Rural Water Supply in Cambodia: A consolidation of data & knowledge and identification of gaps & research needs

Technical note

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Background, objectives, and framework

Most Cambodians (69%) live in a rural setting[1] [1], and among them, most live in higher density semi-rural areas (69% of rural; 55% of the total population) [2]. Rural water supplies (RWS) in Cambodia exist in various forms – ranging from advanced water treatment and distribution systems to simpler individual household (HH) supplies - such as wells, rainwater harvesting, or even manual fetching from lakes, rivers, or ponds.

Over the past decade, many of Cambodia's 12 million rural residents have experienced changes to their water supply practices [1]. Approximately 27% of rural HHs now purchase water from a service provider[2] – most commonly from a piped water supply[3] (PWS) system or a bottled water distributor (Figure 1) – compared to just 11% in 2009[4]. These changes have resulted from the country's continued economic growth, increased HH disposable income, and the emergence, strengthening, and expansion of both centralised and decentralised water supply services. PWSs serve some parts of rural Cambodia and are managed and operated by entities that are usually private, and may be licensed or unlicensed [2].

Decentralised water suppliers (such as locally-operated bottled water kiosks and informal water delivery vendors) have also emerged and expanded their presence in rural areas. Water kiosks typically pump water from a source, treat it, and store, deliver, and sell it in 20-litre plastic jugs. More informal water delivery services (such as tanker trucks, carts, and for-hire pumps) are also widespread – and often function to meet temporary water demands during the dry season.

Water supplies can be broadly classified into two categories – those involving the delivery of water to users or customers by a service provider, and those that are managed and operated directly and independently by HHs – as represented in Figure 2. Despite the recent evolution and expansion of water services, most rural HHs continue to secure water for their daily needs using traditional non-serviced methods (68%) (Figure 1) – including from tube or dug wells that access groundwater aquifers, rooftop rainwater harvesting and storage systems, and natural or constructed surface water bodies (such as ponds, rivers, or lakes). Tube wells may be categorised as either a serviced supply (in the case of public wells operated by a local committee) or a private supply (in the case of privately-owned wells).

Once water from a source has arrived at the HH, it is not necessarily safe for consumption. Microbiological or chemical contaminants present in drinking waters may pose health risks to those that are exposed. Source waters may become contaminated at their origin, contamination may be introduced during transport to the home, or during storage after it has arrived. Some water sources – such as PWS and bottled water – may be more likely to provide water that is safe for human consumption because of treatment and purification prior to delivery. HH water treatment is a relatively common

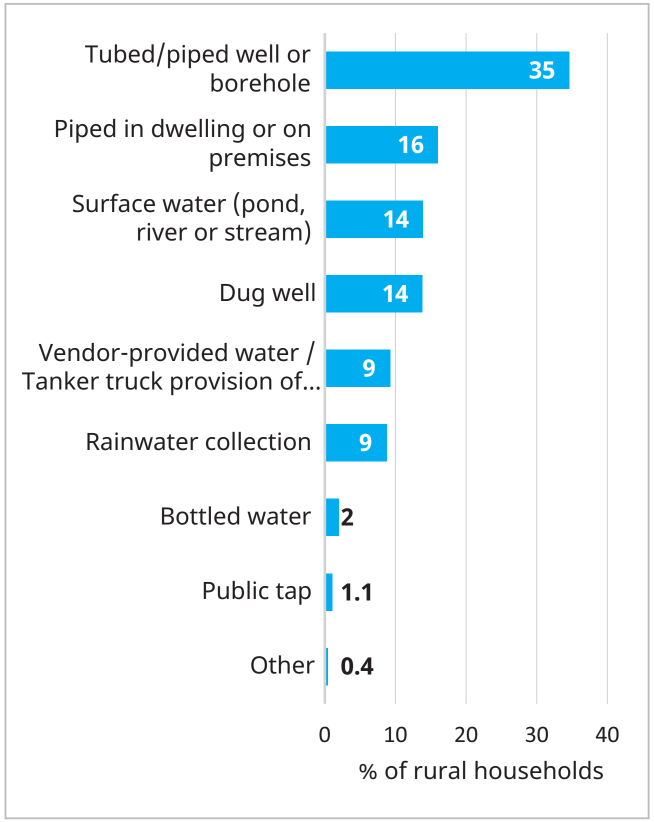

Figure 1 – Main household drinking water source (CSES 2017)

practice in rural Cambodia with boiling being the most widely practiced method. Water filtration products have also been promoted or have been available in some marketplaces for over a decade [1]. Some of these filtration products (such as mineral pot filters) are reportedly being imported from countries around the region while others are produced in Cambodia (such as ceramic and bio-sand filters) [3].

The water supplies that are utilised by rural Cambodians are governed by the Department of RWS within the Ministry of Rural Development (MRD) and the Department of Potable Water Supply (DPWS) within the Ministry of Industry and Handicrafts (MiH) [4, 2]. The Government of Cambodia aims to ensure that 100% of rural HHs have sustained access to a safe water supply by 2025 [4]. DPWS is responsible for the oversight of PWSs and private bottled water operations across the country – and their engagement in RWS has become increasingly important and relevant as PWS coverage has expanded rapidly in rural areas in recent years (Figure 3). Rural water kiosks fall under the authority of MRD as a community-managed water supply and under MiH as a bottled water producer. However, there remains no clear institutional mandate for the regulation of rural kiosks and they are not yet being formally regulated or monitored.

MRD's mandate also extends to the remaining RWSs that are not legally regulated by MiH. MRD implements infrastructure investments directly using public budgets and according to annual plans proposed by Provincial Departments of Rural Development (PDRDs) across Cambodia's 25 provinces. These investments have traditionally centred on the drilling of new wells, construction of community reservoirs and treatment works, and the repairing of existing wells[5]. There has been little evolution to this approach since its emergence in the 1990s. As the total budget allocated to each province is small, PDRDs commonly target their activities to a specific district(s) each year – and subsequently rotate through all of the districts in their province over a given period of years.

Separately, MRD also coordinates and oversees government loans, external investments and activities that are implemented directly or indirectly by development partners and NGOs [5, 2]. This external support has taken various forms, but has generally aimed to increase access to improved water supplies, improved drinking water quality, and/or to strengthen the performance of the RWS sector. Similarly, MIH is also engaged in the oversight of external investments, loans, and mechanisms to support the growth and performance of PWSs in the country.

Various statistics, research, and knowledge have been collected and compiled relating to RWS in Cambodia over recent years – with the aim of aiding policy and decision-makers to understand the context, trends, and needs of the sector. WaterAid has recognised that a consolidation of this information and an assessment of remaining gaps and research needs would be beneficial for the sector. The first objective of this technical note is to present a concise review of RWS statistics and knowledge as informed through routine surveys, research, and expert insights. The findings have been arranged and presented in the form of water supply profiles and covering each supply's respective prevalence, service levels, and performance according to the framework in Figure 2. Additionally, the cross-cutting topics of water quality and health, water resource management, and HH water handling and treatment have also been discussed where relevant. Data and information have been derived from various published and non-published sources (as referenced) and are supplemented by insights and opinions from sector experts.

The second objective of the note is to identify, present, and prioritise sector-level and programmatic gaps – as well as emerging research needs. This technical note may therefore serve to support sector experts to identify, consider, and prioritise future initiatives to strengthen the understanding and performance of RWSs – and to provide those new to the sector with a concise, but holistic overview of progress, performance and emerging issues.

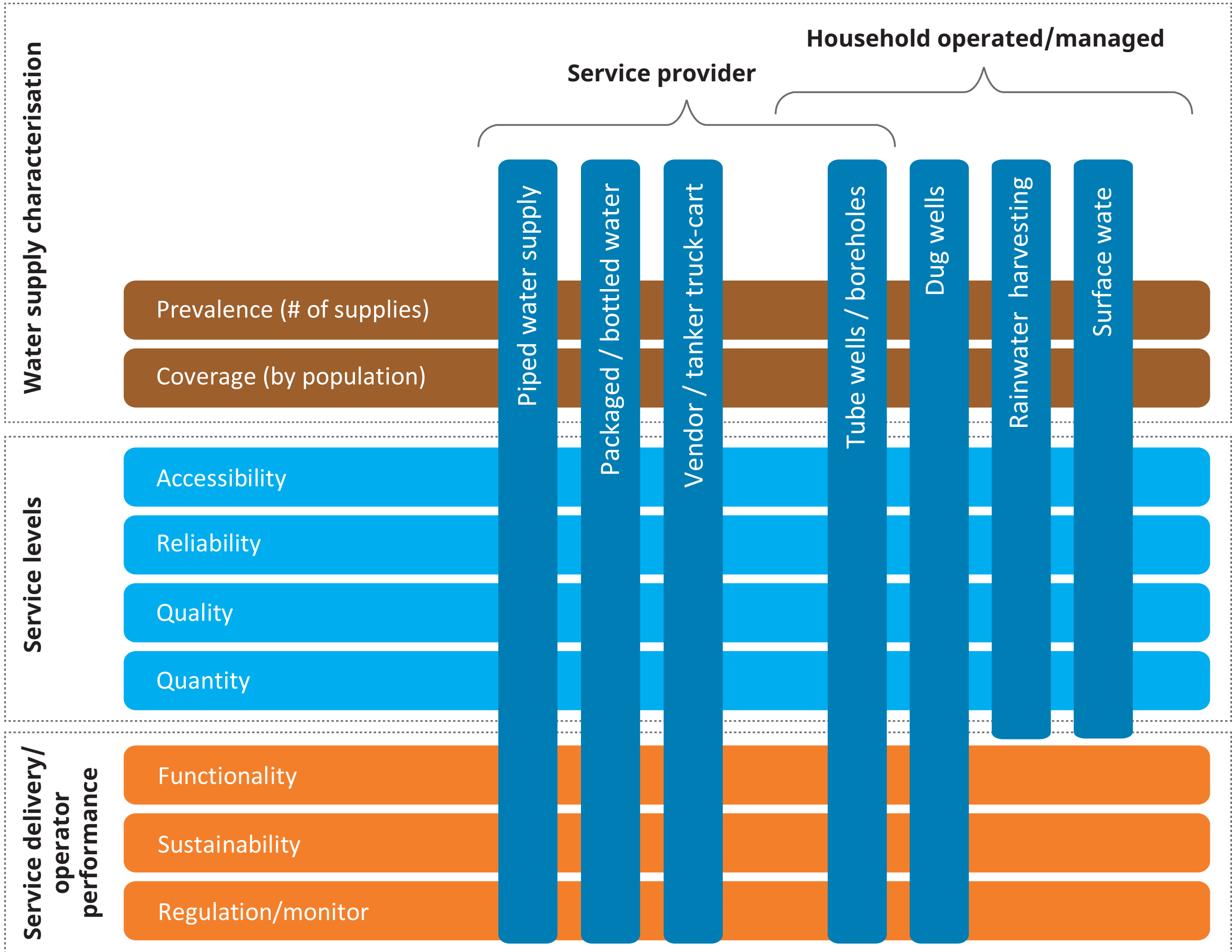

Figure 2 – Rural water supply profile framework

National Statistics and Trends

Rural drinking water supply coverage

The most recent statistics on rural HH drinking water supply (supplies that respondents considered to be primary[6]) are from the annual Cambodia Socio-Economic Survey (CSES) 2017 – as presented in Figure 1 (latest statistics) and Figure 3 (including data from previous surveys to demonstrate recent trends[7]). Tube wells are the most common primary drinking water source for rural Cambodians (35%) – and have remained so throughout the past decade. Surface water (14%) and dug wells (14%) are also common – but their prevalence has been steadily decreasing over recent years. Approximately 55% of the dug wells used for drinking in Cambodia are unprotected[8]. Approximately 27% of rural dwellers obtain drinking water from a service provider - 16% from PWSs, 9% from a vendor, and 2% from a bottled water distributor.

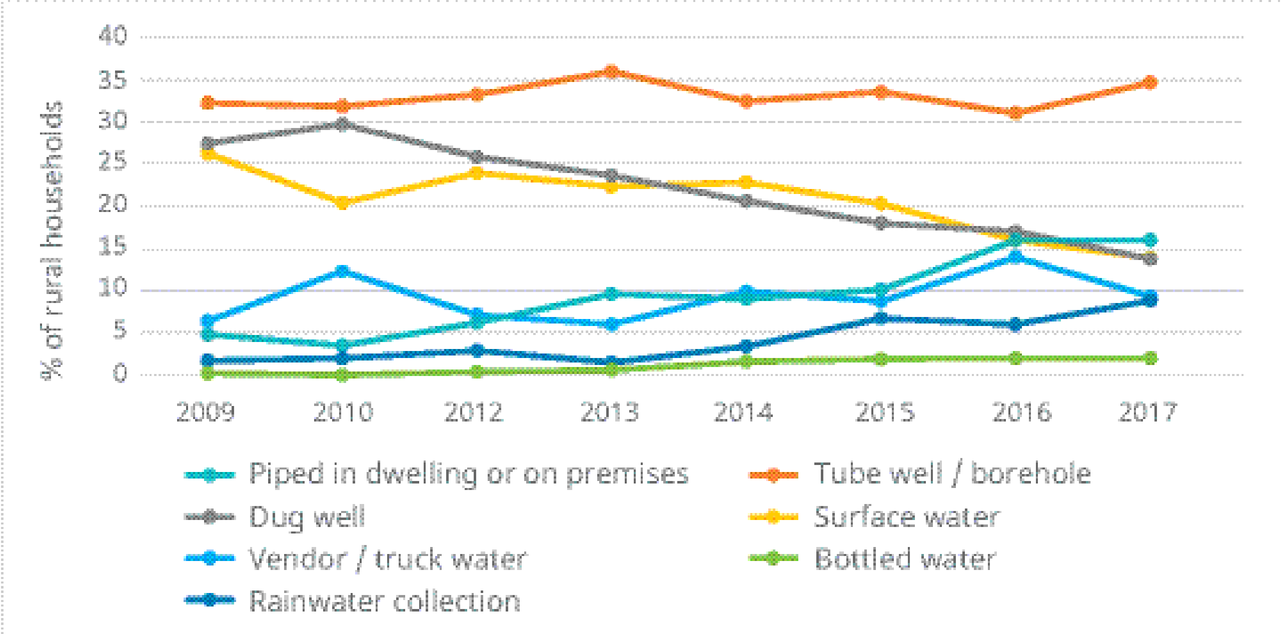

Figure 3 – Trends in HH drinking water sources1 (CSES Surveys 2009 – 2017)

Rainwater collection and storage is not commonly considered to be a primary year-round drinking water source (9%), but its prevalence as such has been increasing in recent years – potentially due to an increasing number of HHs developing large water storage capacities that allow reserves to last throughout most of the year. Despite being an uncommon primary drinking water source, rainwater harvesting is practiced by approximately 86% of HHs in rural Cambodia[9] [6]. Its prevalence also emerges when examining drinking water sources for dry and wet seasons separately – the latter of which typically lasts from May until October. A study conducted by the World Health Organisation (WHO) and MRD in 2013 was designed to characterise water supply practices during the dry and wet seasons separately, and revealed that rainwater served as the primary wet-season drinking water supply for approximately 60% of rural HHs (Figure 4). Drinking water supply habits are strongly influenced by Cambodia's rainy season and rainwater appears to be a preferred water source when it is available [6]. However, the use of rainwater falls dramatically in the dry season – as few HHs have sufficient storage

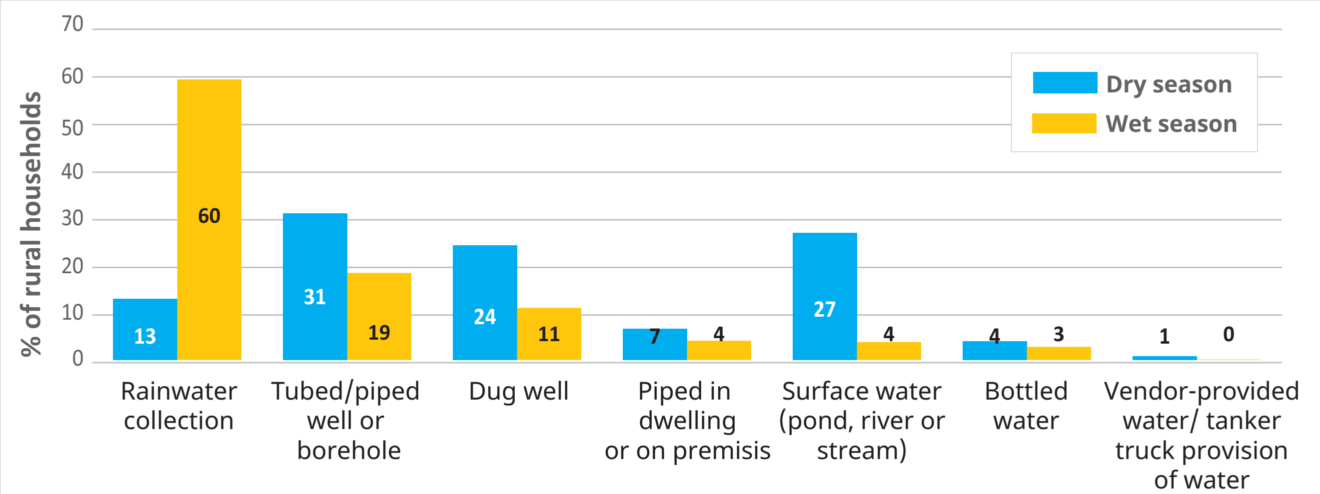

Figure 4 – Main drinking water source by season (MRD/WHO 2013)

capacities. This decrease appears to be compensated by a significant increase in the use of surface water, and to a lesser extent tube wells and dug wells (Figure 4).

Global-level progress on HH water supply coverage has been significant in recent decades, and cross-country comparisons may motivate underperforming countries to address performance issues. Progress has been measured, analysed and compared through the Millennium Development Goals (2000-2015) and more recently Goal 6 of the Sustainable Development Goals (2016-2030). Measurement and reporting against this goal falls under the mandate of the Joint Monitoring Programme (JMP) which is administered by WHO and UNICEF [7]. Progress towards the drinking water component of Goal 6 is characterised using a "ladder" approach with surface water representing the lowest level of service and so called "safely-managed" water systems representing the highest. The most recent estimates suggest that 70% and 95% of rural and urban HHs in Cambodia have achieved at least a basic service level, respectively (Figure 1). Description of the definitions of these service levels is beyond the scope of this note but can be referred to at the JMP's website.

The Cambodian government uses slightly different indicators and definitions to measure progress towards its goal of 100% access to safe water by 2025. Access to safe water is defined by the type of water supply and whether it is classified as being improved or unimproved[10]. As of 2017, rural access to improved water was 58% [1]. The main reason for the large difference between Cambodian government and JMP figures is because the JMP considers all rainwater harvesting to be improved while the Cambodian government considers only those rainwater systems with a storage capacity of >3,000 litres and a tap as being improved[11].

The national RWS statistics presented here suggest that service provider managed water supplies are increasing rapidly in rural Cambodia, but still service a relatively small proportion of the rural population (3.2 million people – or 27% of the rural population). Significant potential remains for the future establishment and expansion of water supply services into viable rural areas. A recent study has estimated that 60% of the rural population resides in areas where such services could be established – and in which only 8% of HHs are currently receiving safe water[12] [2]. Reliance on water sources that are typically associated with poor quality and accessibility – such as surface water and dug

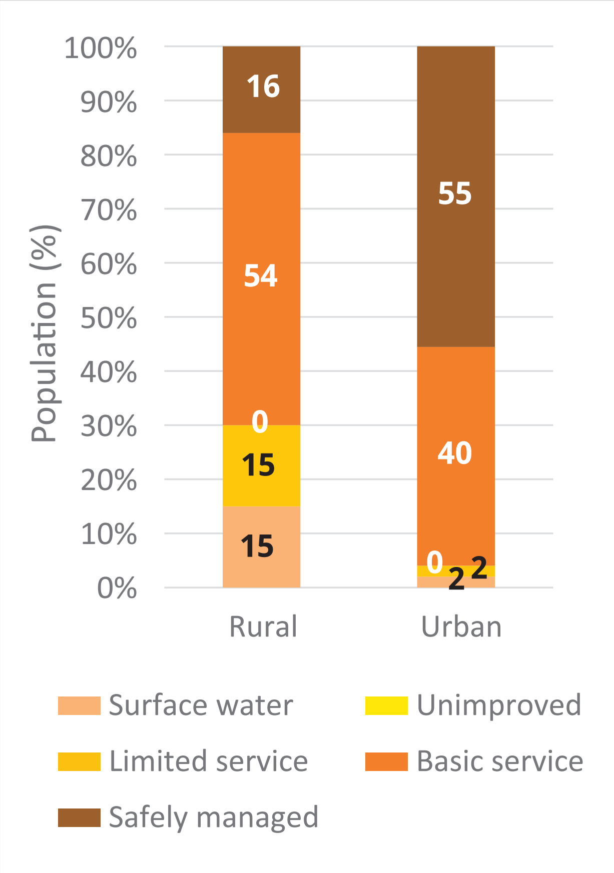

Figure 1 – Progress on rural and urban water supply in Cambodia compared to Sustainable Development Goal 6.1 (JMP 2017)

wells – appears to be gradually decreasing (Figure 3). The use of tube wells as a primary source of drinking water remains relatively steady, ranging between 30-35% of rural HHs. However, the overall prevalence of tube wells is likely to be much higher - as not all wells are used to supply drinking water.

Rural drinking water supply accessibility

Accessibility of drinking water supply is generally high in Cambodia, with only 2% and 7% of rural HHs spending more than 30 minutes to go to their water supply, fetch water, and return home, in the rainy and dry seasons, respectively [8]. In the dry season, the majority of such HHs with poor accessibility obtain their drinking water from distant surface water sources (56%)[13].

HH drinking water treatment

Approximately 71% of rural Cambodian HHs reportedly always treat their drinking water prior to consumption [1]. This figure has increased steadily from 47% in 2004 and 55% in 2009. However, a more thorough study of treatment habits has revealed that such self-reported figures may reflect an overestimation of actual water treatment habits[14] [6]. The boiling of drinking water is a traditional and common practice in rural Cambodia (55%), while approximately 17% of rural HHs reportedly use some type of drinking water filter product [8]. Among those HHs using a filter, roughly one-third reportedly use each of ceramic water filters, bio-sand filters, and mineral pot filters, respectively [6].

Various research studies have been conducted in Cambodia to evaluate HH drinking water treatment practices, technologies, and products. HH water treatment has been found to be associated with improved drinking water quality at the point-of-consumption [6]. Boiling has been found to be effective at reducing pathogen concentrations – but may be less consistently practiced than other more convenient water treatment methods [9]. Ceramic water filters [10], bio-sand filters [11], and mineral pot filters [3] have all been found to effectively reduce bacterial concentrations – either in controlled laboratory studies and/or field studies. In some cases, the use of such filters has also been found to be associated with reductions in the prevalence of diarrhoeal illness [10]. However, such water filtration products may be less effective at reducing concentrations of small pathogens (such as viruses), and may require routine maintenance and eventual replacement of some components.

Drinking water and health

Spare parts for water filter products may not be commonly available in the marketplace – a barrier to their sustained use.

Diarrhoeal diseases are relatively common in Cambodia, with the most recent figures indicating that 13% of rural children under 5 had experienced such an event in the past two weeks (2014) [8]. However, incidences of diarrhoeal disease have decreased from 20% in 2005 and 16% in 2010. Data on the causes of child mortality in Cambodia are out-of-date (latest data from the National Census 2008) but at the time suggested that diarrhoea was responsible for 7% of all child deaths [12]. Combining these figures with that of the most recent childhood mortality estimates[15], crude birth rates[16] [8], and total rural population figures [1] translates to approximately 1,000 under 5 child deaths attributable to diarrhoea in rural Cambodia each year.

The presence of Escherichia coli (E. coli) is commonly used as an indicator to detect whether water has been contaminated by faeces. The MRD/WHO survey conducted in 2013 revealed that 26% of rural HHs demonstrated high risk levels of E. coli (as represented by >100 cfu/100mL E. coli) in water samples taken directly from a drinking glass/cup just prior to consumption. Only 23% of HHs met the Cambodian drinking water quality standard for E. coli (0 cfu/100mL). Lower levels of contamination were found to be positively associated with whether the drinking water had been treated and whether it had been handled in a way that prevented contact with hands. Somewhat surprisingly, no evidence of was found of an association between water quality and whether the drinking water originated from an improved water source or whether the water was stored in covered containers.

The proportion of HHs consuming microbiologically contaminated drinking water in rural Cambodia is high, and this may be a significant contributor – along with sanitation and hygiene – to diarrhoea-related morbidity and mortality. There is evidence that practicing HH water treatment [6] or drinking kiosk-provided bottled water can reduce such risks [13]. Associations between the consumption of PWS delivered water and health outcomes have not yet been explored. Behaviour change communication methods can be deployed to HH and community members to modify habits. Such methods to promote safe drinking water habits may be most efficiently and effectively administered if focused on: 1) the avoidance of contact between water and hands during handling (i.e. using taps or spigots versus bowls, scoops, and/or open water storage jars); and 2) the promotion of consistent treatment of water prior to consumption.

Rural water supply profiles

This section presents summary profiles for each of the rural water supplies that are prevalent in rural Cambodia – with information and data presented according to the framework in Figure 2. The components of the framework have been qualitatively scored using a "traffic light" visual aid – with green, yellow, and red indicating strong, moderate/mixed, and weak performance and conditions, respectively. Black shading indicates that that indicator cannot be scored due to the absence of information and/or data.

Piped Water Supply (PWS)

The water supply profile for PWS in rural Cambodia is presented in Table 1. PWS is generally a preferred water supply option where it is available – however, barriers to connectivity include affordability of the initial connection fees, and to a lesser extent, the volumetric tariff. The primary motivation for establishing a connection is reportedly due to convenience (85%), followed by improved water quality and general HH modernisation [14].

HH access to PWS services has been increasing moderately over the past decade [2] - due in part to continued economic development, entrepreneurial interest in establishing facilities, targeted financing initiatives (towards infrastructure development and expansion), and increased HH affordability. In addition to the 13 existing public urban water utilities, there are approximately 530 private PWS operators in urban and rural Cambodia that are known to the regulatory authority (MiH) and the Cambodia Water Supply Association (CWA) [15]. Approximately 350 of these private operators are categorised as being Small Water Enterprises (SWEs) [16] – defined as those typically serving small towns and rural areas. However, there is no distinction in the licensing and regulation of SWEs versus larger public and private operators.

While PWS services are regulated by MiH, a government decree has been issued that states that non-private (mostly community-managed) PWSs that operate in rural areas are under the authority of MRD. Such public and small-scale PWSs are rare, but their prevalence is increasing due to interest from donors and NGOs. Little is known about their functionality, sustainability, and service levels. To-date, there has not been any major coordination on PWS regulation, monitoring, or strengthening between the two relevant ministries, and recently established national action plans for rural WASH have not acknowledged the role of private PWSs in the sector.

Most SWEs serve between 500 and 2,000 connections (58%) [17] and combined, provide water to between 1.4 and 2.2 million people in 600 communes [2, 16]. The functionality of PWS systems is regarded as being high. Recent analysis has concluded that there is a significant growth potential for the SWEs - in terms of connectivity within their existing coverage areas, expansion into new areas, and further revenue generation [2]. A large proportion of rural Cambodia has been found to be viable for future PWS coverage – including most semi-rural areas [2]. This high growth potential is supported by the fact that 79% of SWEs are reportedly planning expansion investments [18].

However, much of the remaining viable area is likely to be less economically attractive in the PWS marketplace that is dominated by private suppliers that are driven by profits. The thresholds for risk and profitability amongst those investors interested in rural PWS provision is not yet well characterised – and it is conceivable that eventually SWEs may shift growth ambitions towards increasing connectivity within their existing coverage areas rather than expanding into new frontiers. In fact, from 2011 to 2017 the total number of SWEs operating in Cambodia increased only slightly. However, on average the existing SWEs have significantly increased and expanded their coverage areas during that time period [18].

Table 1 – PWS profile

Component	Parameter	Characterisation	Score	Rationale	Gaps & Priorities
Rural (& small-town) PWS coverage	Prevalence (# of systems)	Rural & small-towns - 347 SWEs (2017) [18]		Rural PWSs are an improved water supply, and although overall coverage remains low (16%), it is increasing moderately year-by-year. Significant potential for growth remains - as indicated by low-moderate coverage rates within the licenced areas and a high proportion of the rural population estimated to be living in viable areas (60%) compared to the overall level of coverage (16%).	Continued monitoring of the increasing HH coverage of PWS should continue through the annual CSESs and the registries of SWEs themselves (through MiH licensing and CWA membership). To monitor future growth and coverage, there will be a continued need to refine and update figures for PWS connectivity (% of HHs in licensed area that are actually connected) [19] and proportion of viable areas where licenses have been granted by MiH. A study of potential institutional mechanisms and incentives to promote expansions into less viable areas may be important [20]. Further study of the determinants of SWE connectivity (the reasons why some SWEs are able to achieve higher connectivity than others) is also needed [19]. The effectiveness and sustainability of emerging PWS promotion and demand-creation programmes may also require assessment [20].
	Rural coverage (as a main drinking water supply)	Rural only - 16% (2017) [1]			
	Rural connectivity (proportion of HHs in licensed area that are actually connected)	Rural & small-towns - 47% (2015) [17] ; 51% for SWEs serving < 1,500 HHs ranging to 37% for SWEs serving >3,500 HHs [18]			
	% of rural population living in potentially viable areas	60% (combined kiosks and PWS) (2017) [2]			
	Coverage trend	Increasing moderately			

HH water supply service levels	Accessibility	Very high once a connection is established (2016) [1] – but is limited to geographies where PWSs exists and socio-economic factors		PWS taps are almost always inside the home or dwelling. Public standpipes are rare [1]. PWS services can only be secured by a HH in locations where a connection to the distribution network is viable. Within such areas, actual connectivity is influenced by affordability of connection fees and tariffs, and willingness to change water habits.	Implementation of pro-poor mechanisms to promote PWS connections within service areas are being piloted, and should continue according to best practices and the existing knowledge base. Such programmes should be assessed to determine their performance.
	Reliability	Generally high, but with some data gaps to be addressed (2015) [17, 21]		Most SWEs report that they are supplying water for >20 hours per day and larger systems (>5,000 connections) are able to achieve continuity of supply (24-hr service) [17]. From the HH perspective, 75% of customers have reported that they typically receive 24-hour water supply while 20% receive between 12-23 hours per day [21].	A continuity of service (24 hour per day and 7 days per week) benchmark should be integrated into MiH's monitoring system to ensure accountability of SWEs towards customer satisfaction on reliability and minimising water quality risks due to negative pressure in the distribution network.
	Quality	There are high levels of uncertainty due to a lack of data. High compliance with national water quality standards has been reported among the few SWEs that can report quality data (2015).		MiH is regulating the water quality among licensed suppliers – however data on compliance with national drinking water standards is not publicly available. MiH recognises that water quality is a priority and testing and/or treatment capacities among SWEs are often low [22]. Improvements to water treatment and water quality monitoring are likely to result from ongoing efforts to improve licensing and accountability through MiH. CWA has also reported that 39% of surveyed SWEs routinely test for chlorine levels in distribution waters and 94% of tests have met national standards [17]. HH storage of PWS water is a common practice to ensure availability during outages and to reduce the taste of chlorine in the water – but is resulting in increased level of contamination prior to consumption [23].	An annual report on water quality compliance of licensed PWSs (perhaps as part of an annual benchmarking report) would bring clarity to the question of water quality conditions. In the meantime, further study of existing primary and secondary water treatment, appropriate technologies, related capacity gaps, and water quality conditions among SWEs may be a priority. Further efforts by MiH and CWA to connect SWEs to water treatment and water testing capacities and technologies will also be a benefit. Factors influencing HH use of PWS water for drinking may also need to be explored (particularly relating to perceptions of chlorine, habits of storing PWS water at the HH, and potential water quality degradation).

Compo-nent	Parameter	Characterisation	Score	Rationale	Gaps & Priorities
	Quantity	High		Water quantities among connected HHs are believed to be sufficient as water outages appear to be uncommon [17]. Data on water source/resource constraints among SWEs (particularly during the dry seasons) are not available.	Potential water resource constraints and sustainability of water sources that support PWS operations requires further study.
Service delivery / operator perfor-mance	Functionality	High		Dysfunctional and/or abandoned systems are not believed to be common [22]. Water losses are reportedly low to moderate on average (19% loss rate) among those that can report such figures [17, 15].	Frequency and duration of service outages and measurement of water losses could be integrated into MiH's monitoring and benchmarking.
	Sustainability	Recent figures on operational and full cost recovery of SWEs are not available.		Historical figures have shown that most operators have been profitable (83%) and able to achieve operational and full cost recovery [24]. Insufficient data exists on current sustainability conditions. MiH's recent prakas on water tariffs aims to ensure and maintain full cost recovery – but will also depend on SWE efficiency and performance. Some risks to sustainability have been identified including high interest rates, low revenue during rainy season [24], and high energy costs [15].	As a preliminary step, data should be generated (through MiH licensing and monitoring) on the proportion of SWEs that are reporting income and expenses and implementing accounting practices that could establish whether they are actually achieving operational and full-cost recovery. Various operational inefficiencies have been identified [15] and require further quantification, prioritisation, and resolution as the sector and SWEs strengthen in the future.
	Regulation	Licensing coverage is increasing rapidly		61% of SWEs are now licensed (up from approximately 33% in 2011) with most non-licensed SWEs having their licensing application in-progress [18]. Some qualitative evidence has emerged indicating that the burden of regulation – including tariff caps and heavy administrative requirements – is an issue [20].	Efforts to license all SWEs are ongoing and sector-wide compliance with national regulations will require continued monitoring, capacity assessment, capacity development, and targeted investments.
	Monitoring	An MIS has recently been initiated by MiH, but in practice only deployed for larger (typically urban and public) systems so-far [22]		Further evolution and refinement are needed to expand the number of PWSs (and SWEs) that are licensed and actively reporting into the MIS. Additional indicators could eventually be added to further enhance the utility of the system.	The preliminary MIS should be periodically reviewed to determine the proportion of licensed operators actively reporting and the need for any additional future indicators.

Methods to incentivise the establishment of new SWEs or to expand the coverage of existing PWSs into less economically attractive areas may need to be explored. However, the capacities of the SWEs – both management and financial - and their access to capital all remain key barriers that will have to be addressed in order to approach Cambodia's PWS coverage capacity.

SWEs sell their water to their customers for on average 2,200 riel ($0.54 USD) per m3 [2, 17] and one-time connection fees are typically between 250,000 and 350,000 riel ($50-$80 USD) [17]. Reaching the full potential of rural connectivity in Cambodia will likely require the establishment and expansion of social support or financing mechanisms for the poor – particularly for the high cost of connection fees. Evidence suggests that there are large differences in PWS connectivity between the poor and non-poor due to affordability constraints [14]. Among unconnected poor HHs that are physically able to connect, 71% have reported that they have chosen not to connect because the connection fee was unaffordable [21]. The average SWE is operating in an area where approximately 23% of HHs are poor.

Various programmes have been initiated to promote connections among the poor using such approaches as subsidies, payment by instalment, and micro-financing, and this remains an emerging area of interest for the sector [22].

Despite the positive outlook on PWS in Cambodia, there are some emerging challenges. Many connected HHs continue to use other water sources to supplement their water supply needs – particularly rainwater [21]. Water from a PWS connection is commonly relied on more heavily during the dry season when rainwater is less available. This results in inconsistent water demand (particularly for those operators that are only serving rural areas) and thus inconsistent income. Into the future, improving reliability (24-hr service), increasing trust in chlorination and the quality of the water, and increasing HH disposable income may shift HH practices towards greater reliance on piped water – including in the rainy season.

While the proportion of SWEs licensed by MiH has increased significantly in recent years – an additional challenge is posed by the nearly half that remain unlicensed due to weaker capacities. Significant efforts are needed to raise performance levels associated with the operations and facilities of these SWEs in order to meet MiH licensing requirements. Licensing is likely to be a catalyst for further improvements – through legal requirements, monitoring, and reporting. However, these needs will need to be supported by operational and technical support - particularly with regard to business management, treatment process upgrades, and monitoring. Many SWEs have also chosen to become members of the Cambodia Water Supply Association (CWA) in order to access networking and support services (approximately 40%) [15]. A Management Information System (MIS) has been launched and is being administered by MiH – with intentions to motivate PWS operators to improve their performance and meet compliance standards. Laws and regulations are also likely to continue to evolve and adapt to the growing and evolving sector. An upcoming Water Law is being drafted by MiH to further professionalise and strengthen the sector and its regulation.

Despite these challenges, the context for the sustainability of the SWEs appears to be strong but not fully characterised.

Table 2 – Water kiosks and bottled/packaged water profile

Component	Parameter	Characterisation	Score	Rationale	Gaps & Priorities
Rural water supply coverage	Prevalence (# of service providers)	NGO-supported kiosks – Approximately 300 rural kiosks (2018) [26] Private kiosks – Unknown (but likely few) Corporate bottled water producers – Unknown (but likely many)		Bottled and/or packaged drinking water is an improved water supply by international standards[18] but an unimproved water supply by Cambodian standards [1]. The number of HHs that use such water as a primary drinking water source is not clear. The number of total kiosk customers (including occasional customers) is also unclear – but could be around 500,000-600,000 HHs (or 5% of the total rural population). Water kiosks serve a moderate and growing number of rural HHs [1] – however overall coverage remains quite low. Several NGOs continue to support the expansion of rural water kiosks through initiatives to promote their product within existing service areas while also establishing new kiosks in communes that are viable [2]. It has been estimated that approximately 800 rural kiosks could be established in viable markets [2]. A large growth potential remains. The recent emergence of private kiosks indicates that the kiosk approach may be attractive to the private sector to compliment future expansion.	NIS should ensure that in future CSESs that kiosk water is correctly and consistently categorised by enumerators – whether purchased from a kiosk directly, from a local shop, or delivered directly to the home. There appears to remain ambiguity as to whether these options should be categorised as bottled water or vendor water. Given the nature of these water services (water is treated and marketed as being potable), the Cambodian government should re-consider whether bottled water should remain an unimproved water supply or be redefined as improved as per the global definition. NGOs that are supporting water kiosks should monitor the numbers of their customers and the connectivity in their service areas.
	Prevalence (# of HHs served)	NGO-supported kiosks – Estimated to be 400,000 for TS1001 alone (unknown for other suppliers) (2017) [26]			
	Rural coverage (as a main drinking water supply)	Uncertain - but probably around 11%[19] (2017) [1]			
	% of rural population living in potentially viable areas	60% (combined kiosks and PWS) (2017) [2]			
	Rural connectivity (proportion of HHs in the coverage area that are actually customers)	19% (TS1001 only) (2017) [26]			
	Coverage trend	Increasing			

Service levels	Accessibility	Likely to be high, but affordability limitations have not been fully characterised		Kiosk operators (particularly those NGO-initiated) reportedly conduct regular HH deliveries throughout their coverage area [2] – in addition to on-site resale at the kiosk itself and in local shops. Accessibility levels are high for customers that are willing to pay the small extra fee for delivery. Most customers choose to have water delivered to their home (65%) [26]. Accessibility to the product may be limited by affordability – particularly the initial cost of the plastic jug [2]. There have been some reports of informal subsidies or payments by instalment applied by some operators.	An affordability survey among non-customers living within kiosk service areas could inform planners on future targets for connectivity and informing the design of promotional aides to raise connectivity. Pro-poor support mechanisms could be further explored – potentially based on some methods that operators have already trialled.
	Reliability	May be high, but has not been fully characterised		Delivery vendors are not available on-demand but conduct their deliveries routinely throughout their service area. As the team of staff is small, delivery may be interrupted by unforeseen circumstances. However, the actual reliability of delivery services has yet to be characterised.	An assessment of the reliability of water deliveries would be useful (potentially through a customer satisfaction survey).
	Quality	Presumably high – but further verification needed		Bottled water distributers intend to provide customers with a safe product for direct human consumption. Water treatment systems have reportedly been established at all NGO-initiated kiosks. There is no regulation of kiosks in Cambodia, and the responsibility is with the facility operators (and/or NGO platforms) to monitor water quality. TS1001 conducts monthly monitoring of all kiosks through its three laboratory facilities and a bi-annual independent laboratory verification. Lien AID puts the responsibility for water testing on the operators themselves. Water quality conditions at some kiosks have been independently evaluated by provincial authorities and UNICEF, and revealed the presence of significant microbiological contamination in some samples taken from both the treatment systems and the 20L jugs themselves.	In the absence of any regulation of rural kiosks and with the presence of some adverse water quality results - improved monitoring of water quality, mitigation of problems, and transparency of monitoring results is needed to ensure consumer protection and trust in the services being offered.
	Quantity	High		Water quantities are likely to be sufficient for drinking if the HH is able to maintain sufficient reserves (potentially 2-3 jugs at one time) and consistent re-supply (which depends on the reliability of deliveries and affordability).	

Component	Parameter	Characterisation	Score	Rationale	Gaps & Priorities
Service delivery / operator perfor-mance	Functionality	Moderate-high – with some future risks		Most kiosks that have been established remain functional, but there are some cases where facilities have been deactivated – either temporarily or permanently[20]. TS1001 reports an overall functionality rate of 80% over their 10 years of implementation, but this rate has increased significantly in recent years [26]. Lien AID's functionality rate is 83%, but they are working to bring non-functional facilities back online. Infrastructure from non-viable sites may also be relocated for use at a new site. Maintenance and repairs are conducted by the operators themselves.	Future functionality may be threatened when operators experience a major (expensive) breakdown and if they do not have the willingness to make investments to keep the system operational. As the kiosks are quite new, it is not clear how operators will respond when such an event occurs. The fact that some hardware components are imported from abroad may make repair and eventual replacement challenging.
	Sustainability	Sustainability to-date appears to be high, but longer-term risks remain		NGO-initiated kiosks have reportedly been able to achieve operational cost recovery [2]. Full cost recovery is a long-term goal of TS1001 [26].	Further financial analysis is needed to determine whether kiosks can achieve full-cost recovery.
	Regulation & monitoring	None		Both NGO-initiated and private water kiosks are not yet regulated in Cambodia. Institutional arrangements have not been defined, including any separations between NGO-initiated and privately-initiated facilities.	Licensing and regulatory frameworks for kiosks need to be established as they now serve a large segment of the rural population. Institutional arrangements for regulation and oversight need to be clarified – with execution likely suitable under the mandate of MiH. Monitoring and reporting are needed to ensure accountability, safety, and transparency in this emerging area within the water sector.

Particularly, data and reporting on operational and full-cost recovery is uncommon and not fully institutionalised. Potential financial risks include high interest rates on loans and poor levels of operational efficiency that may threaten cost recovery. There is some regional evidence that smaller operators are struggling due to lower number of customers, lower population densities and economies of scale, and poor operational efficiencies [25].

Additional data gaps include the understanding of service levels such as quality and reliability. The frequency and duration of service outages experienced by rural customers are not well reported and water quality conditions remain poorly characterised - particularly the presence of primary water treatment, residual disinfection (i.e. chlorine), presence of water quality testing, and compliance with national standards. The establishment of the MIS is a good first step towards addressing these monitoring needs, and can be taken forward through future expansion (to include SWEs), strengthening (to include more indicators), and improved utility (to support annual sector performance benchmarking).

Water kiosks & packaged / bottled water

Packaged water is distributed in Cambodia through a variety of brands and in bottles and jugs of various size. Such products are marketed as being safe for consumption and their producers claim to have treated the water through various methods[17]. Packaged water is often utilised as an intermittent supply of drinking water – such as during travel away from the HH – but in some cases may serve as a HHs routine source of drinking water. In such cases, packaged water is purchased in large quantities – typically in 20 litre (L) plastic jugs. In recent years, the availability of such jugs has rapidly expanded into the local marketplaces in many rural areas due to the emergence of decentralised water production facilities called kiosks. Rural kiosks serve only the residents living in their local service area. Water is sourced from groundwater aquifers, surface water bodies, or nearby PWSs – and then treated and packaged in 20L jugs for resale. Resale occurs in several different forms: on-site purchase; purchase from local shopkeepers; or home delivery for an additional fee. The service area of each kiosk typically follows commune or village boundaries. The concept of rural bottled water kiosks was originally initiated in Cambodia through the organisation 1001fontaines - now in Cambodia referred to as 1001 Teuk Saat (TS1001). Recently, the approach has also been promoted by other organisations including Lien AID, World Vision, and Good Neighbours. Some private rural kiosks are also known to exist. Separately, large-scale water bottling factories also have broad distribution networks which carry large 20L water jugs into the rural marketplace.

The water supply profile for kiosks and packaged/bottled water serving rural Cambodia is presented in Table 2. To-date, there are approximately 300 rural kiosks delivering water to an estimated 500,000-600,000 customers. TS1001 has initiated over 200 kiosk facilities while Lien AID has initiated 75 facilities [2]. Other organisations have initiated fewer systems. Future expansion plans are ambitious, with TS1001 alone aiming to reach 1 million customers by 2020.

NGO-initiated kiosks rely on external donor investments to cover the capital costs of the facilities themselves. Commune authorities are first engaged and once a site has been assessed, found to be viable, and approved by the authorities – a local operator would subsequently be recruited. This operator will then manage and operate the facility – generating income from water sales. For TS1001 supported kiosks, operators must pay a franchising fee to the NGO to contribute towards coaching, water testing, branding/ marketing, monitoring and reporting, and the initial provision of consumables

[26]. The facility is owned by the commune government while the treatment hardware remains the property of TS1001. For Lien AID, ownership of the entire facility and its assets are transferred to the community, through the authority of the commune council and the management committee. Operators of a Lien AID initiated kiosk are responsible for their own water testing and Lien AID provides advisory support as needed. For both TS1001 and Lien AID, any maintenance and repair needs are the responsibility of the operators.

To become a first-time customer, HHs must initially pay for the plastic jug itself in addition to the water inside it. Jugs typically cost between 10,000 and 15,000 riels ($2.50-$3.25 USD). After this initial purchase, once emptied, the empty jug is given back to the kiosk operator who substitutes it with a filled jug for only the price of the water. Twenty-litre refills cost customers around 1,500 riels ($0.32 USD) for HH delivery and 1,200 riels ($0.30 USD) if purchased directly from a shop or the kiosk itself.

Rural water kiosks are now well established and are likely to continue to play an increasing role in the water decisions of many rural inhabitants. Significant growth potential exists through expansions into new areas and ongoing promotion within areas where services are already available. Further study could be performed on barriers among non-customers living inside a coverage zone and on affordability constraints. Without oversight and regulation, operators that already have significant independence may not be kept accountable for maintaining the safety of their product.

An initial step may be to properly define kiosk-derived water in the national survey instruments. A second step may be to establish an institutional and regulatory framework – including licensing and accompanying monitoring and reporting requirements – similar to that for PWSs. Such a framework would likely cover both NGO-initiated and private kiosks.

There are some preliminary concerns about the kiosks' abilities to deliver safe water at all times. This requires further study and confirmation. There may be opportunities to introduce innovative and appropriate water treatment or testing products suitable to the kiosks' context. Drinking water safety planning may be an appropriate concept to apply at the kiosks – to ensure risks are identified and mitigated. Additional financial analysis is also needed to establish the financial health of the kiosk operators and whether full-cost recovery is attainable as a future goal.

Lastly, analysis may be required on the interface between the kiosk approach and PWS approach – and to what extent they are complimentary or in competition. It is clear that there are still inefficiencies associated with the use of PWS water for consumption (mostly due to distaste for chlorine) but it is unclear whether this behaviour will continue into the long-term. The risks associated with the recontamination of stored PWS water are also not yet clear. As such, kiosk water may have a complementary role for drinking purposes only, until trust, palatability, and reliability of rural PWSs improve to meet customer satisfaction and shift habits towards on-demand consumption.

Delivered water services (excluding bottled water delivery)

Water delivery services (including those involving delivery by pump, cart or truck) are reportedly common across much of rural

Cambodia – however their actual prevalence is unknown[21]. Such services rarely constitute a HHs primary water supply, but become active in the dry season (and even more so towards the end of the dry season) when local water supplies in some areas dry up (such as shallow wells and ponds) [27]. Water delivery services are classified as an unimproved water supply. Deliveries are typically ordered via telephone [27] and average costs range from 3,000 riel ($0.75 USD) per m3 for a mobile pump operator to 4,000 riel ($1 USD) per m3 for carted/trucked water. The water supply profile for delivered water services is presented in Table 3. While water delivery services generally provide low levels of service (poor water quality, high costs, and low accessibility) their appropriateness and relevancy to some particular geographical context may emerge in the future – such as through the trucking of water from a piped supply to areas outside of its network that experience water scarcity.

Tube wells

Tube wells are the most common water supply in rural Cambodia and have been so throughout recent decades. All tube wells are classified as improved water supplies. Tube wells can be sub-classified as either service provider operated or privately operated (Figure 2). Service providers may include local governments or water supply user committees. Tube wells operated by service providers were more likely to have been constructed using public or donor funds. Tube wells that are operated and managed directly by HHs were typically paid for by the HH themselves.

Privately constructed and operated tube wells have become increasingly common in rural Cambodia over the past decade due to increased affordability combined with the prevalence of shallow groundwater tables throughout much of the country. Various private well drillers exist throughout Cambodia, and in the past MRD has maintained a registry of those it has inspected and approved. Most wells are fitted with a hand pump – the most common of which are VN6 suction pumps (primarily sold through the marketplace) and Afridev mechanical pumps (primarily used as part of NGO or large-scale infrastructure development projects). The water supply profile for tube wells is presented in Table 4.

Dug wells and surface water

Dug wells and surface water are common primary drinking water supplies in rural Cambodia [1]. With the exception of protected dug wells (those that have a lining, apron, and cover), they are unimproved. Surface waters are predominantly derived from rivers, lakes, natural ponds, community ponds, and streams. Fortunately, their prevalence as a primary HH drinking water supply has been gradually decreasing in recent years. Reasons for these decreases may be attributable to the increased coverage of SWEs, increased affordability, and dissatisfaction with the accessibility and quality of water that dug wells and surface water provide.

Dug wells are predominantly hand dug down to the unconfined aquifer water table. Most are lined with cement rings, but few meet the definition of “protected”. Most users fetch water by a bucket on a rope, but windless cranks and rope pumps are also options, although uncommon. The water supply profile for dug wells and surface water is presented in Table 5.

Table 3 – Delivered water service profile

Component	Parameter	Characterisation	Score	Rationale	Gaps & Priorities
Rural water supply coverage	Prevalence (# of service providers)	Unknown		Water delivery services represent an unimproved water supply. National coverage is reported to be 9% [1], but this figure appears to also include bottled water kiosks, which have been assessed separately in this note. A survey in 2012 did separate kiosk and delivered water, and revealed that very few HHs rely on delivery services as a main water source [6]. Water delivery services may take many different forms including delivery by tanker truck, motorised cart, push cart, or for-hire pumps (that transport nearby surface water over a distance into HH storage jars and tanks) [27].	Water scarce areas where seasonal delivery services operate should be identified and prioritised for future water supply development projects to eliminate the scarcity of permanent water supplies. Such issues could also be resolved by enhancing water delivery services, potentially through sourcing water from distant piped supplies and coordinating deliveries to reduce costs.
	Coverage (as a main drinking water supply)	0.1% in wet season, 0.8% in dry season (2012) [6]			
	Coverage trend	Unknown			
Service levels	Accessibility	Likely low		Vendors may not be accessible to the customer when needed, as they may not be based within their community and may only operate temporarily when demand exists. Water delivery services are also very expensive – largely due to transportation costs associated with moving large volumes of water.	HHs in water scarce areas may be paying large portions of their disposable income on seasonal water delivery services. However, the severity of this issue is unclear and further study may be needed.
	Reliability	Likely low		Water delivery services, by their very nature, are often temporary and not available on-demand. Therefore, in most circumstances, their operations cannot be consistently relied upon by their customers year-round and complaints of delays between the time when an order is placed and when it arrives at the HH have been reported [27].	-
	Quality	Low		Delivered water is typically not treated (94%) and often originates from surface water (80%) [27] – indicating that quality is low.	-
	Quantity	Likely low		Water quantities may not be sufficient for HH needs, as delivered water is often used a last option and may not be replenished on-demand once it runs out.	-

Service delivery / operator performance	Functionality	N/A		Not applicable	-
	Sustainability	N/A		Not applicable[22]	-
	Regulation	None		Water delivery services are not regulated in Cambodia.	-
	Monitoring	None		Water delivery services are not monitored in Cambodia.	-

Table 4 – Tube well profile

Component	Parameter	Characterisation	Score	Rationale	Gaps & Priorities
Rural water supply coverage	Prevalence (# wells)	500,000 (estimated) [28]		Tube wells represent an improved water supply. National coverage as a main year-round drinking water source is reported to be 35% [1]. However, some HHs may rely on tube wells for domestic or irrigation purposes and not for drinking (potentially due to water quality issues). Coverage has remained steady over the past decade. The proportion of tube wells operated privately or by service providers is not known. Tube wells are likely to remain an important part of the rural water supply context – particularly in areas of low population density where SWEs will not be able to provide services in the future.	Priority geographical areas for the promotion and development of tube wells have not been formally identified. However, such a study could be performed by determining which parts of the country have viable groundwater aquifers (quantity and quality), and overlapping areas where unimproved water supplies (particularly surface water) remain prevalent, and subtracting areas where SWEs already exist or may be viable in the near future.
	Coverage (as a main drinking water supply)	19% in wet season, 31% in dry season (2012) [6]			
	Coverage trend	Steady			
Service levels	Accessibility	High		Private tube wells are typically situated within the HH's property [8]. Public tube wells may be within the community and may require travel to/from the water point and water conveyance – potentially using pumps, buckets, or jugs – to bring the water back to the home. However, few tube well users reportedly travel long distances to fetch water, and therefore overall accessibility is high [8]. Tube well construction requires a large financial investment, and affordability may be limited among the poor.	Among HHs that continue to rely on unimproved water supplies, it is unclear what barriers exist to accessing improved supplies – particularly tube wells and particularly with regions that remain outside the service area of SWEs.

	Reliability	Moderate		Reliability of the groundwater supplied by tube wells has been reported to be high in some studies, but data is limited to select geographical regions [29]. Deeper groundwaters in confined aquifers may be less susceptible to seasonal groundwater fluctuations associated with monsoons and flooding than those in an unconfined aquifer. However, most tube wells are reportedly drilled into the unconfined aquifer and the over-exploitation of groundwater reserves over past decades is beginning to produce some reports of falling aquifers in parts of the country [28].	Seasonal fluctuations in water levels may threaten future reliability of groundwater supplies. The establishment of groundwater resource monitoring programmes is vital to support the understanding of seasonal reliability and long-term sustainability.
	Quality	Moderate		The quality of groundwater delivered by tube wells is highly variable, but generally high. Shallow groundwaters within higher density rural areas where pit latrines are common may be susceptible to faecal contamination [30]. Arsenic contamination has been widely reported in some parts of the Mekong Delta region, as well as adverse health effects associated with long-term consumption [30]. Recent evidence suggests that the proportion of individuals exposed to arsenic via drinking water may have significantly decreased due to blanket water testing and education activities and promotion of alternative safe water supplies [31]. Elevated iron concentrations and hardness levels are also widespread in some areas, causing discolouration and taste issues. Groundwater salinity is an emerging issue in coastal areas. Fluoride, nitrate, and manganese have also been detected in some parts of the country [31, 28]. Testing of groundwater quality has been limited to specific geographical areas or surveillance activities – mostly related to the arsenic crisis.	Groundwater quality issues have been extensively explored and characterised in Cambodia – particularly in the areas where wells are most common. However, the quality and safety of individual wells cannot be assured without routine water quality testing – which is largely unavailable to the average well operator. Efforts to decentralise water testing facilities may be justified in the future as capacities and resources to sustain these services increase. Arsenic contamination is so widespread and hazardous that monitoring efforts should continue into the future, despite the fact that exposures have significantly decreased.
	Quantity	High		Water quantities are generally sufficient for HH needs, although this is heavily dependent on year-round reliability and long-term sustainability – which may be threatened in some areas where groundwater resources have been exploited.	-

Service delivery / operator perfor-mance	Functionality	N/A		Functionality has not been assessed and monitored systemically and nation-wide, but several studies have characterised tube well functionality rates in local areas. These studies found that functionality levels of tube wells are surprisingly high (88% in one district of Kampot) [29]. One study has also revealed that privately operated wells are much more likely to be repaired than those publicly operated [34].	Functionality levels have been poorly characterised in Cambodia and the data available may not reflect nation-wide conditions. Additionally, further exploration of functionality rates by pump type is needed to determine whether wells are reaching their intended design life and whether users have been able to coordinate repairs when needed.
	Sustainability	Moderate		While little information is available related to the sustainability of groundwater resources, one study in the Mekong Delta suggests that groundwater levels will fall below the pumping capacity of traditional suction pumps by around 2030 [29]. At the time of writing, Action Aid is implementing a groundwater resource monitoring project across 7 provinces, the results of which should provide improved data on aquifer sustainability. Several regional studies have also been conducted, but data is often conflicting. The sustainability of hand-pumps is also a concern due in part to ineffective management of public supplies, lack of knowledge on minor repairs, and a lack of locally available service providers for repairs. As dysfunctionality rates appear to be low, short-term sustainability of tube well infrastructure may be high. However, as an increasing number of wells approach the end of their design life and fall into major dysfunction, capital costs associated with replacement or major refurbishment are unlikely to sustain services, due to limited public budgets and the absence of mechanisms to identify and resolve incidents of major breakdowns. Sustainability of the hardware associated with private tube wells is likely to be higher.	Deep groundwater resources (>100 meters) have been poorly explored, but if present in some areas, may unlock future reserves of water resources. Until then, ongoing groundwater resource monitoring is urgently needed along with management of groundwater extractions to maximise existing supplies.

	Regulation	Low		Well drilling activities and well repair services are not yet formally regulated in Cambodia. As a result, the quality of construction and repair works is a concern. Management of groundwaters are the responsibility of the Ministry of Water Resources and Meteorology (MoWRAM) as stipulated in the Law on Water Resources Management (2007). However, enforcement of abstractions and planning/management of water resources is largely not occurring. Groundwater for consumption is regulated by the Drinking Water Quality Standards of Cambodia – however mechanisms to measure compliance are not in place.	An exploration of what elements of the Water Resources Management Law are and are not yet being implemented could be explored to develop practical recommendations on how aquifers could be better managed in the future. Monitoring data may be a key driver towards advocating for this issue. Regulation and training of well drillers and repair services may improve functionality of tube wells. Mechanisms to assess compliance with water quality standards – such as provincial laboratories – may be considered in the future if capacities improve.
	Monitoring	Moderate		Water resources are not yet systemically monitored. Tube wells in rural Cambodia are monitored to a limited extent. MRD reportedly coordinates the monitoring of wells for every commune in the country, through the upward reporting of the quantities of existing wells of various types to each PDRD. This dataset remains privately held by the Department of Rural Water Supply and functionality and other criteria are not assessed. A well monitoring platform had been established in 2010 but is no longer dynamic [36].	Efforts could be made to routinely analyse and report on MRD's routine monitoring data on existing wells throughout the country. Adding functionality status to the survey would add significant value to the data. Efforts to monitor new well constructions and the activities of well drillers could also inform policy and decision-makers on the status and trends associated with this important type of water supply for the country.

While a study of service levels associated with users of such unimproved water supplies as dug wells and surface water may serve to characterise the severity and prevalence of water issues, it is clear that efforts need to be made to promote improved supplies in such contexts.

Rainwater collection

Rainwater harvesting is a traditional and cultural practice in Cambodia and ceramic storage jars are common throughout most of the country. The large majority of rural HHs harvest and consume rainwater (86%) – but it serves as the primary water source for only 60% and 13% of HHs, in the wet and dry seasons, respectively. Only 9% of HHs regard rainwater as their primary year-round drinking water supply. Rainwater collection is only considered to be an improved water supply by the Cambodian government when storage capacities are greater than 3000 litres and the water is accessed from a tap. Such configurations are generally uncommon and therefore nearly all rainwater harvesting in Cambodia is considered unimproved. By global definitions, all rainwater harvesting is considered improved. This discrepancy in definitions between global and national levels has resulted in a moderate difference in national rural water supply performance – particularly if analysing performance for wet and dry seasons separately.

Rainwater collection is likely to continue to be an important water supply option in rural areas for the foreseeable future. The costs associated with rainwater harvesting materials and equipment is low – after which the water captured is free. However, the reliability of the supply of water is fully dependent on rainfall events which can be unpredictable. As such, rainwater collection is nearly always a secondary water supply option – with the exception being those HHs that have space for and can afford large volumes of storage capacity – so that they rarely (if ever) run out of water.

Rainwater is a preferred drinking water supply during the times when it is available [37] – particularly due to its purity compared to surface water (which often has high turbidity) and groundwater (which can be impaired by taste-impacting iron and hardness, and health impacting arsenic) as well as the convenience of rainwater being collected and stored in the HH. The widespread practice of collecting rainwater appears to be undermining the performance of SWEs to some degree – as demand for these water services commonly decreases during the wet season when rural HHs increase their reliance on rainwater. The water supply profile for rainwater collection is presented in Table 6.

Table 5 – Dug well and surface water profile

Component	Parameter	Characterisation	Score	Rationale	Gaps & Priorities
Rural water supply coverage	Coverage (as a main drinking water supply)	Surface water: 4% in wet season, 27% in dry season (2012) Dug wells: 11% in wet season, 24% in dry season [6]		Dug wells and surface water represent mostly unimproved water supplies. National coverage as a main year-round drinking water source is reported to be 28% - 14% for dug wells and 14% for surface water [1]. Use of these sources for drinking is significantly higher in the dry season versus the rainy season – likely because rainwater is more preferred, but is not being stored in sufficient quantities to last through the dry season [8]. Coverage has been decreasing gradually over recent years. Most dug wells and surface water access points do not have any formalised management structures – with the exception of those dug wells that may have a pumping apparatus and that are shared by a community.	To meet the Cambodian government's ambitious targets on access to improved water supply, villages and communes that have large proportions of the population consuming water from dug wells and surface water will need to be targeted strategically for water supply development projects to continue to reduce reliance on these unimproved water supplies.
	Coverage trend	Decreasing			
Service levels	Accessibility	Moderate		While accessibility to water supplies is generally high in rural Cambodia, those few HHs that travel longer distances to fetch water most commonly do so for surface water [8]. Dug wells and surface water are often utilised in contexts where no water supply infrastructure exists – and it is likely that they are more commonly relied on by the poor.	Barriers to the access of improved water supplies among those that continue to rely on unimproved supplies requires further study – particularly if efforts will be made to target such communities and HHs for future infrastructure projects.
	Reliability	Unknown		Dug wells may be most susceptible to seasonal fluctuations in groundwater levels as they often cannot be dug far below the water table. Similarly, small surface water bodies such as ponds and streams may disappear during periods of drought. Dug wells and surface water may be most vulnerable during the dry season – which is when they are relied upon the most [8]. Therefore, reliability may be low, but there is very little data to validate this assumption.	-

	Quality	Low		The quality of water provided by dug wells and surface water is typically poor – and thus its classification as an unimproved water supply [37]. Protected dug wells are intended to prevent contamination from the surface, but some evidence from Cambodia suggests that the aquifers themselves may be susceptible to microbial contamination in areas were population densities are moderate and pit latrines are prevalent [30].	-
	Quantity	Unknown		No data was found on the quantities of water available to users of dug wells and surface waters – and conditions are likely to be highly variable. For example, ponds may offer a very limited quantity of water, while rivers and lakes would offer nearly unlimited supplies. A dug well used by a single family may provide a nearly unlimited supply while one shared by many HHs may struggle to replenish itself.	-
Service delivery / operator perfor-mance	Function-ality	High		With the exception of rope pumps and hand pumps used to convey water from dug wells or community ponds, these types of sources typically do not involve any infrastructure that needs to be maintained or repaired. Some exceptions may exist for silted dug wells that need to be dredged or community ponds that need to be deepened. However, dug wells and surface water typically remain functional into the long-term due to their simplicity.	-
	Sustainabil-ity	Moderate		Surface water and dug wells may be most susceptible to the long-term effects associated with climate change. They are highly dependent on rainfall, and susceptible to droughts.	Any assessments on the impacts of climate change on water supply and drinking water should carefully consider the proportion of the population that continues to rely on these water supplies that are most vulnerable to future climactic changes.
	Regulation	Low		Beyond the Law on Water Resources Management, dug wells and surface water used for drinking purposes are not regulated in Cambodia.	-
	Monitoring	Low		The number of dug wells in each community is reportedly tabulated as part of MRD's ongoing water supply monitoring initiatives. Surface water bodies used as a water supply are not monitored.	-

Table 6 – Rainwater collection water profile

Component	Parameter	Characterisation	Score	Rationale	Gaps & Priorities
Rural water supply coverage	Coverage (as a main drinking water supply)	60% in wet season; 13% in dry season [6]		The majority of rural Cambodian HHs collect, store, and drink rainwater, but rarely as a primary year-round source. However, the proportion of HHs that have large storage capacities and drink rainwater as their main year-round source has been rising in the past few years – potentially due to the wider availability of large volume storage containers and increasing affordability.	The Cambodian government could reconsider its definitions of improved and unimproved rainwater collection, and potentially align them with global definitions in the future. Rainwater harvesting will remain an important water supply option for rural Cambodians in the future. Improved forms of rainwater harvesting should continue to be among the options considered and promoted to communities and HHs that continue to rely on unimproved supplies.
	Coverage trend	Increasing slightly			
Service levels	Accessibility	Moderate		Rainwater is almost always harvested and stored at or around the HH, and is therefore easy to access when available. Rainwater harvesting materials and equipment are generally affordable – particularly when compared to PWS connections and wells.	-
	Reliability	Low		Reliability of rainwater harvesting is generally low, as supplies are subject to uncontrollable rainfall events. However, those HHs with larger storage capacities, and that use their stored reserves sparingly during times of infrequent rainfall, are much more likely to achieve a reliable supply – and particularly during the wet season months. Reliability of rainfall may be subject to future impacts associated with the effects of climate change.	-

	Quality	Moderate		Rainwater is relatively pure as it falls from the sky, but can quickly come into contact with contamination as it reaches the ground. The threat of contamination from unclean rooftops that trap rainwater can be partially mitigated by discarding the initial run-off – either manually or through an automatic first-flush system. Once stored at the HH, the quality of the water is subject to handling and storage conditions. Rainwaters may remain clean if stored in closed containers and accessed in such a way to prevent contamination (i.e. using a tap). However, the majority of rural HHs store rainwater in open or semi-open jars and handle the water using scoops and cups [6].	-
	Quantity	Moderate		Rainwater harvesting typically provides sufficient water quantities for a limited number of HHs needs, during the times when it is available. Quantity service levels during such times could be considered to be high for HHs with at least a moderate storage capacity. Due to its purity, rainwater is often preferred for drinking, and at times of limited availability, other supplementary water supplies may be used to serve other domestic water needs. During such times, quantity service levels may be lower. When stored rainwater reserves are depleted, the household no longer has sufficient quantities of water and must secure water from another source.	-
Service delivery / operator perfor-mance	Functionality	High		Harvesting and storage equipment and materials are generally available locally and at low cost [37]. Once investments are made, little maintenance and repairs are required to keep rainwater systems functional. The quality and durability of ceramic jars may vary considerably across producers – but their lifespan is typically long if handled properly.	-
	Sustainabil-ity	Moderate		Rainwater can be considered to be sustainable when thought of annually – but is intermittent for most HHs within a given year. The sustainability of rainwater as a predictable water supply may be threatened in the future due to the effects of climate change.	The potential implications associated with climate change and rainwater harvesting (particularly for drinking) have yet to be well characterised in the Cambodian context.
	Regulation	N/A		Rainwater harvesting is almost always a private and HH water supply and therefore is not subject to government monitoring and regulations.	-
	Monitoring	N/A			-

Sector priorities and research needs

Priorities and knowledge gaps specific to each type of water supply have been discussed in the previous sections and water supply profiles. This section summarises overall sector priorities and emerging issues.

Improving water supply coverage

SWEs, tube wells, and rainwater harvesting will continue to be important improved water supplies for the country into the future. As the 2025 Sector Vision and 2030 SDGs come to an end over the coming decade, Cambodia's RWS performance will be evaluated. Efforts to convert those HHs that continue to rely on unimproved water supplies to improved ones will have to be implemented efficiently and effectively if these targets are to be achieved. As a first step, villages, communes, and districts should be ranked by the proportion of their residents that continue to rely on unimproved supplies. Subsequently, feasibility studies would have to be developed for the lowest ranked areas to determine which improved water supply options may be viable and the best means by which they could be promoted or established[23]. Such analysis should be informed by separate investigations to determine which parts of rural Cambodia[24] could viably sustain water services delivered by SWEs. The routinely updated Commune Database (CDB) and the periodically[25] administered National Census may also serve as suitable data sources to inform these analyses. The next National Census will be administered by the National Institute of Statistics in 2019.

Strengthening RWS service delivery

Water supply services are likely to be an increasingly relevant and important part of the RWS landscape in many rural parts of the country – with the exception for those living in areas with a low population density. The speed at which these services will grow and expand will depend heavily on: 1) the extent to which their delivery can be made cost-effective to achieve economic viability in rural areas where economies of scale are lower; 2) the rate at which financial, managerial, and technical capacity gaps are addressed; and 3) how financing and subsidy opportunities evolve – both to incentivise the establishment of new facilities in areas that are viable but less economically attractive and to connect poor HHs to existing supplies.

Various opportunities exist to improve the understanding of how RWS services are currently being delivered. These opportunities include further economic analysis relating to full-cost recovery and sustainability, and the strengthening of routine monitoring and benchmarking of licenced service providers. Opportunities also exist to enhance service delivery performance through the reduction of operational inefficiencies (such as energy costs), establishment of capacity development programmes, design and roll-out of financing mechanisms, and improved clarity of regulatory authorities among the relevant line ministries. The proactive recognition of potential future shocks and risks (particularly those relating to water resource management, climate change, and sudden economic downturns) will be important towards ensuring the long-term functionality and sustainability.

Improving access to safe drinking water

National targets for RWS have been defined entirely on the basis of whether or not a HH's water supply is improved and unimproved. While the promotion and increasing coverage of improved water supplies should continue, decision and policy makers should also acknowledge that the use of improve water supplies may not actually correlate with safe drinking water. Increased attention should be placed on the fact that HH water treatment and safe water handling are more accurate predictors of safe water – and evidence-based tools and methods should be integrated into community health messaging and awareness programmes to promote safe water habits. The periodic monitoring of safe drinking water at the point-of-consumption[26] may also serve to ensure that reduced exposure to faecal matter is actually being achieved.

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[1] Defined by the National Institute of Statistics (NIS) based on population density and reliance on agricultural practices as a primary income source.

[2] A public or private operator of a water supply system that provides water to users or customers

[3] A water supply network that distributes water through pressurised pipes to users or customers taps

[4] CSES had disaggregated main drinking water sources by wet and dry seasons over the period 2009 to 2014. Since 2015, only the primary drinking water source was surveyed.

[5] Historical expenditures have been around $1 million USD per year [5]

[6] The main drinking water source for the entire year

[7] For the purpose of comparison and continuity, the dry season figures from 2009 to 2014 are presented alongside the main overall drinking water source from 2015/16 in Figure 3.

[8] Meaning that they are lacking features needed to minimise the risk of contamination (such as a lining, cover, and/or platform)

[9] As identified through a national assessment of primary, secondary, and tertiary drinking water sources

[10] Improved water sources (tube wells, protected dug wells, piped water) are believed to be less likely to be contaminated than unimproved water sources (surface water, unprotected dug wells, water vendors)

[11] Additionally, but less consequentially, tanker water and bottled water remain unimproved by Cambodian definitions – while the JMP has recently begun to classify them as improved.

[12] Safe being defined here as those consuming treated 20L bottled water and/or connected to a licensed PWS

[13] As calculated by the author from DHS 2014

[14] The aforementioned MRD/WHO study asked HHs to prepare a glass of water as they normally would, and then asked whether anything had been done to the water in the glass to make it safer to drink. When the questioning was posed in this way, only 46% reported that the water in the glass had been treated.

[15] Under-5 mortality in rural areas was 52 deaths per 1,000 live births in 2014

[16] Crude birth rate in rural Cambodia was 22.4 per 1,000 people in 2014

[17] In the case of NGO-initiated facilities, treatment equipment is typically imported from abroad

[18] Under the MDGs, bottled water was considered unimproved, but was redefined as being improved under the SDGs

[19] Rural kiosks are likely to have been incorrectly defined in the NIS MICS surveys – as they may have been categorised by enumerators as either: 1) vendors, tank trucks, and carts (9%); or 2) bottled water (2%). The combined total of 11% is therefore a likely overestimation of total bottled water coverage (kiosk, delivery or shopkeeper) as the figure may also include HHs that purchase water from tanker trucks and carts as their primary supply.

[20] Temporary deactivation may be due to the kiosk operator stepping away from the business. Permanent deactivation may be due to rapid depopulation in the commune or a non-viable site [26]

[21] As previously discussed, informal water delivery services have been combined in the same classification category as kiosk bottled water deliveries in national surveys

[22] Water delivery service providers tend to operate temporarily when and where there is demand, and do not intend to serve as a permanent supply. Therefore, sustainability has not been assessed.

[23] Such studies could be integrated into broader water supply development planning initiatives

[24] Likely at a commune-level resolution

[25] Approximately every 10 years

[26] Perhaps as part of the routinely administered Knowledge, Attitudes, and Practices (KAP) survey or through monitoring initiatives connected to the SDG ‘safely-managed’ drinking water indicator

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