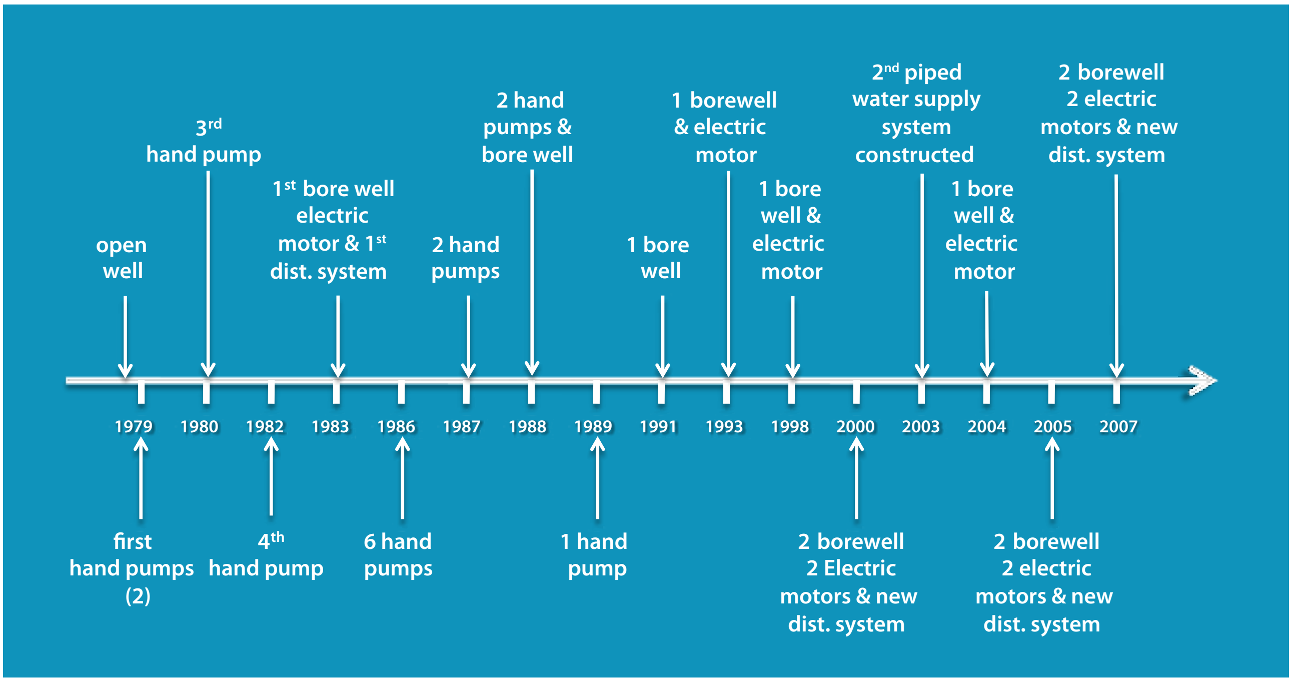
Most reported costs reflect actual expenditure, not the ideal costs required to deliver sustainable services. On the one hand reported costs may be lower than ideal costs, because they are not sufficient to provide an adequate service. On the other hand, they may over-report some costs because they reflect inefficiencies caused for instance by tied aid or procurement systems which lead to more expensive (imported) options or by other factors such as weak utility management, high leakage, limited supply chains, limited road coverage, corruption, etc. Overall, the costs needed to provide a sustainable service ('ideal' or 'normative' costs) are likely to be considerably higher than the reported costs.

2.2 Costing infrastructure components

Many studies in the sector specify the construction costs – for example, a new borehole with a motorised pump – as the costs of a new water service. However, that is only the capital expenditure, which was spent once in the past, and tells us little about ongoing costs. For its budgeting, the providing agency needs to know not only the cash costs of the new installation for that year but also the 'total' cost of maintaining the service; that is the cost per year, which needs to include the cost of fuel for the pump, the salary of the operator, replacement parts etc. How can that cost figure be accurate if nobody really knows how long the pump is going to last? If we simply take the 'supposed' life of the infrastructure, we would be aggregating actual costs incurred (CapEx plus OpEx) but matching them to a normative assumption (a 'guesstimate') of how long the pump will deliver water. Adding to this uncertainty, we then have to add the need for occasional but significant maintenance to pump and motor (if for example, the bearings on the pump or the gasket on the motor have to be replaced). How are these costs included and to what extent can they be averaged over the life of the system to give a total cost per year?

In practice, water and sanitation service providers have to manage a stream of payments relating to a multitude of fixed assets, all with different construction dates, and different operating and capital maintenance expenditure requirements. This applies not only to large urban water and sewerage networks. Figure 4 illustrates the multiplicity of asset systems and asset lives in a single village in India. What is the annualised 'cost' of WASH services in this situation?

Figure 4: Timeline of WASH capital expenditure (CapEx) and capital maintenance (CapManEx) in Ankushapur



Source: Ratna Reddy, WASHCost (India)

One way of comparing historical expenditure on infrastructure is to annualise capital investment costs (using an estimated life span for the assets), adding the resulting number to the annual recurrent costs. In budgeting terms, once the investment has been made it no longer has to be incorporated, except for ongoing capital investments for the extension and enhancement of services. Past capital expenditure however may need to be financed through ongoing interest payments (cost of capital) and the assets will certainly need to be renewed at the appropriate moment through capital maintenance, both of which need to be budgeted for and funded along with the ongoing operating and minor maintenance expenditure.

2.3 Costing sustainable service delivery

One challenge faced by planners and providers of water services who want to use cost comparisons to underpin policy decisions is to ensure that they compare like with like. Methodologically, one option is to compare the costs of similar levels of service rather than of the technologies used to provide the services. By developing the concept of service levels, it is intended to provide a structure to analyse the cost data being collected in different countries and settings.

The motivation for developing a framework for analysis based on service levels is driven by two main assumptions. The first is that service levels reflect operational reality in the field, namely an emerging intermediate level of service that mixes elements of basic point source/communal latrines services with those of modern utility services provided through household taps/sewerage systems. The second is that differences between levels of service are non-linear and not directly comparable. One approach therefore, is to compare the costs of similar service delivery models and provide cost ranges against a level of detailed information. This is more useful than looking at a single aggregated service delivery indicator. In taking this approach we recognise that the realities of hydrogeology (rainfall, geology and groundwater as well as surface water) can, on occasion, require specific technologies to meet the service challenge and that costs may vary considerably from average service level costs.

To compare the costs of providing a service in different contexts or with different technologies, it is essential to first agree on what constitutes a service. Service levels for water supply have been developed by identifying a set of core indicators – quantity, quality, accessibility and reliability (Moriarty et al., 2011). Each allows for several different levels of service, and the service level for each indicator can be combined to give one overall service level. Only those indicators that can realistically be identified and relatively easily assessed have been chosen, while the levels are informed by differences in service that are recognisable to most service users and service providers. The existing Joint Monitoring Programme (JMP) norms (WHO/UNICEF, 2008) and existing norms from four very different countries (Burkina Faso, Mozambique, Ghana and India) have been used to calibrate the levels (Moriarty et al., 2011).

Given that sanitation services are fragmented across a chain of service delivery activities or functions, each with its own associated costs and institutions or actors, a full sanitation service implies both that these functions are fulfilled and that the linkages in the chain are well articulated. In other words the service level is not just about a toilet, but about how it is used and maintained and what happens to the excreta. This represents a substantial expansion from the Millennium Development Goal (MDG) focus on latrines or facilities for the containment of excreta to a service delivery approach that takes the entire delivery chain into account.

Table 2 (on next page) illustrates the five service levels for water and the indicators used to compare costs. The four main indicators chosen for defining water service levels are quantity, quality, accessibility and reliability as explained in detail in the second edition of Working Paper 2 - Ladders for assessing and costing water service delivery (Moriarty et al., 2011).

Table 2: Water service levels

Service level	Quantity (lpcd)	Quality	Accessibility distance and crowding (mpcd)	Reliability
High	>= 60 Litres per person per day	Meets or exceeds national norms based on regular testing	Less than 10	Very reliable = works all the time
Intermediate	>= 40 Litres per person per day	Acceptable user perception and meets/ exceeds national norms based on occasional testing	Between 10 and 30 minutes (Less than 500m AND <= normative population per functioning water point)	Reliable/secure = works most of the time
Basic (normative)	>= 20 Litres per person per day			
Sub-standard	>=5 Litres per person per day	Negative user perception and/or no testing	Between 30 and 60 minutes (Between 500m and 1000mAND/OR more than normative population per functioning water point)	Problematic =Suffers significant breakdowns and slow repairs
No service	<5 Litres per person per day	Fails to meet national norms	More than 60 minutes (More than 1000m)	Unreliable/insecure = completely broken down

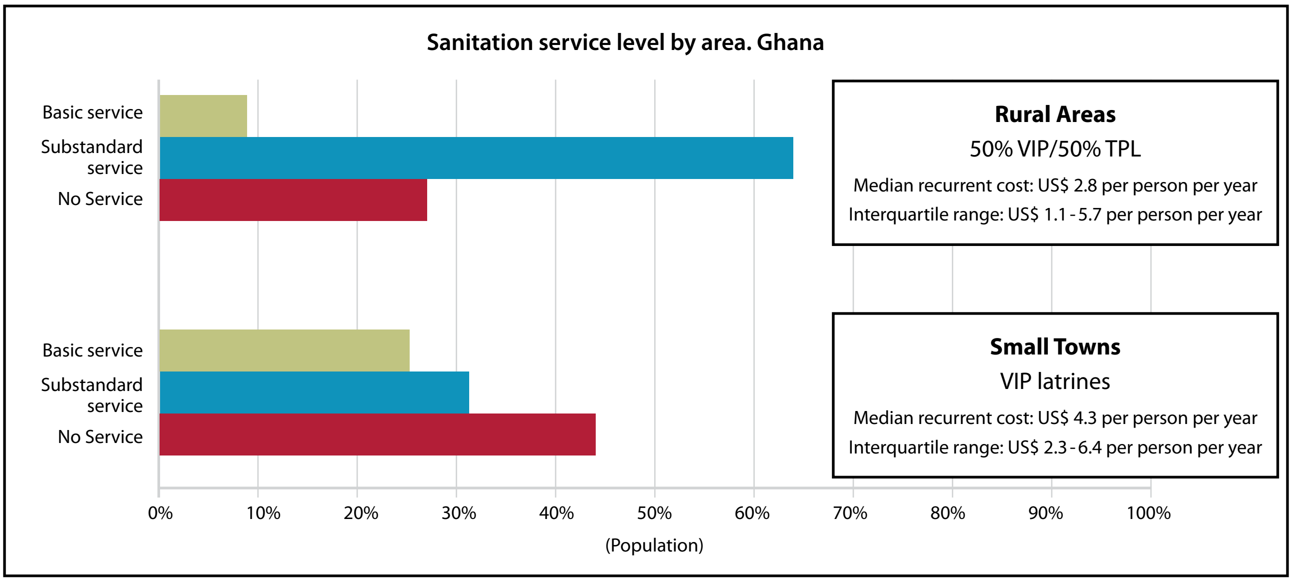
Table 3 illustrates four service levels for sanitation and the service parameters and respective indicators which indicate a sanitation service: accessibility, use, reliability and environmental protection. They are explained in detail in the second edition of WASHCost Working Paper 3 - Assessing sanitation service levels (Potter et al., 2011).

Table 3 Sanitation service levels

Service level	Accessibility	Use	Reliability (O&M)	Environmental protection (pollution and density)
Improved service	Each family dwelling has one or more toilets in the compound	Facilities used by all members of HH	Regular or routine O&M (incl. pit emptying) requiring minimal user effort	Non-problematic environmental impact disposal and re-use of safe-by products
Basic service	Latrine with impermeable slab (HH or shared) at national norm distance from HH	Facilities used by some members of HH	Unreliable O&M (incl. pit emptying) and requiring high user effort	Non-problematic environmental impact and safe disposal
Limited service	Platform without (impermeable) slab separating faeces from users	No or insufficient use	No O&M (pit emptying) and an extremely dirty toilet	Significant environmental pollution, increasing with increased population density
No service	No separation between user and faeces, e.g. open defecation			

Each of the service levels for a specific area can then be costed. Figure 5 provides an example of total expenditure against service levels for sanitation in small towns and rural areas. Interestingly, higher expenditure does not necessarily result in higher service levels, especially if it is mostly spent on capital investment, neglecting maintenance aspects.

Figure 5: Example of expenditure per person per year and sanitation service levels in Ghana



NB: Interquartile range is the range with the top and bottom 25% removed – i.e. it is the range of the middle 50%

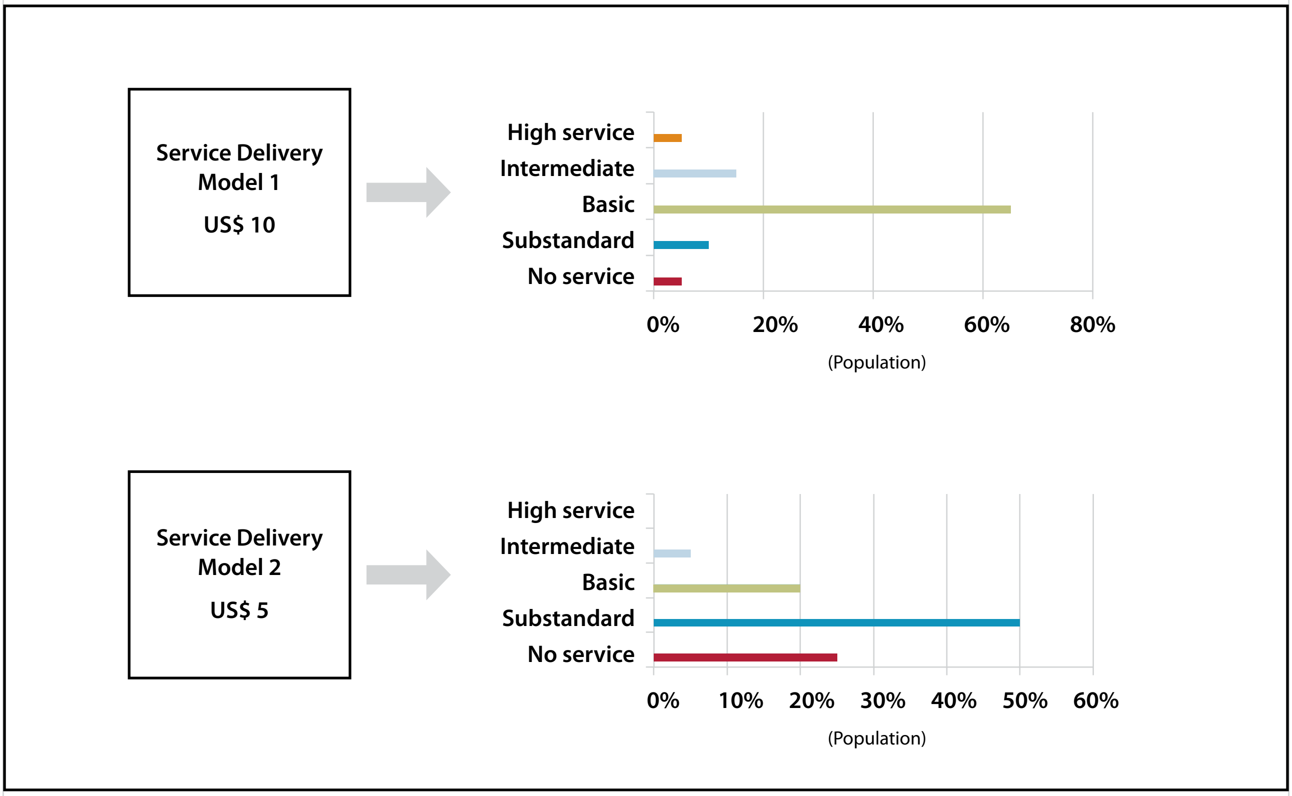
2.4 Costing service delivery models

It is not enough to know the total costs of services in one area. We also want to be able to compare different methods of delivering services in various settings. The question we aim to answer with this cost analysis is 'What are the costs and service levels provided by specific delivery models?' It is possible to do an analysis of costs per technology but once the total expenditure per year per person has been calculated for a community or village or region, those costs need to be related to the services provided in the same areas.

Figure 6 provides an example: in one group of villages there are mainly two service delivery models: a small piped system operated by a small utility (Service Delivery Model 1 – SDM1) and point sources operated by community organisations (Service Delivery Model 2 – SDM2). In this example, SDM1 costs US$ 10 per person per year to provide a basic service to 65% of the population in their served areas and SDM2 costs US$ 5 per person per year to provide 50% of the population in their different served areas with a substandard service. SDM1 looks like the better alternative – twice the cost but more than three times the number of people receiving a basic service or better. However, not every setting is suitable for a small piped system and it might well be that a combination of these two models – SDM1 in small towns and large villages, and SDM2 in scattered villages – might be the most effective combination of services in an area. Clearly, there is room for improvement in both services to bring people up to at least a basic service.

In some communities, in Burkina Faso and India, for example, both services might exist side by side, and households use a mix of services to meet their needs. In this situation, it might appear that SDM2 should just disappear as it does not deliver the same level of service. However, SDM2 might be very convenient for some households, it might be delivered at a lower price (rather than cost) or even free of charge, and it might be used as a backup system in case of failure of SDM1. In India, handpumps are considered to be part of the security of the village system to be used in an emergency. This complicates costing since they may deliver a very low volume of water most of the time, but still be considered value for money as part of the security of supply.

Figure 6: Total expenditure per person per year and service delivery models - example



3 Cost analysis, accounting practices and their purposes

Governments and donors need to know on an annual basis how much they have to invest in capital infrastructure and how much they have to budget to cover more regular payments (recurrent expenditures) to ensure the access and delivery of a certain level of service. Where there are user charges, planners and consumers need to know whether these charges are adequate and fair.

The previous section focused on cost calculation possibilities; in this section we discuss three methodologies within contemporary accounting practices, each of which makes use of unit costs:

- Cash accounting and cash flow management (used by accountants)
- Fixed asset accounting for asset management, known in our context as regulatory accounting (used by accountants, regulators, planners, utilities)
- Economic cost approach including life-cycle assessments (used by planners, economists)

Table 4 (on page 20) provides a summary of how different cost components are accounted for using the different approaches. None of these approaches are necessarily related to prices or tariffs for water and sanitation. They do however indicate the necessary amount of funds to be budgeted for any service provider, funds which might be derived from any combination of tariffs, taxes or international taxes/transfers.

3.1 Cash accounting and cash flow management

Cash flow management is concerned with the efficient use of the company's cash and short-term investments (Gregory, 1976). Cash accounting is an accounting method where receipts are recorded during the period they are received and expenses in the period in which they are paid. Cash flow management is important because most businesses can survive several periods of making a loss, but if they run out of cash they are likely to fail.

When access to cash is difficult and expensive, cash flow management is critical for businesses to survive. This is the situation faced by many developing countries when utilities are trying to expand services for water and sanitation. Unit costs are needed to determine investment cash flows (cash spent on capital expenditure and, rarely, cash received from the sale of long-life assets), operational cash flows (cash earned from user fees etc. and cash spent on recurrent activities) and financing cash flows (cash received from lenders as debt and as equity from owners or shareholders and cash paid as amortisation of debts in interest and principal repayments and as dividends to shareholders). By contrast, fixed asset accounting recognises costs when incurred rather than when paid (the accrual principle) but also separates out the CapEx (and the manner in which it has been financed) and reports it in the overarching financial statement (balance sheet). Any revenue or income from the service provision is accounted against the OpEx (the cost of operating the fixed assets), the CapManEx (the cost of maintaining those fixed assets in a serviceable condition) and the Cost of Capital (the cost of financing the fixed assets) in the Income and Expenditure statement (or Profit and Loss Account if private sector).

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

3.2 Fixed asset accounting and asset management: the regulatory approach

Cash accounting and fixed asset accounting both necessarily record costs that occurred in the past (historical costs). One reason for accounting, and one purpose of WASHCost, is also to estimate likely future costs so as to ensure ongoing services.

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

Asset management is "the combination of management, financial, economic, engineering and other practices applied to physical assets with the objective of providing the required level of service in the most cost-effective manner"[2] . The asset management plan gives visibility to the costs of regular operation and maintenance, non-regular maintenance, replacement and renewal plans over the short and long term, conducted to minimise costs while ensuring the functionality of each asset in the system. A significant component of the plan is a long-term cash flow projection for the activities. The costs profile will cover the life of the longest-lived asset in the system, so as to estimate the whole-life cost, and make it possible to determine average annual costs (Ingenium, 2006).

Fixed assets normally include land, buildings, motor vehicles, office equipment, machinery and, in the WASH sector, water and sanitation facilities. These assets are not directly sold to the end users but are used in service delivery. Fixed asset accounting is used for assets which cannot easily be converted into cash. These fixed assets are depreciated, which means that the expenses generated by the use of the assets are accounted for. Depreciation (the wear and tear that reduces an asset's historical value) is usually spread over the economic useful life of an asset because it is regarded as the cost of an asset absorbed over its useful life[3]. Steven Kachelmeier and Michael Granof (1993) conducted a study of 216 subjects. Their findings suggest that depreciation is a useful cognitive reminder to decision-makers in governmental organisations of the need to replace long-lived assets as they physically deteriorate. However, historical depreciation is not necessarily sufficient to cover the replacement costs of increasingly expensive assets due to the effects of inflation. This is especially true of assets that last a long time.

The main objective of the development of an asset management plan is to ensure that infrastructure assets continue to deliver an agreed level of service over their life-cycle in the most cost effective manner. For asset management, assets need to be valued at current costs rather than at historical, investment costs. This can be measured by using data from inventories and past costs, revalued by using inflation indices. The reason for using current costs is to ensure that sufficient funds are made available to undertake capital maintenance – which has to be carried out at today's prices. If a depreciation approach is taken, based upon the historical costs of constructing those assets, there will not be adequate cash available from tariffs or budgets to undertake the necessary renewals. Unfortunately, in rural water

2 New Zealand Infrastructure Asset Valuation and Depreciation Guidelines, 2006

3 http://en.wikipedia.org/wiki/Fixed_asset

supply, there is very frequently not even an inventory of the number of facilities built or their location, let alone any understanding of the current cost of maintaining them.

Table 4: Summary of accounting and costing practices and how different cost components are considered

Cost components	Cash accounting	Fixed asset accounting (regulatory approach)	Life-cycle assessments (economic cost approach)
Real, historical or estimated costs?	*Real and historical costs: 'backwards looking'*	*Real and historical costs:* *A combination of 'backward looking' and 'forward planning'*	*Estimated future costs: 'forward looking'*
Capital expenditure (software & hardware)	CapEx accounted as spent	CapEx accounted as constructed/spent, then updated to present day 'real'/ 'current costs' or 'modern equivalent asset values'	CapEx – as estimated from plans/budgets
Comments:	*Once paid for in cash accounting terms there is no further accounting for these assets*	*Indicates ongoing value of assets in financial reporting* *Appropriate inflation rates to use for revaluation are a matter for debate*	*Costs ideally based upon evidence-based cost models* *What is a valid asset life to assume? What are valid discount rates?*
Operating expenditure	Any minor and operating maintenance expenditure undertaken as charged	OpEx relative to Operations Management System standards as in current expenditures and as estimated from plans/budgets	All future operation costs are to be discounted to their present value, including any externality costs (over abstraction and waste water disposal) and 'free' labour costs
Comments:	*How can you know that enough is being spent on operations and minor maintenance to ensure 'good enough' services?*	*When using set standards to ensure adequate provision, how can you build in drivers for efficiency?*	*Based upon many assumptions: discount rates, externalities, inflation rates of different components*
Capital Maintenance	Major maintenance as it arises ignoring serviceability – or done through a new project (more Capital Expenditure)	CapManEx – 'broad equivalence' to real fixed asset using depreciated replacement cost. CapEx depreciation relative to risk based AMPs (Asset Management Plans) linked to serviceability.	*Present Value* of CapEx and any presumed (guessed) significant renewal required over presumed economic life of assets
Comments:	*Tends to undervalue/ignore capital maintenance – hence likely to be unfunded in budgeting procedures as it puts pressure on cash flow*	*How to ensure that depreciation of assets is accounted for and funds are available?* *Needs to be used at a simplistic level to ensure funds to maintain serviceability*	*Tends to be 'normative' in its approach. Lacks accuracy and too many 'guesstimates'*
Cost of capital	Interest rates payable on any relevant loans, including guarantee charges	Weighted average cost of capital (WACC): average interest on loans and/or equity returns/ dividends (e.g. water funds taken for other purposes in a municipality)	Opportunity cost of capital (economic understanding of value of capital used in next best alternative use)
Comments:	*Amortisation of any borrowing (actual interest rate & capital repayment) over life of loan, not related to life of assets*	*Repayment of any capital borrowing through cash flow management* *Is there sufficient accounting separation in municipalities to determine appropriate 'dividends?'*	*Discounted at opportunity cost of capital, varying from 3-7% for HICs and recommended 10% for LICs*

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

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

A paper which traced the use and application of the life-cycle costing technique in the US finds that LCC was originally developed in the 1960s by the US Department of Defence to enhance the cost effectiveness of its defence system equipment. LCC then evolved and started being applied in other industrial sectors (Sherif and Kolarik, 1981). Over the years, a major area of application has been the construction of buildings where estimated savings usually result from increasing the initial investment to significantly reduce energy consumption. In 2002, one set of methodologies was formalised in the 14040 series of ISO standards[4] providing an internationally accepted framework for conducting life-cycle assessments. Their most common use includes (green) building construction and energy conservation. Examples are the life-cycle costing approach to energy conservation of the governmental National Energy Efficiency Committee (NEEC) of Singapore[5] and the life-cycle assessment and life-cycle costs tool for commercial building developments in Hong Kong[6].

Life-cycle assessments consider an economic approach to costs. "LCC seeks to optimise the cost of acquiring, owning and operating physical assets over their useful lives by attempting to identify and quantify all the significant costs involved in that life, using the present value technique" (Woodward, 1997). Using a 'present value analysis' or 'engineering economics' approach is particularly useful when comparing alternative means of delivering future services. A comparison might need to be made, for example, between an expensive dam (high CapEx) with subsequent gravity flow transmission of water (low operational expenditure – Opex) and a cheaper well-field development of a groundwater source (lower CapEx) which requires high ongoing recurrent costs (high OpEx).

The conventional way of understanding which might be most suitable is through present value analysis. This approach takes into account what is known as the 'time value of money', reflecting the sense that society might give a higher value to money available for use now than to money available in the future. This analysis ignores any aspects of inflation as this is not relevant to the comparison and choices between alternatives in the future. It simply recognises that money that is available now could be used or invested and produce returns sooner or bigger than investments in the future. The approach of discounting future costs to the present rests on the 'opportunity cost of capital' (the likely return on use of that money in the best alternative) and enables a fairer comparison between different schemes with different intensities of capital and operational expenditure.

This approach is usually extended to include not only the present value of future costs but also an estimate of future benefits (net present value analysis). The resulting 'benefit-cost ratio' is an important tool for policy-makers to understand whether and what future investment can be justified.

4 ISO 14040-44-48 (2002-2006): Environmental management - Life cycle assessment -Principles and framework, International Organisation for Standardisation (ISO), Geneva http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=29872

5 http://www.nccc.gov.sg/main.shtm

6 http://www.emsd.gov.hk/emsd/e_download/pee/lceabc_lcea.pdf

Where service providers (government agencies) continue to use a cash accounting approach the estimation of the present value of the costs of future investment can be converted into an annual payment through the use of a 'capital recovery factor' which calculates how much would have to be budgeted for on an annual cash basis in order to repay a loan on that investment. This is a useful indication of future costs, particularly when estimates of future operational expenditure and occasional capital maintenance expenditure are added. It also includes recognition of the cost of capital in the interest rate or discount rate used in the calculation. However, in reality there is often a difference between the assumed lifetime of the assets and the likely lifetime of any financing. If the likely lifetime of an asset is used (which is usually shorter than the assumed lifetime) an additional annual cash sum is required during the lifetime of the loan.

The present value, 'engineering economy' approach is very convenient to consider future investments, and is accurate in so far as the assumption about the life of the asset is accurate, being most useful where there is a single asset system – which is not the case in most water supply and sanitation systems.

3.4 Final consideration on the three accounting approaches

Each of these three approaches is important and useful for different purposes. The economic approach is vital for deciding between possible future investments. The cash accounting approach helps governments and government agencies budget for future cash requirements. Fixed asset accounting has been found to be most useful in aggregating costs in the capital intensive water and sanitation sector (as with other utility sectors).

Fixed asset accounting provides the most useful answer to the question: *"What is the cost per year per person of delivering clean water and good sanitation services?"*

It can reasonably be argued that the accounting charge for capital maintenance, that is depreciation, also requires a guesstimate of asset life. This is indeed the case at the starting point for budgeting but, over time, the life-cycle costs approach seeks to determine the actual costs for capital maintenance required to maintain services by basing estimates of lifespan on real life experience with a particular technology in a particular area. Regulatory accountants talk about a 'broad equivalence' over time between the depreciation charge in the accounts and the actual expenditure on capital maintenance. With the LCCA it is possible to determine what is a reasonable amount to budget to ensure ongoing services; as those involved come to better understand the life cycle of asset systems so as to be able to repair, renew and rehabilitate systems before services fail. This approach is described in further detail in Briefing Note 1.b 'Services are forever' (Franceys & Pezon, 2010)

By investigating historical and current costs it is possible to share the best available evidence-based information with policy-makers and planners with regard to the future costs of achieving universal WASH services. Ideally we wish to be able to say with some confidence that analysis of the evidence and cross-country comparisons calibrate our understanding of costs and service levels. However, service levels might not be cost sensitive – management models, as well as many other external variables, impact costs and service level. Therefore, this analysis needs to be done with care.

4 How to compare and report costs: a step-by-step approach

This section first describes common mistakes in comparing and reporting costs and then offers a step-by-step approach to doing it correctly.

4.1 Common mistakes in reporting costs

Most reports do not make explicit which unit costs are estimates and which are based on empirical evidence. Most cost estimates depart from a micro analysis of considering every single component of a piece of infrastructure. Useful estimates for engineers are based on a 'bills of quantities' approach and most country-wide studies use this methodology. The limitation of reporting on these unit costs is that they are usually estimates rather than actual expenditures. In South Africa and India official bills of quantities are published showing very high costs that are used as 'acceptable ceilings'. On the other hand, when cost reports are based on large data collection using contractors' reports, these are more approximate to 'real costs'. Costs estimated in bills of quantities and costs actually incurred by large contractors have different degrees of accuracy.

Secondly, most unit costs for non-networked water services are calculated per person or per household per year for easier comparison of existing available data. In networked water supply services, it is most common to use the price per cubic meter, as this is presumed to reflect the total cost (but in practice rarely does) and, to some extent, the efficiency of the utility. In non-networked (mostly rural) water supply services, the cost per cubic meter is rarely known given the lack of metered distribution. Most sanitation unit costs are provided per household and divided by the (estimated) size of the household, which differs per country and even within countries, to arrive at a cost per person. Furthermore, water unit costs per person are often reported using a normative population and not the de facto served population. In many instances only the cost per infrastructure is provided and there is no measure of the population covered. A borewell constructed for a population of 500 people might be used by 200 or by 1000 people. The cost per person is very different in these circumstances, and service levels may fall if a source is overused.

Finally, yesterday's costs are not the same as today's. Inflation can be a significant element and there may be different levels of inflation in the construction sector or in the costs of chemicals like chlorine when compared to the usual measures of inflation in retail prices.

Many costs are reported in US dollars or euros, having been converted from local currency units to an international currency using a market exchange rate. The exchange rate is usually not mentioned, nor is the original local currency unit or the date. Comparing like with like becomes a challenge unless costs are converted from the local currency into an easily comparable currency in a specific or current year, using the necessary tools of inflation indices, currency market exchange rates or purchasing power parity (PPP).

4.2 Step-by-step approach to comparing and reporting costs

In 1992, Rassas described what is required for comparing and reporting costs in "A primer on comparing and using cost data in water and sanitation reports" (Rassas, 1992). The list below (Table 5) adapts and expands the rules of thumb to address the limitations mentioned above:

Table 5: A step–by-step approach for comparing and reporting costs

Steps	Purpose	Description
1	Costs of what?	Make sure that the cost (not the price) of different components is clearly stated. Mention which components are included in the costs and which are not.
2	Units of costs	Make clear the unit in which costs are reported: annual costs, per person, per household, per volume.
3	Real vs. estimated costs	Mention which costs are real and which are estimates. - For annualisation of costs state whether actual or ideal life spans have been used. - For the population served mention specifically whether this is based on the actual population, the 'designed for' population or an estimate. - For the volume, specify if the quantity is based on actual measurements (real) or is based on the design estimate or some other estimate. State if it is for water provided (sent out from the source) or water received, which may not be the same due to leakages, and unaccounted for abstractions. Refer to the source of the costs or the methodology used for collecting them.
4	Comparing costs over time	Choose a reference year and adjust all costs to that year to account for changes over time in the value of money. Base this on market inflation or choose another index such as the GDP deflator whichever is most sensible given the situation (explained below).
5	Compare costs from country to country	Convert all figures into a single currency (usually US dollars, because the most complete Databank[7] containing comparable financial data across the world uses it as a base for all its calculations). Choose the market (US$) or the purchasing power parity exchange rate (PPP US$) whichever is most sensible given the situation (explanation below).
6	Financial or economic approach	Finally, mention which costs are reported using financial analysis ('nominal' or 'real/ current' costs) or economic analysis ('present costs') – explained below.

4.3 Comparing costs over time: GDP deflator and market inflation rates

Cost data are often collected/reported for different years and from different countries. It is often necessary to convert these data to make them comparable. Take the following example: Operational and minor maintenance expenditures for VIP latrines in Ghana have been collected from 2002, 2004 and 2007. What is the equivalent OpEx in 2011? Because of inflation it is highly unlikely that these costs will be the same in 2011 and therefore the figures need to be adjusted. The first step in this process is to compare costs from different years in a specified local currency. There are two main methods which can be used: using the GDP deflator or the reported market inflation rates.

In the example below, the inflation rate (GDP deflator) has been used to bring all costs to their value in the year 2011. Unlike an inflation rate based on a price index (consumer price index), the GDP deflator is not based on a fixed basket of goods and services. The basket is allowed to change with people's consumption and investment patterns. Specifically, for GDP, the 'basket' in each year is the set of all goods that were produced domestically, weighted by the market value of the total consumption of each good. Therefore, new expenditure patterns show up in the deflator as people respond to changing prices. The advantage of this approach is that the GDP deflator measures changes in both prices and the composition of the basket – i.e. as prices and consumer preferences change, the GDP deflator accurately tracks both automatically. For this reason, the GDP deflator is in most ways a more accurate, and thus

7 The Dababank (http://databank.worldbank.org/ddp/home.do?Step=1&id=4) is a consortium of several international organisations with harmonised approaches to global financial data.

ideal, measure of pure price changes in the overall economy. GDP deflators[8] are available for most currencies at the Databank.

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

Alternatively, the consumer price index (CPI) can be used to measure the inflation rate. Inflation refers to the percentage increase in general price levels from one year to another (usually representing a changing basket of the most commonly purchased items). The official inflation rates (Consumer Price Index) are also available from the Databank[9].

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

For water supply and sanitation (sewerage) projects, it is sometime possible to collect country-specific construction indices prepared by the respective Department of Public Works or the GNP deflator. However, these are less relevant for international comparisons.

4.4 Comparing costs from country to country: market (US$) and purchasing power parity exchange rates (PPP US$)

Having inflated/deflated all costs for the chosen 'current' year, the following step is to convert costs in local currencies into US$ market rates or US$ Purchasing Power Parity (PPP). We use the US dollar as the most commonly referred to currency for international comparisons. This is due to the size of the US economy in global terms and the subsequent use of the dollar in international trade and by the international finance institutions. For local comparisons costs from other countries can be converted to the national currency. The PPP between two countries is the rate at which the currency of one country needs to be converted into that of the second country to represent the same volume of goods and services in both countries. PPP is used because exchange rates can be misleading. Market exchange rates are based on short-term factors and are subject to substantial distortions from speculative movements and government interventions. Comparisons based on exchange rates, even when averaged over a period of time such as a year, can yield misleading results. For example, it is claimed that the imbalance in water implementation costs between many African countries and India can be partly explained by the undervaluation of the rupee, perhaps by a factor of almost three, by the sophistication of the Asian supply chain (which reduces costs in Asia) and by the dependence of the African supply chain on rent-seeking international imports (which increases costs in Africa). PPP conversion factors[10] are available from the Databank.

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

Alternatively, unit costs can be analysed using the official 'market' exchange rate. This is useful because if an X amount of US$ are needed to reach 100 boreholes in a specific country, the cost of implementation must be related to the amount that it costs in the local currency to drill the boreholes. To determine how much budget is needed in a specific country to implement programmes, the market inflation rates are used and the cost calculations are based on the official exchange rate. This step is also more accurate in situations when most of the labour and materials are imported.

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

8 Databank code: Inflation, GDP deflator (annual %)

9 Databank code: Official exchange rate (LCU per US$, period average)

10 Databank code: PPP conversion factor, GDP (LCU per international $)

4.5 Financial or economic approach: current, nominal and present costs

In the convention of cost discussions, 'current' or 'real' costs typically refer to a financial approach that considers past costs brought to today's values by removing the effects of inflation. 'Present' costs are typically an economic approach and refer to future costs brought to today's values by discounting against the time value of money.

4.5.1 Financial approach: nominal or current (real) costs

A nominal value is the actual amount of currency at a specific date. Take the following example: In 1990, the cost of a latrine was US$ 10. By contrast, the real or current value reflects the purchasing power of a given expenditure. Real or current values have been explained above. Current values are relevant because with inflation the value of money decreases over time and governments, and eventually consumers, have to pay more to obtain the same service. This can be a serious problem with projects which are based on fixed grants or loans, especially where construction lasts several years. It is similarly a problem where budgetary allowances from government departments for OpEx and CapManEx are not increased to allow for inflation. When there are user charges for WASH services provision there is also a challenge regarding the extent to which those charges are regularly raised in line with inflation and not allowed to lag by several years. If governments allow too many automatic price rises inflation can become stronger and consumers ever poorer (where income and wages do not increase by the same amount). Where charges are not increased to cover inflation services deteriorate as managers no longer have sufficient resources.

Real or current costs or prices have had the effects of inflation removed from past costs. Any 'nominal' costs which need to be reported over a number of years are therefore adjusted by the relevant inflation factor so that they can then be quoted according to one specified year, ideally the most recent, as real costs (all costs in 2011 prices). In some accounting systems this is managed through current cost accounting, where all assets are brought to the current cost each year in order to gain the best understanding of underlying asset value and real profits or accounting surpluses.

4.5.2 Economic approach: present costs

The present value approach incorporates what is known as the 'time value of money'. This idea incorporates the effect of growth in money saved in a bank or another savings institution. The idea is that US$ 100 'in the hand' now is worth more than the same amount given or used in a project in a year's time, even if you ignore the effects of inflation. Within that year that US$ 100 could have gained in value from the interest earned or from being used more productively. At an interest rate (or return from productive use) of 10%, the US$ 100 would be worth US$ 110 after a year and, on the basis of compound interest, US$ 121 after two years. The concept of present values then suggests that US$100 in one year's time has a present value of US$ 90.9 (US$ 100/US$ 110) and in two years' time a present value of US$ 82.6 (US$ 100/US$ 121), both assuming a 10% 'discount rate' or cost of capital. This is a useful technique to bring future costs to present values, ignoring the effects of inflation (which would have to be added as a guesstimate of future inflation in any budgeting exercise).

Cost-benefit analysis brings past and future income into present net value by applying a discount rate which reflects the social opportunity cost of capital (the returns on capital in the event that the money was applied elsewhere). Because they will be used for cost-benefit analysis, some unit costs in the sector are not reported using current prices but as net present values (using discount rates). The discount rate used by economists varies broadly depending on the assumptions made (institutional structure, government policy and macro-economic conditions) and therefore costs which use different discount rates can only be compared with some caution. The lower the discount rate, the lower the overall cost estimates. These estimates vary widely. The Copenhagen Consensus (Whittington et al., 2008) uses a 3–6% range of discount rate for the sector, assuming that governments in developing countries have ready access to capital and that this would be the rate of return if donor money was invested in alternative projects. On the other hand the World Bank uses a 10% discount rate for (water infrastructure) project evaluation, assuming that investment capital in developing countries is scarce and the opportunity costs of the project being evaluated are therefore high. More recently, Carlevaro (2010) has used an 11% discount rate for a WHO cost benefit analysis study of water and sanitation projects.

A significant element of the costs incurred in achieving access to water and sanitation can come from communities supporting capital investment programmes through their labour – excavating trenches for pipes or preparing aggregate for concrete well rings. Households also support their sanitation capital expenditure through manual labour. Perhaps the most significant labour contribution is to operational expenditure through women and children collecting water. These non-financial costs can also be captured using household surveys (these are part of the LCCA indicator list), giving policy-makers, donors and planners the option of undertaking a purely financial analysis of costs or a full economic analysis. Costing time spent on these activities is not easy and is particularly complex in a country where paid employment in rural areas is the exception rather than the rule. The cost is often a theoretical one: "that is what it would have cost if someone had been paid to do it", or "that is what the householder has forgone by not doing paid work for that time". It can be argued both ways, but this 'economic cost' is not usually included in costing services, since the purpose is to budget for actual costs that need to be spent. Of course, if it was necessary to pay community members for this work in a situation of full employment, the real cost of water and sanitation services would rise accordingly.

5 Conclusion

The life-cycle costs approach offers a different perspective to look at problems in the water and sanitation sector which entail complex and unpredictable change processes with no easy solutions. Service level analysis, which encompasses quality, quantity, access, use, reliability and environmental protection provided to users, can lead to a more nuanced understanding of where underlying problems of coverage and slippage may lie.

Existing approaches which compare interventions in sanitation using engineering costs can be misleading. By contrast, LCCA considers a wider range of costs and seeks to define real lifespans and the number of users per system in cost comparisons. Using the life-cycle costs approach enables effective comparison of different WASH delivery systems within a district, country or region, in part because comparisons are based firmly on costs per services delivered, per year, per person. The LCCA can be tailored to specific needs and critical issues in each country.

Historical information on costs is dispersed throughout the sector in fractured memories or different documents with no central repository. A general recommendation across the WASHCost project is that (financial) data management should be strengthened at all levels. In addition, a general commitment is recommended for greater transparency and freedom of access to information. By improving accounting and the management of financial information, sector actors can be better equipped to plan for sustainable sanitation and water services, supporting financial mechanisms and targeted subsidies for the poor.

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Annexes

Table 6: **Checklist Life-cycle cost components – Water**

Life-cycle cost components	Resources	Infrastructure – service delivery	Demand/Access – user coping costs
Water	Costs involved in sustainable provision of water resources of required quantity and quality	Costs incurred by service providers when constructing, operating and maintaining water supply infrastructure	Costs incurred by users who routinely access formal, informal and private water supply systems to meet demands (domestic, municipal, commercial, industrial, MUS, livestock etc). These costs include any costs that are not met by the service providers.
CapEx Hardware *Capital investment in fixed assets: first time, extension, enhancement and augmentation*	- **Costs of WASH-related land treatment:** Source protection measures involving: extensive land treatment, construction of small recharge structures, bending and terracing to prevent soil erosion and sedimentation, water conservation measures within urban areas etc - **Costs of WASH-related engineering structures:** flood control structures, large groundwater recharge structures etc - **Costs of unconventional water sources:** desalination plants, wastewater treatment, inter-basin transfers - **For triangulation purposes:** government subsidies	- **Costs of constructing water storage infrastructure:** reservoirs, tanks etc - **Costs of water supply infrastructure:** wells (public and private) , canals, pumps, reticulation systems, balancing reservoirs, water tankers (public and private), water trains, offices, warehouses, etc - **Costs incurred when dry or low-yielding bore wells are drilled** - **Costs of water treatment plants:** desalination, fluoride, polluted water etc - **Costs of "overdesign"** relating to demands of floating populations, climate change mitigation - **Additional pro-poor costs:** related to pro-poor setting of water points and/or provision of MUS water - **Costs of small-scale water supply infrastructure:** community roof-water harvesting systems, community storage tanks, community connections etc. - **Costs of installing water meters:** point-of supply meters, telemetry systems, vehicles, IT systems for processing info - **Costs of water quality monitoring:** test kits, laboratories, vehicles, buildings, sampling equipment etc - **Cost of putting in place of billing system:** vehicles, IT costs etc - **For triangulation purposes:** government subsidies to construction	- **Community contribution to initial infrastructure costs** e.g. percentage charged by service provider - **Costs of water supply infrastructure purchased by users** e.g. water storage tanks or cisterns, filtration systems, piping, roof water harvesting systems - **Costs of private borewells**. If needed by users to augment the supply from the water provider - **One-off connection charges:** e.g. charge for connecting supply to individual houses

Life-cycle cost components	Resources	Infrastructure – service delivery	Demand/Access – user coping costs
CapEx Software *One-off work with stakeholders prior to/ or during construction or implementation, extension, enhancement and augmentation*	- **Cost of resource assessments:** resource assessments and audits (quality and safe yield) to identify source(s), specialist analysis, use of GIS and remotely sensed data, ground truth of secondary information - **Design costs:** source protection measures, facilitation of stakeholder participation - **Regulation costs:** establishment of groundwater protection zones, sanctuaries and/or strategic reserves - **Costs of Information, Education and Communication, institutional development and capacity building** - **Cost of compensation for people moved for dams or protection zones**	- **Infrastructure assessment costs:** Assessment of the status of existing infrastructure - **Demand assessments costs:** assessment of current and future seasonal demands for all uses and users that access WASH infrastructure - **Engineering design costs:** Costs of preparing GIS based maps to support and underpin design and planning processes, technical surveys, etc - **Costs of active stakeholder participation:** facilitated multi-level planning - **Costs of using specialist knowledge:** scenario building as an integral part of planning process, modeling and forecasting supply and demand - **Costs of IEC, institutional development and capacity building** - **Costs for demand creation for improved services:** construction of "show case" sites, exchange visits - **Cost of purchasing land on which to locate WASH infrastructure:** e.g. private operator buying land	- **Costs of active stakeholder participation:** e.g building and supporting community level organisations that participate in stakeholder-driven planning processes , facilitating planning processes etc - **Costs of using specialist knowledge:** by users to design infrastructure that they fund - **Costs of IEC, institutional development and capacity building:** skills needed as part of developing and sustaining community-level organisations, in users O&M activities etc
Costs of Capital	- **Cost of interest payments:** e.g., World Bank loans - **Returns on equity**	- **Cost of interest payments:** World Bank loans, personal loans (e.g. for small-scale private service providers) - **Equity provided to shareholders/ investors**	- **Cost of interest payments:** Personal loans (e.g. household connections), microfinance (either personal or group/ community based) - **Community surplus:** distributed to members or re-invested

Life-cycle cost components	Resources	Infrastructure – service delivery	Demand/Access – user coping costs
OpEx *Operating and minor maintenance expenditures*	- **Cost of maintaining structures listed in CapEx** - Costs of enforcing regulations relating to pollution and groundwater protection zones, transport, ground-water level recorders etc - **Possible payments to land users** under "payment for environmental services" schemes aimed at maintaining water quality of surface or groundwater resources - **Cost for raw water abstraction** (e.g. operator paying regulatory authority for abstracting water) - **For triangulation purposes:** government subsidies	- **Cost of operating and maintaining infrastructure listed in CapEx** - **Costs of O&M:** electricity or fuel, water man/water women costs, repairs, spare parts - **Costs of emergency or back-up supplies:** Payments to vendors or farmers for "emergency" water supply - **Costs of monitoring** - **Rent of land** (e.g. private operator paying for land use) - **Cost for using of system** (e.g .operator paying district or municipality for use of infrastructure) - **Costs of billing scheme:** meter reading, meter repair, billing system, debt collection - **Cost of complaints/breakdown system:** ensuring that demands are met 365 days/year, ensuring norms are achieved, breakdown notification and response system - **Costs of enforcing regulations:** checking meters, checking for illegal connections or water uses, pollution monitoring - **Costs of leak detection:** reducing unaccounted for water (UAW) - **For triangulation purposes:** government subsidies	- **Cost of transport** (payment for cart, buckets, etc) - **The cost incurred to complement the service:** cost of filtration/treatment (i.e. consumables, chloride, buckets, fuel for boiling water) - **The cost incurred to supplement the service:** contribution to OpEx, costs of alternative sources - **For triangulation purposes:** profit margin of the operator
CapManEx *Asset renewal, replacement and rehabilitation costs*	- **Cost of rehabilitating or repairing structures** particularly after extreme event such as cyclones	- **Costs of rehabilitating, renewing or replacing infrastructure**	- **Costs of rehabilitating, replacing or renewing infrastructure** incurred by users

Life-cycle cost components	Resources	Infrastructure – service delivery	Demand/Access – user coping costs
Expenditure on direct Support (ExpDS) *Post-construction support activities for local-level stakeholders, users or user groups*	- **Costs of supporting community-based organisations:** watershed management committees, ensuring women and poor participate actively in meetings - **Costs of supporting local governments:** specialist support at all levels, local-level artisan support - **Costs of long-term resource-related IEC and capacity building programmes** - **Other government departments** (e.g. pollution control, planning etc)	- **Costs of supporting community-based organisations:** water user committees, sanitation and hygiene groups, ensuring women and poor participate actively in meetings - **Costs of supporting local and intermediate level government institutions:** specialist support at all levels, local-level artisan support - **Costs of long-term infrastructure-related IEC and capacity building programmes** - **Other government departments** (e.g. State-government WASH departments)	- **Costs of post construction IEC activities** incurred by users
Expenditure on Indirect Support (ExpIDS) *Macro-level support, planning and policy making*	- **IWRM costs:** inter-sectoral planning and management of resources at different scales, alignment of these plans, sharing of information, managing a common information base, ensuring ecological flows are maintained - **Monitoring (at source) costs:** water quality and quantity monitoring networks, water quality laboratories and info bases - **IT systems and support costs:** Costs of capacity building in IT systems, developing and upgrading IT systems etc - **Other government departments** (e.g. finance, planning etc	- **IWRM costs:** inter-sectoral planning and management of water, power etc infrastructures at different scales, alignment of these plans, sharing of information, managing a common information base, ensuring ecological flows are maintained - **Monitoring (at point of supply) costs:** water quality and quantity monitoring networks, water quality laboratories and info bases - **IT systems and support costs:** costs of capacity building in IT systems, developing and upgrading IT systems etc - **Other government departments dealing with water** (e.g. finance, planning, education, health, etc) - **NGO costs for supporting the sector**	Not applicable

Table 7: Checklist life-cycle cost components – Sanitation & Hygiene

Life-cycle cost components	Resources	Infrastructure – service delivery	Demand/Access – user coping costs
Sanitation & Hygiene	Costs involved in protecting water resources from disposal of black and grey waste water and storm water.	Cost incurred by service providers when constructing, operating and maintaining sanitation ,environmental sanitation and grey and black waste water and storm water infrastructure. Also other costs incurred by service provides that relate to CLTS and/or creating and maintaining demand for and ownership of improved sanitation, environmental sanitation and hygiene practices.	WASH costs incurred by users who routinely access formal, informal and private grey and black waste water and storm water systems to meet demands. These costs include any costs that are not met by the service providers.
CapEx Hardware *Capital investment in fixed assets: first time, extension, enhancement and augmentation*		- **Costs of off-site black waste water transport and disposal structures:** combined or separate conventional sewerage lines, manholes, overflow structures, shallow/small bore sewerage systems, etc - **Costs of off-site black waste water treatment:** Conventional sewerage treatment, Constructed wetland, oxidation pond, etc - **Costs of sludge disposal:** disposal, land for drying, etc - **Costs of off-site grey waste water disposal/treatment:** closed or open (street) drains, outlet structures - **Costs of storm water drainage:** open storm water drains, outlet structures, etc - **Costs of storage of storm water:** pond/tank for surface storage, infiltration wells for groundwater storage - **Costs of waste water quality monitoring:** test kits, laboratories, vehicles, buildings, sampling equipment, etc - **Costs of putting in place billing system for off-site sanitation systems:** vehicles, IT costs, etc - **For triangulation - subsidies:** department/programme contributions to on-site household) sanitation or grey waste water disposal (e.g. soakpits at homes and public taps, storage for productive use); subsidy costs of public on-site sanitation facilities (e.g. schools, public latrines, health and community centres)	- **Costs of on-site (household and public) sanitation:** single/double pit latrines, ecosan toilets, septic tanks, etc - **Costs of on-site grey waste water treatment/disposal:** soakpits at homes and public taps, storage structure for productive use, etc - **User costs of on-site storm water disposal:** (open) drains, soakpits - **One-off connection charges:** e.g. individual houses connected to sewerage system

Life-cycle cost components	Resources	Infrastructure – service delivery	Demand/Access – user coping costs
CapEx Software *One-off work with stakeholders prior to/ or during construction or implementation, extension, enhancement and augmentation*	- **Cost of environmental impact assessments:** EIA and audits (quality and quantity) to identify safe disposal (sites), specialist analysis, use of GIS and remotely sensed data. Also includes assessment to prevent surface or ground water pollution by poor design or construction of on-site sanitation or drainage systems.	- **Infrastructure assessment costs:** assessment of the status of existing infrastructure - **Demand assessments costs:** assessment of current and future (seasonal) demands for all uses and users that access sanitation infrastructure - **Demand creation costs:** awareness raising, social marketing, social mobilisation - **Design costs:** facilitation of stakeholder participation in alternative designs - **Engineering design costs:** costs of preparing GIS based maps to support and underpin design and planning processes, technical surveys, etc - **Costs for hygienic behavior change:** costs for campaigns for hand washing, safe sanitation by all, etc. These could be related to Community Led Total Sanitation programmes and/or attempts to reach NGP status (India). - **Costs of active stakeholder participation:** facilitated multi-level participation in demand creation, demand assessment, planning, etc - **Costs of using specialist knowledge:** e.g. scenario building as an integral part of planning process - **Costs of IEC, institutional development and capacity building:** for design/implementation/ management of (alternative) technologies - **Regulation costs:** safety during construction - **Costs of purchasing land on which to locate waste water infrastructure**	- **Costs for hygienic behavior change:** community investment in campaigns for hand washing, safe sanitation by all, etc - **Costs of active stakeholder participation:** building community level organisations for participation in demand creation, demand assessment, planning, etc (e.g. ODF strategies) - **User costs of IEC, institutional development and capacity building:** especially in skills to maintain behavior change, maintaining on-site sanitation facilities
Costs of Capital		- **Cost of interest payments:** World Bank loans and others - **Returns on equity**	- **Cost of interest payments:** personal or group loans for e.g. household latrines and other microfinance schemes related with sanitation

Life-cycle cost components	Resources	Infrastructure – service delivery	Demand/Access – user coping costs
OpEx *Operating and minor maintenance expenditure*	- **Costs of enforcing regulations** relating to pollution of water sources	- **Cost of operating and maintaining infrastructure listed in CapEx:** fuel, spare parts etc - **Costs of O&M:** electricity or fuel, labour costs, government contributions - **Costs of monitoring** - **Costs for using of system** (e.g operator paying district or municipality for use of infrastructure (license costs)) - **Costs of billing scheme:** billing administration, debt collection - **Costs of enforcing regulations:** checking safe discharge	- **Costs of hygienic behavior:** e.g. use of soap - **Costs of paying service fee (taxes) for connection to sewerage system** - **Costs of regularly emptying and disposing latrines** - **For triangulation:** costs for using public sanitation facilities
CapManEx *Asset renewal, replacement and rehabilitation costs*		- **Cost of rehabilitating or repairing structures/systems** particularly after extreme event such as cyclones, floods	- **Costs of construction of new latrine pits/latrines:** especially in case of double-pit and when initially only one pit was constructed - **Costs of non-regular emptying and disposing latrines**
Expenditure on direct Support (ExpDS) *Post-construction support activities for local-level stakeholders, users or user groups*	- **Costs of long-term environmental-related IEC and capacity building programmes**	- **Costs of supporting community-based organisations:** water user committees, sanitation and hygiene groups, ensuring women, men, children and poor participate actively in campaigns/meetings - **Costs of supporting local and intermediate level government institutions:** specialist support at all levels, local-level artisan support - **Costs of long-term infrastructure-related IEC and capacity building programmes** - **Other government departments:** e.g. water supply	- **User costs of participating in IEC, institutional development and capacity building**
Expenditure on Indirect Support (ExpIDS) *Macro-level support, planning and policy making*	- **IWRM costs:** inter-sectoral planning and management of resources at different scales, alignment of these plans, sharing of information, managing a common information base - **IT systems and support costs:** Costs of capacity building in IT systems, developing and upgrading IT systems etc	- Monitoring costs: waste water quality laboratories and info bases - **IT systems and support costs:** costs of capacity building in IT systems, developing and upgrading IT systems etc - **Cost of developing adequate policies and legal framework:** environmental health related to waste water, CLTS etc - **Health costs:** inter-sectoral planning and management of demand at different scales, alignment of these plans, sharing of information, managing a common information base, ensuring health/hygiene awareness is maintained - **Other government departments dealing with sanitation** (e.g. finance, planning, education, etc) - **NGO costs for supporting the sector**	