| Manuscript Number: |  |
| Article Type: | General paper |
| Full Title: | Life-cycle costs approach for sustainable private piped water service delivery: a study in rural Viet Nam |
| Keywords: | Vietnam; Life-cycle costs; Rural water supply; Private sector; Enterprise |
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| Funding Information: | Department of Foreign Affairs and Trade, Australian Government  
Not applicable |
| Abstract: | While private sector involvement in rural water supply in Viet Nam has been incentivised through subsidies and tax benefits, there is limited understanding of the costs or relative business opportunities for private enterprises and what this means for system sustainability. In particular, the life-cycle costs associated with the delivery of safe and sustainable water services in rural Viet Nam are not well known, potentially compromising their long-term sustainability. To address this gap, this study assessed the cost structures of fourteen water schemes in Viet Nam managed by private enterprises. Results showed that both capital and operational expenditures varied widely across the schemes assessed. Twelve of the fourteen schemes generated an operating profit in the most recent calendar year; however, when taking into account depreciation, as well as historical subsidies and connection fee payments, only four of the schemes were profitable based on a 20-year design life assumption. The study has implications for equitable piped water provision, complementing previous research that has demonstrated barriers to achieving universal access when relying on user-pays systems such as those provided by private water enterprises. Despite the challenge of collecting high quality cost data, the results provide a useful reference point to inform business planning for enterprises (e.g. connection fees and tariffs), policy and support mechanisms provided by government and development partners, as well as asset management processes for rural water supply. |
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Life-cycle costs approach for sustainable private piped water service delivery: a study in rural Viet Nam

Short title: Life-cycle costs approach for sustainable rural piped water supply in Viet Nam

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Abstract

While private sector involvement in rural water supply in Viet Nam has been incentivised through subsidies and tax benefits, there is limited understanding of the costs or relative business opportunities for private enterprises and what this means for system sustainability. In particular, the life-cycle costs associated with the delivery of safe and sustainable water services in rural Viet Nam are not well known, potentially compromising their long-term sustainability. To address this gap, this study assessed the cost structures of fourteen water
schemes in Viet Nam managed by private enterprises. Results showed that both capital and operational expenditures varied widely across the schemes assessed. Twelve of the fourteen schemes generated an operating profit in the most recent calendar year; however, when taking into account depreciation, as well as historical subsidies and connection fee payments, only four of the schemes were profitable based on a 20-year design life assumption. The study has implications for equitable piped water provision, complementing previous research that has demonstrated barriers to achieving universal access when relying on user-pays systems such as those provided by private water enterprises. Despite the challenge of collecting high quality cost data, the results provide a useful reference point to inform business planning for enterprises (e.g. connection fees and tariffs), policy and support mechanisms provided by government and development partners, as well as asset management processes for rural water supply.

Keywords

Vietnam; Life-cycle costs; Rural water supply; Private sector; Enterprise.

Introduction:

In recent years, the rural water sector in low- and middle income countries has been characterised by a move away from an infrastructure-focused model to a service delivery model. This shift has been spurred by the growing recognition of non-functional and unsustainable systems, hindering the realisation of the health and welfare benefits that would normally be expected to flow from improvements in water supply infrastructure (Burr 2013). A service delivery model requires the full costs of WASH services to be better understood and managed, so that systems can be maintained, potentially expanded, and sustained in the long-term (World Bank, 2017).
The required costs and investment to expand and sustain services is a critical issue facing the sector. The higher bar set by the Sustainable Development Goals (SDGs) for Targets 6.1 and 6.2 requires countries to aim for ‘safely managed’ services rather than provision of access to ‘improved’ infrastructure alone. ‘Safely managed’ in the water services context means that water supplies must be located on premises, available when needed, and free of faecal and priority chemical contamination (UN 2017). Hutton and Varughese (2016) found that capital investments required to achieve SDG targets 6.1 and 6.2 amount to about three times current investment levels, and that financial and institutional strengthening will be critical for ensuring any increase in capital investment leads to sustainable services. This research contributes to this broader call for strengthening the enabling environment through an improved understanding of the real costs associated with delivering sustainable water supply services in rural areas, so that these costs can be met through a range of sources.

There is growing support for the Life-Cycle Cost Approach (LCCA) as a tool for driving sustainability improvements in the rural water supply sector, including in Viet Nam. In a water service context, life-cycle costs refer to the full set of costs associated with delivering an adequate water service indefinitely (Fonseca et al 2010). Application of a LCCA to WASH in countries in the Global South is nascent, but has been spurred by the WASHCost initiative, which aimed to make LCCA methodologies more accessible to the rural WASH sector (Fonseca et al 2011). Prior to the present study, LCCA had yet to be applied to rural water services in Viet Nam, and is not known to have been applied to privately operated rural water services anywhere in the world. This is despite growing acknowledgement among policymakers of the need to better understand the true costs associated with providing rural water services. Illustrative of this is Viet Nam’s National Action Plan, which articulates a desire for the development of regulations on cost norms (referred to as technical economic standards in
Viet Nam) for clean water supply in rural areas in pursuit of SDG target 6.1 (Government of Viet Nam 2017). Without rigorous research into life-cycle costs of rural water supplies, sustainability improvements in the rural water sector will not be realised.

Few peer-reviewed studies have analysed revenue and expenditure (costs) of small-scale rural water services in low- and middle-income countries. Rather, LCCA has primarily been used for urban systems located in well-resourced countries (Jones et al, 2012). In the Global South, a life-cycle approach to determine the cost of water scheme options is difficult because there is limited data available for such systems and water system design is very dependent on the local context (Jones et al, 2012). Reddy et al (2012), assessed the cost of water provision in 43 villages in Andhra Pradesh, India, and found that unit costs were substantially higher than the prescribed cost norms. This study drew on secondary data obtained from a range of pre-existing sources, including official records of district-level authorities and household surveys. In a study focused on schools in Kenya, data were collected from NGO and government offices, local hardware shops and 89 rural primary schools across three Kenyan counties (Alexander et al, 2016). This study estimated that current expenditures on WASH were approximately 60% of what was needed to meet recurrent costs (Alexander et al, 2016). Another study of rural water supplies in Kenya analysed water committee records, and found expenditure levels varied greatly across schemes, with both operational model and seasonality influencing the magnitude and timing of operation and maintenance costs (Foster & Hope, 2017). These studies show that LCCA is useful in identifying financing gaps and economic sustainability issues, which without being addressed, can lead to non-functional or under-performing water schemes.
Background: Privately operated piped water services in Viet Nam

Rural Viet Nam has seen rapid growth in piped water service coverage in recent years due to a supportive policy environment, and in line with the new SDG target of safely managed services. Between 2000 and 2016, around 16,200 piped water schemes were constructed in rural areas (Mansour 2016), resulting in an increase in piped water access from 920,000 people in 2000 (1.5% of the rural population) to 12.5 million people (20.1% of the rural population) in 2015 (UNICEF/WHO 2018). This trajectory is likely to continue, with Vietnam’s Country Strategy on Rural Water Supply and Sanitation to 2020 setting the target that by 2020: ‘all rural residents use clean water meeting national standards, and access at least 60 litres/person/day’ (CERWASS, 2000). The elevated SDG ambition of safely-managed water services, with its requirement of being ‘on premises’ and free from contamination, provides further impetus to accelerate the expansion of piped water systems.

Government and development actors in Viet Nam have increasingly promoted private sector management models through a range of policy levers and funding support. According to the Viet Nam Government’s Ministry for Agriculture and Development (MARD), private enterprises manage 13% of rural water supply systems in Viet Nam, with the community managing 70% and pCERWASS and state boards managing 17% of schemes (Directorate of Water Resources, 2018). In the Vietnamese context, private water enterprises are entities that have invested private funds in a water system and own and/or operate the system under a formal or informal agreement with a Provincial People’s Committee (PPC), or a Commune People’s Committee (CPC). Policy support for private sector involvement in the delivery of rural water services in Viet Nam dates back almost two decades. The National Rural Clean Water Supply and Sanitation Strategy 2020 (developed in 2000 and updated in 2011) stated that the Viet Nam
Government will encourage the private sector to invest in and to construct rural water facilities, especially piped water supply systems.

Since the adoption of the National Rural Clean Water Supply and Sanitation Strategy 2020 strategy, measures have been put in place to facilitate and incentivise privately owned rural water supply schemes, including access to land, loans support, water tariff and tax subsidies, yet it is not well understood who benefits from these support systems. The NRWSS called for ‘improving business environment so that private sector can compete with state owned enterprises on an equal basis’, as well as ‘strengthening the private sector’s capacity in technical as well as business skills’ (CERWASS, 2000). In 2009, the government issued ‘Decision 131’, which laid out a framework for supporting eligible enterprises, including incentives to operate in rural water supply and sanitation contexts (MARD, 2013 in Gero et al 2014). Decision 131 and its guidance in Circular 37 (2014) supports private enterprises to access to land, soft loans capital subsidy and mobilization, water tariff and tax discounts. However, this policy has not always been realised in practice, and recent research suggests this support is not consistently offered (Gero and Willetts, 2014; Willetts et al, 2017), and nor is it well understood who receives access to these subsidies, and who benefits as a result (Grant et al, 2016b). In line with the Viet Nam Government policy encouraging privately owned rural water schemes, international donors and NGOs have also sought to encourage private sector actors to fill water service funding and capacity gaps in rural Viet Nam (Grant et al 2016a and 2016b). This includes subsidisation of privately managed and owned piped water systems, paying for system extensions, building capacity and training WASH entrepreneurs (Gero and Willetts 2014).

Despite the policy incentives, research has found that there is little understanding of the financial viability of the private water enterprises, nor the required oversight of their financial performance and what this might mean for a water scheme’s sustainability (Willetts et al 2017).
This is an important issue to clarify in light of government data that suggests approximately 14.4% of rural piped systems are not working, and a further 16.8% are performing poorly (Directorate of Water Resources 2018). A recent assessment of the water supply sector in Viet Nam suggests institutional capacity and monitoring and regulation remain the areas most in need of strengthening (World Bank 2017). Delivering sustainable WASH services requires asset management processes that enable infrastructure to be maintained and/or replaced at the end of its useful life, and support systems function and potentially expand with increased demand (Reddy et al 2012). As noted by Moriarty et al (2013), the first step to ensuring financial sustainability of services lies in identifying the full life-cycle costs of service provision and the revenue sources that can meet those costs.

Tailored policy instruments, and mechanisms to implement them are needed for the rural water supply sector in Viet Nam. A recent multi-country assessment of rural water service delivery models concluded that Viet Nam had low levels of institutional capacity, monitoring and regulation (World Bank 2017). Nonetheless, at the national and provincial level, Viet Nam is engaging in a number of policy initiatives to explore technical/economic norms and unit cost calculation for rural water supplies. For example, under Joint Circular 75, the Central Government of Viet Nam has developed a process to calculate the costs of providing a water service for a scheme assuming an asset with a 20-year life. Subsidies are able to be provided by provincial governments to cover the gap between the estimated revenue they will receive from the regulated water tariff paid by the consumer, and the real cost of providing a sustainable, safe water supply over the 20-year period. It is unclear, however, how this has been implemented in practice, partly due to the urban-centric nature of the policy instruments available to the water supply sector. This can be seen in the policy supporting the setting of tariffs based on anticipated life-cycle costs (Joint Circular 75 and Decision 590) which was
designed for large urban water utilities, and the methodology is therefore not immediately transferrable to small-medium rural water enterprises. For example, the policies are oriented towards large-scale water schemes which lead to expected infrastructure and subsequent tariffs being higher, which may be unacceptable to provincial government departments and result in non-approval of proposed tariffs and subsidies.

Sustainably financing rural water supply systems

The benefit of an improved understanding of how much a piped water service costs in the short and long term is that sources of financing can be matched to the costs. This means that operation and maintenance can be financed, capital works are upgraded and replaced when needed, and services are provided in a safe and sustainable manner. Three sources of financing are commonly considered in the water supply sector, known as the “Three T’s”: (1) taxes from individuals and businesses (2) transfers such as overseas aid, remittances or market interest rate lending (3) tariffs paid by households, businesses and governments (OECD, 2009). In a systematic review of success factors of the community management of rural water supplies over the last 30 years, Hutchings et al (2017) found that over 90% of high performing cases received external financial support for a variety of expenditures, including CapEx, OpEx, and CapManEx, and materials from external organisations (Hutchings et al 2017). While this paper does not address community managed rural water systems, the research points to the typical need of a range of finance sources, in order to achieve high performing small scale rural water supply systems, including from external sources, should that be needed.

The policy drivers for increased piped water supplies, yet the poor attention paid to their financial sustainability to date provided a useful context for this study to investigate life-cycle costs private rural water services. The study focused on collecting empirical cost data, as well
as how those costs are then met and allocated between different stakeholder groups, which is a challenge that every water governance context needs to contend with. This includes, for example, how much of the total cost is passed on to customers, to what extent services are subsidised, by whom and for whom. The broader purpose of the study was to provide the Government of Viet Nam (at Central, Provincial and Commune level) and its development partners a better understanding of the costs and revenues of small-scale piped water systems over time. Its findings can support government agencies to develop evidence-based policies, regulations and incentive structures, aid private enterprises in business planning and structuring connection fees and tariffs, and inform efforts of development partners to design and implement targeted support mechanisms.

Methods

This investigation adapted the LCCA process developed by WASHCost (Fonseca et al 2011) to quantify the costs associated with delivering piped water services for 14 schemes in rural Viet Nam. The study also identified the factors that drive and influence those costs, and assess the ability of scheme operators to cover those costs.

Financial data were collected from 14 privately owned and operated piped water supply schemes between December 2016 – March 2018. The sites were selected through a purposive sampling process, with four located in the northern part of the country and ten in the south (Figure 1). This geographical representation was considered important given variability in technical, institutional and socio-economic characteristics. For example, in the north of Viet Nam private enterprises are often larger than those in the South/Mekong region, and draw from surface water sources to a greater extent.
Figure 1. Locations of water supply systems assessed

Data collection instruments were designed to capture a comprehensive set of costs associated with the construction, operation and maintenance of small-scale piped water services. The structure and contents of the questionnaire were informed by the WASHCost LCCA framework (Table 1). Additional questions relating to a scheme’s technical and operational characteristics (e.g. size, service level, water source) were also included. The data collection tool was piloted in December 2016 and then refined prior to use across all participating schemes. As the focus was on the costs incurred by the service providers themselves, no data were collected on direct or indirect support expenditure (as is commonly included in the WASHCost methodology).
**Table 1. Life-cycle cost categories (modified from Fonseca et al 2011)**

<table>
<thead>
<tr>
<th>WASH Cost Category</th>
<th>Description</th>
<th>Included in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital expenditure (CapEx)</td>
<td>Expenditure on ‘first-time’ construction, installation or purchase of new infrastructure and equipment. Covers both hardware and software and includes system expansions.</td>
<td>Yes</td>
</tr>
<tr>
<td>Operating and minor maintenance expenditure (OpEx)</td>
<td>Expenditure on recurrent or regular inputs (e.g. labor, fuel, chemicals) or activities (e.g. routine maintenance)</td>
<td>Yes</td>
</tr>
<tr>
<td>Capital maintenance expenditure (CapManEx)</td>
<td>Expenditure on renewal, replacement or rehabilitation of equipment or system components</td>
<td>Yes</td>
</tr>
<tr>
<td>Cost of capital (CoC)</td>
<td>Cost of accessing financing, which includes interest on loans and dividends to shareholders</td>
<td>Yes</td>
</tr>
<tr>
<td>Expenditure on direct support (ExpDS)</td>
<td>Expenditure on local support activities, including those directed to ensuring local government has adequate capacity and resources to carry out planning, implementation and regulatory functions</td>
<td>No</td>
</tr>
<tr>
<td>Expenditure on indirect support (ExpIDS)</td>
<td>Expenditure on broader sector-level activities such as planning and policy development</td>
<td>No</td>
</tr>
</tbody>
</table>

Data on the various costs, revenues and system characteristics were provided by the individual responsible for overall management of each scheme from a range of sources. The interview process was conducted in Vietnamese, and typically lasted half a day or more. Financial information was drawn from various sources, including accounting records, invoices and respondent recall. Respondents were subsequently followed up with additional questions where
data were ambiguous, anomalous or missing. Ethics approval for the study was obtained from the Institute for Sustainable Futures, University of Technology Sydney.

For each scheme, individual cost items were aggregated and assessed for each category as defined by the WASHCost methodology. Operational expenditure (OpEx), cost of capital (CoC) and capital maintenance expenditure (CapManEx) were annualised for consistency, and all costs were converted to US dollars in 2016 by applying deflator factors and a period average exchange rate of USD 1 equal to VND 21,935 (World Bank 2018a, 2018b). Costs were overlayed with reported revenue in order to assess the profitability of schemes. To compare the WASHCost life-cycle cost methodology with Viet Nam government-endorsed accounting practices for water service providers, annual depreciation was calculated based on a straight-line method applied to capital expenditure. To identify major cost drivers, OpEx was disaggregated into five key categories: labour, electricity, chemicals, taxes and ‘other’. Average costs were also compared across different factors and dimensions, including water source, season, scheme size, age, and service level.

Results:

Scheme characteristics

While all schemes included in the study were small rural piped water schemes, they had a wide range of characteristics that should be taken into account in interpreting the study results. The 14 schemes varied in age, size and production capacity as shown in Table 2. The age of the schemes ranged from four to 21 years, and on average supplied water for 20 hours per day. The average tariff was USD 0.32 per cubic meter, and average connection fee was US$53. Half of the schemes drew on surface water and the other half drew on groundwater. Based on WASHCost definitions of water service levels, the schemes typically performed to a high standard against quantity and accessibility, to an intermediate to high standard in terms of
reliability, while the extent to which schemes provided water of acceptable quality was unclear (Table 3). It is important to note that these service standards were self-reported by scheme operators, and were not independently verified. Although water quality testing was reported to take place periodically, the lack of readily available information on water quality meant it was not possible to determine whether these schemes met the SDG criteria for “safely managed” water services.

Table 2. Summary characteristics of the schemes included in the research (n=14).

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>System age (years)</td>
<td>14.2</td>
<td>6.3</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Hours of service per day</td>
<td>19.5</td>
<td>5.4</td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td>Number of connections</td>
<td>1,633</td>
<td>986</td>
<td>720</td>
<td>3,555</td>
</tr>
<tr>
<td>Production capacity (m³/day)</td>
<td>1,144</td>
<td>783</td>
<td>120</td>
<td>2,400</td>
</tr>
<tr>
<td>Water supplied per connection (l/day)*</td>
<td>311</td>
<td>136</td>
<td>125</td>
<td>556</td>
</tr>
<tr>
<td>Tariff (USD/m³)</td>
<td>0.32</td>
<td>0.04</td>
<td>0.26</td>
<td>0.38</td>
</tr>
<tr>
<td>Connection fee charged (USD)</td>
<td>53</td>
<td>49</td>
<td>0</td>
<td>153</td>
</tr>
</tbody>
</table>

* Note that the number of connections includes business and community institutions (hotels, schools, water consuming businesses) and so this does not reflect domestic production/use per connection.
Table 3. Typical service levels for 14 schemes included in the research

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Service standards categorisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>High (&gt;= 60 Litres per person per day)</td>
</tr>
<tr>
<td>Quality</td>
<td>Unknown (No water quality data made available, though all schemes tested water quality at least twice a year and 11 of 14 schemes included water treatment plant)</td>
</tr>
<tr>
<td>Accessibility</td>
<td>High (Less than 10 minutes to access the source due to household connections being the norm for these 14 schemes)</td>
</tr>
<tr>
<td>Reliability</td>
<td>Intermediate to high (Reliable/secure = 13 of the 14 schemes were reported to work most of the time with an average of 19.5 hours of service per day).</td>
</tr>
</tbody>
</table>

**Capital expenditure**

Capital expenditure (CapEx) reported by scheme operators averaged USD 324 per connection, and varied between USD 55 and USD 522 per connection (Table 4). Around one-quarter of capital investment related to system expansions subsequent to initial construction. For those schemes reporting the source of financing, 80% of capital investment was financed by the scheme owners either directly or via loans taken out from a bank/lender, 9% by NGOs, 7% by government and 4% by households. However, modelling of water connection fees suggests up to 20% of capital investment may have been covered by households. External subsidies constituted a larger proportion of system upgrades and expansions compared with initial construction cost (27% vs 10%). Schemes that were younger than 10 years tended to report higher levels of CapEx per connection (USD 380 vs 294), as did schemes drawing on surface water as opposed to groundwater (USD 371 vs 273), and schemes with a water treatment plant (USD 359 vs 199). Scheme size had no clear association with CapEx per connection.
Table 4. Cumulative CapEx invested by scheme

<table>
<thead>
<tr>
<th>Scheme code</th>
<th>Region</th>
<th>Source</th>
<th>Age</th>
<th>No. connections</th>
<th>CapEx (USD)</th>
<th>Total</th>
<th>Per connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>N001</td>
<td>North</td>
<td>SW</td>
<td>4</td>
<td>3,555</td>
<td>1,171,567</td>
<td>330</td>
<td></td>
</tr>
<tr>
<td>N002</td>
<td>North</td>
<td>GW</td>
<td>7</td>
<td>764</td>
<td>395,885</td>
<td>518</td>
<td></td>
</tr>
<tr>
<td>N003</td>
<td>North</td>
<td>SW</td>
<td>8</td>
<td>3,500</td>
<td>1,802,491</td>
<td>515</td>
<td></td>
</tr>
<tr>
<td>N004</td>
<td>North</td>
<td>SW</td>
<td>15</td>
<td>720</td>
<td>375,875</td>
<td>522</td>
<td></td>
</tr>
<tr>
<td>S001</td>
<td>South</td>
<td>GW</td>
<td>17</td>
<td>1,466</td>
<td>80,954</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>S002</td>
<td>South</td>
<td>GW</td>
<td>20</td>
<td>2,642</td>
<td>761,251</td>
<td>288</td>
<td></td>
</tr>
<tr>
<td>S003</td>
<td>South</td>
<td>GW</td>
<td>19</td>
<td>1,850</td>
<td>470,905</td>
<td>255</td>
<td></td>
</tr>
<tr>
<td>S004</td>
<td>South</td>
<td>SW</td>
<td>17</td>
<td>1,000</td>
<td>325,106</td>
<td>325</td>
<td></td>
</tr>
<tr>
<td>S005</td>
<td>South</td>
<td>GW</td>
<td>6</td>
<td>2,300</td>
<td>276,755</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>S006</td>
<td>South</td>
<td>SW</td>
<td>19</td>
<td>1,000</td>
<td>393,734</td>
<td>394</td>
<td></td>
</tr>
<tr>
<td>S007</td>
<td>South</td>
<td>SW</td>
<td>20</td>
<td>1,017</td>
<td>183,675</td>
<td>181</td>
<td></td>
</tr>
<tr>
<td>S008</td>
<td>South</td>
<td>GW</td>
<td>7</td>
<td>1,000</td>
<td>458,462</td>
<td>417</td>
<td></td>
</tr>
<tr>
<td>S009</td>
<td>South</td>
<td>SW</td>
<td>19</td>
<td>1,071</td>
<td>379,435</td>
<td>354</td>
<td></td>
</tr>
<tr>
<td>S010</td>
<td>South</td>
<td>GW</td>
<td>21</td>
<td>980</td>
<td>262,820</td>
<td>268</td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>14.2</strong></td>
<td><strong>524,208</strong></td>
<td><strong>324 (144)</strong></td>
<td></td>
</tr>
<tr>
<td>(SD)</td>
<td></td>
<td></td>
<td></td>
<td><strong>1.633 (986)</strong></td>
<td><strong>(453,577)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Recurrent expenditure**

Operational expenditure (OpEx) reported by scheme operators averaged USD 23.9 (range USD 13.9 – 48.4) per connection per year and 0.22 per cubic meter, and varied between USD 14-48 per connection year and 0.09-0.34 per cubic metre (Table 5). Only one scheme reported unit OpEx that exceeded their volumetric tariff, indicating that OpEx was likely covered by tariffs in most of the schemes involved in this study.

Labour and electricity constituted the major operational cost categories, amounting to 43% and 25% of the average costs respectively, followed by taxes (10%) and chemicals (9%) (Figure 2). The water resource upon which a scheme relied had an influence on OpEx: schemes lifting...
groundwater spent almost 41\% more on electricity (per cubic meter of water supplied) than those drawing on surface water, but their chemical costs were 79\% lower. Scheme size – particularly when measured by volume of water supplied – exhibited a negative association with unit operational costs (p<0.001), indicative of economies of scale. OpEx incurred by schemes in the South appeared to be heavily influenced by monthly rainfall, suggestive of rainwater harvesting practices diminishing demand for piped water (Figure 3).

Table 5. Operational expenditure by scheme

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<th>No. connections</th>
<th>Tariff (USD/m$^3$)</th>
<th>OpEx per year (USD)</th>
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<th>Per cubic meter</th>
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<td>(10.9)</td>
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Figure 2. Disaggregation of operational expenditure by major cost categories

Note: Other includes materials, water quality monitoring, rental costs, fuel and other administrative expenses. Data did not allow for disaggregation of costs for scheme S002.

Figure 3. Operational expenditure and rainfall by month in southern Vietnam (seven schemes in Bến Tre and Long An Province)

Scheme operators reported additional costs, albeit relatively minor, relating to capital maintenance (CapManEx) and cost of capital (interest repayments) (Tables 6 & 7). For the CapManEx attributed to replacement of specific infrastructure components, 53% related to pipes and meters, 19% to pumps and 16% to treatment plant. In aggregate terms, the annualised CapManEx amounted to 8% of operational expenditure, perhaps raising questions about
whether recall bias may have resulted in an underestimate. Most schemes reported historical CapManEx, though the average annualised amount was relatively small (USD 2.60 per connection per year; 0.02 per cubic meter). Older schemes reported higher levels of CapManEx, with systems more than 10 years old recording CapManEx four times that of schemes under 10 years. Six schemes reported paying interest on loans; when averaged across all schemes these payments amounted to USD 0.98 per connection per year (USD 0.01 per cubic meter).

Table 6. Capital maintenance expenditure (CapManEx) by scheme

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### Table 7. Cost of capital (CoC) expenditure by scheme

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<th>Per cubic meter</th>
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**Profitability**

Twelve of the 14 schemes generated an operating profit in the most recent calendar year, though three of the profitable schemes generated a surplus of less than USD 1,000 (Table 8). Only one scheme reported making a substantial loss. When taking into account depreciation, historical subsidies and connection fee payments, four of the schemes were profitable based on a 20-year design life assumption.
Table 8. Operating profit by scheme in most recent year (USD)

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The study found that barriers to implementation of policies around cost-reflective tariffs and subsidies included capacity issues of the private enterprises and government staff, disincentives to pass on subsidies, and insufficient documentation. Private water enterprises were not found to have the financial capabilities to conduct LCCA, and government actors were reported to not always calculate tariffs in a transparent manner, as they may not want to be obliged to pass on subsidies through provincial budgets. These barriers to LCCA and calculation of tariffs and subsidies have reported to result in the amount that is offered to the private enterprise, by way of a subsidy, not being deemed acceptable to the enterprise. The study found that insufficient
documentation contributed to the inability for enterprises and authorities to calculate the life-cycle costs accurately.

**Discussion:**

This study is the first to quantify a broad suite of costs associated with water service delivery in rural Viet Nam. It is also the first to document service delivery costs incurred by privately owned and operated schemes in low- and middle income countries more broadly. In doing so, the analysis generated a range of new insights relating to cost variation, cost drivers, capital maintenance and depreciation, tariff determination and connection fees, evidence gaps and the financial sustainability and profitability of small-scale piped schemes.

The results demonstrate how life-cycle costs on a unit basis, can vary dramatically. This variation makes it challenging to define standardised cost norms (technical economic standards) in the Vietnamese context. Rather, if cost norms are developed, as was planned for some jurisdictions in Viet Nam, they should take into account a range of key factors, and be flexible to local circumstances. Key factors which influenced costs included scheme size, water resources (source, quality and reliability), climate, and service level. These multiple influences mean that generalized cost norms or benchmarks should be interpreted and employed carefully and in light of contextual factors. Moreover, formulation of such norms should be premised on a range or distribution of values that are appropriate to rural small-medium size water schemes, rather than just being based on urban water utilities norms or single numerical values or averages.

The drivers of the variation in costs in this study aligned with previous research, while others are novel observations. The relationship between cash flows and rainfall is similar to that documented in rural Kenya (Foster & Hope, 2017), while Burr and Fonseca (2013) also noted that a drop-off in water use can impact life-cycle costs. However, in contrast to Burr and
Fonseca, this study found no economies of scale when it came to capital investment. Rather, it was unit operational expenditure that reduced with scheme size. Variation of costs based on context, while unsurprising, was an important finding of this study with significant policy implications for policy contexts such as Viet Nam wishing to set norms related to costs to inform connection fees and tariffs. Reported CapManEx (expenditure on asset renewal) was, on average, surprisingly low. This could have been a result of respondent recall issues, despite systematic and rigorous data collection processes being implemented in the study. Additionally, it is not known if the reported low levels of CapManEx were due to adequate levels of spending for operational expenditure (regular maintenance), or if infrastructure was being pushed to its limit prior to being replaced. The difficulty of obtaining reliable cost data is a known challenge of conducting research into water service costs in rural areas of low-and middle-income countries (Burr & Fonseca, 2013), so some costs such as CapManEx are likely to have been underreported. Record keeping was often poor, making it difficult to verify data provided. This applies particularly to historical costs that were incurred more than 12 months prior to the time of data collection, meaning the challenge of collecting robust information was most acute for CapManEx and CapEx associated with older schemes. This is compounded by the fact older schemes were more likely to have changed hands (either in ownership or managerially) since the initial construction. It is likely that estimates for both of these cost categories were an underestimate of true values. Implications of low CapManEx, whether it be as a result of under-reporting, poor data availability, or under-investment, point to the need for a better understanding of how assets are being maintained or upgraded such that they can provide long-term services for the community.

Beyond the reported CapManEx costs collected through this study, depreciation was also calculated as a way to consider whether reported CapManEx costs were likely to be sufficient to maintain assets. Depreciation is a critical consideration, not least because it is promoted by
relevant policy instruments in Viet Nam. For example, Circular 45 (Guiding regulation on management, use and depreciation of fixed assets) sets out the way depreciation is to be calculated for fixed assets, and includes an annex which identifies a minimum and maximum design life over which a range of fixed assets should be depreciated (Government of Viet Nam, 2013). This study found that a simple straight-line depreciation of capital investment that assumed a design life of 20 years resulted in an average of USD 16.20 per connection per year, which was six times greater than the CapManEx estimate. This may point to underinvestment, under-reporting of CapManEx or a combination of the two. Whether it be an underinvestment or case of under-reporting or both, the findings point to a broader maintenance and financing challenge that water service providers will need to overcome in Viet Nam and beyond.

Most of the schemes appeared to be profitable in the previous calendar year. However, given the low level of reported CapManEx, the profitability reported is unlikely to be reflective of the life-cycle costs required to ensure ongoing sustainability of the scheme. When depreciating capital investment using a straight-line method, and factoring in historical subsidies and connection fee payments, only three schemes appeared to be profitable under a 20-year design life assumption. The study found that older schemes had much higher CapManEx which demonstrated that these costs can be expected to increase over the life of a system (unless proactive maintenance is undertaken). The results suggest that subsidies will likely be needed to ensure ongoing commercial viability in the face of depreciating assets and related capital maintenance costs. Alternatively, the viability of schemes could be improved by increasing tariffs, taking into account equity and ensuring affordability for all.

Tariff levels appeared to be adequate to cover operational expenditure, but not likely the life-cycle costs. Tariffs for piped water supply in Viet Nam are capped by provincial authorities, and in the 14 schemes included in this study, the tariff ranged from USD 0.26 to USD 0.38 per
cubic meter. As the profitability analysis suggests, these were generally sufficient to cover operation and maintenance costs, and in some cases (33% of schemes studied) capital investment too. In Viet Nam, there are various policy instruments in place to encourage pricing to be set with reference to real costs (such as Circular 75, 2012) but these instruments have been found not to be applicable to rural water supply and sanitation contexts, given their focus on larger urban utilities. The prescribed tariff setting methodology in the water supply sector globally considers a range of key principles including that the user pays; cost-recovery; the principle of the human right to water based on UN Resolution UN 64/292; that the price is affordable and if not, then subsidies are offered; water conservation and natural resources management; and economic efficiency (Vucijak, 2015). In this study, there was little evidence that the tariff rate charged to customers had been set with consideration of the key principles outlined above, and in some provinces, tariffs were not tailored to each scheme based on its unique costs, but the maximum tariff allowed was charged. Questions remain as to whether or not CapManEx is adequately resourced, however, if such costs are factored in to the life cycle costs, then tariff levels may not be sufficient to cover all costs associated with a small-scale piped water scheme. To further clarify this area, systems for tracking financial flows would need to be put in place to ascertain the full range of costs over the longer term, with consideration of how to ensure tariffs remain affordable for all.

Connection fees are an important source of revenue for private enterprises to meet the costs faced in early phases of establishment of their business. Connection fees in this study were found to vary from to USD 153 to no fee. Some schemes offered free or low-cost connections if households were located close to existing pipeline or were deemed to be poor. Research on equity dimensions of small-scale private water schemes in Viet Nam revealed that connection fees were a key barrier for poor households to connect to piped water services in rural contexts (Grant et al 2016a and 2016b; and Carrard et al 2019). Poor households were also found to
have experienced disadvantage in terms of being able to access services from private enterprises in a number of ways, including that poor householders sometimes paid higher fees; piecemeal service coverage disadvantaged the poor; and support mechanisms were unevenly applied (Grant et al 2016b). Therefore, determining connection fees within the context of the three T’s (taxes, transfers/subsidies and tariffs) is best done with consideration of equity implications, informed by research in Viet Nam which demonstrated that inequality can be further entrenched when people are not able to afford to connect to piped water schemes. Further consideration of how connection fees contribute to overall revenue sources and commercial viability for enterprises will be important for understanding any related requirement for government subsidies to avoid exclusion of the disadvantaged.

In the Vietnamese context, the Cost of Capital (CoC) is often missed or not mentioned in water tariff policy and price setting. Life-cycle cost analysis for rural piped water supply schemes ideally includes and reveals the CoC, and further research could also consider the opportunity costs of taking on a private water enterprise over other types of businesses (from an investment perspective). Most private enterprises do not factor in the cost of capital when setting their tariffs, which could result in them not knowing the benefits and risks of investing in a private water scheme. Water operators reported that the CoC cost them between USD 0.77 and USD 5.35 per connection, but this could be an underestimate. Further research is required to ascertain the real CoC for water scheme operators, and how this is incorporated into the full life-cycle costs used to inform the tariff. This study focussed on the real costs that had been accrued by the private water enterprises, not the opportunity costs of taking on a private water enterprise in comparison to other business ventures.

Life-cycle costs vary across country and local contexts, and relate strongly to the relevant water supply service level. Both the OpEx and CapEx reported in this study were substantially higher.
than those documented by the WASHCost initiative in Burkina Faso, Ghana, Mozambique and India (Burr and Fonseca, 2013). This disparity is somewhat similar to the findings of Hutchings et al (2007) who also found higher costs than those reported by WASHCost, and there are a number of possible explanations for this discrepancy. First, the schemes assessed in this investigation offered a higher service level than those included in WASHCost. In particular, all schemes served only private connections, whereas public taps are a common feature of rural piped schemes in India and sub-Saharan Africa. This is likely to have a major impact on both the upfront capital investment and recurrent expenditure when measured on a per capita basis. Clearly, it is likely to be more expensive to construct, operate and maintain a system that supplies 100 people through 20 private connections than through one public tap. In addition, most of the 14 schemes examined in this investigation had water treatment processes in place, which may not have been the case in the WASHCost systems. Another contributing factor could be the degree to which funds are directed towards routine, preventive maintenance rather than reactive CapManEx items. Notably, CapManEx reported by WASHCost schemes was considerably higher than schemes in this assessment, which may indicate the WASHCost schemes were spending an insufficient amount on OpEx to mitigate costly equipment replacement (Nyarko et al 2010). Further research is needed in the Vietnamese context to characterise how levels of OpEx influence CapManEx requirements in the long-term, including in relation to the relevant water supply service level.

The results are subject to a number of caveats and limitations. First, in many cases costs were estimated by operators and may be impacted by recall bias. This is demonstrative of the challenge of capturing comprehensive and reliable cost data in a low resource setting, and is not unique to this study (see e.g. Burr & Fonseca 2013). Additionally, where schemes had been

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1 This comparison was done by converting the costs from this study to USD (2011) in PPP terms per person.
handed over or sold from community/government to private enterprises, there was often a loss of documentation, so original and accurate CapEx costs were not known in some of these cases. Second, the schemes were not selected randomly and do not necessarily constitute a representative sample of privately-operated water supply schemes in Viet Nam. Third, half of the assessed schemes had been in operation less than 15 years, and so the full set of life-cycle costs are unlikely to have materialised for these schemes. Fourth, costs calculated on a ‘per connection’ basis may have been distorted in cases where schemes served large institutional customers, such as water-intensive industries and public sector entities. Fifth, the schemes analysed in this study ranged significantly in size and type, drawing from different water sources in a range of geographic contexts. Therefore, care needs to be taken when generalising from a small and varied data set. Finally, researchers found an unwillingness by some private enterprises to share financial information which was an anticipated risk, especially if the enterprises did not already have a relationship with the interviewing team/research partnership.

While all costs associated with rural water service delivery were sought to be recorded in this study, it was not possible to obtain accurate records of all externalities, including the cost of governance. As this study focused on the service provider, the analysis did not account for external support costs (both direct and indirect) which might otherwise be incurred by government authorities and non-government organisations. The focus on private operators also gave rise to a grey area regarding labour costs – in some cases the operator described the income received by family members as a salary (and therefore represented a cost to the business) and in other cases this was described as a share in the profit.
Conclusions

This study sought to quantify the life-cycle costs associated with privately-operated water services in rural Viet Nam. The findings have clear implications for policy and practice in Viet Nam for government, donors and NGOs. The results provide a valuable reference point for development of cost norms (technical economic standards), both in terms of the magnitude of costs and the distribution and drivers of those costs. This can inform the design of regulations for tariff formulation, support mechanisms such as subsidies and other incentives, initiatives to assist operators with business planning, and data collection requirements and tools to aid these processes.

The findings address an important knowledge gap in the Vietnamese rural water sector, and if responded to, would support Viet Nam to move towards achieving SDG target 6.1. The findings reveal the need for further nuanced and carefully contextualised life-cycle costs analysis, given that results show that both operational and capital expenditures varied widely. A range of factors influence unit costs, including scheme size, water source, climate and service level, while labour and electricity stand as the key operational cost drivers. Promisingly, most enterprises appeared to be financially sustainable, though further investigation is needed to determine whether tariffs are sufficient to cover future capital maintenance requirements, and whether current levels of investment in capital maintenance are sufficient in light of capital depreciation. It is hoped the results can inform measures of government and development partners to more effectively target support for water service providers, and – most importantly – ensure high quality and equitable rural water services are sustained indefinitely.

In the Vietnamese context, the study revealed the need for better evidence on life-cycle costs to inform government policy on private water service provision, on the basis of four important points,. Firstly, the study revealed that governments in Viet Nam (national and provincial)
need to invest in evidence-based processes to ascertain the real costs of water supply schemes over the long-term, and use these to inform: a) appropriate ranges for technical economic standards for water schemes b) affordable and appropriate tariff structures and subsidies, and c) transfer of assets processes from government agencies to other types of water supply providers (such as private enterprises) underway in Viet Nam. Secondly, a better understanding of how enterprises are investing in Capital Maintenance Expenditure (CapManEx) along with drawing on depreciation forecasts and Cost of Capital (CoC) is required to ensure that water supply schemes are maintained in the long-term, in line with a strategic asset management approach. Calculating depreciation along with collecting CapManEx costs is important to ‘sense check’ investment levels (in terms of actual vs optimal). Thirdly, private water enterprises should to be required and supported to collect financial data on a regular basis, and provide this to relevant authorities and donors. Finally, care is needed when comparing life-cycle costs from one context to another, as costs are highly contextualised.

Lastly, it is important to stress that a good understanding of life-cycles costs is only one element of rural water sustainability and functionality. Addressing this issue an important step, but does not obviate the need to support other asset management, service delivery and sector-level governance. In addition to adequate financing arrangements and appropriate service delivery models, sustainable services require building blocks relating to institutional capacity, asset management, water resources management, and monitoring and regulation.
Acknowledgements (300)

This study was funded by the Australian Department of Foreign Affairs and Trade (DFAT). DFAT did not have any involvement in the study design or in the collection, analysis and interpretation of data or writing of the report. The decision to submit the article for publication was made solely by the authors.

The authors thank the research team who carried out this study including Doan Quang Huy Institute for Economics and Water Resources Management (IWEM); Nguyen Hong Quan, Hanh Nguyen, Per Ljung, and Thuy Bui Thanh from East Meets West Foundation, Viet Nam (EMWF).

The research team sincerely thanks private enterprises and government representatives who were part of this study. The time and information provided by private enterprise owners to support this research was greatly appreciated.
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1 Based on the information provided by water scheme owners, three of the schemes had no centralised treatment (S001, S002, S003).