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PAPER

Self-supply as a safely managed water service: comparative analysis and predictors of water service outcomes in rural Nepal

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Abstract

Self-supply is ubiquitous in rural areas of South Asia, including in Nepal, where more than a third of the country's population obtains their drinking water from private tubewells. However, there has been little research into the service levels delivered by self-supply or its performance relative to public water services. Drawing on data from 1289 tubewells in Sarlahi District in the Terai region of Nepal, this study compared the performance of private and community tubewells in terms of water quality and availability and identified factors that predict service levels. Compared with community tubewells, private tubewells had significantly higher odds of providing water that was free from contamination and available in sufficient quantities when needed (OR 2.12, 95% CI 1.19–3.77, $p = 0.011$). However, inequities were evident among private tubewell users, with marginalized or lower-caste groups having significantly lower odds of accessing a safely managed water service (OR 0.68, 95% CI 0.54–0.85, $p < 0.001$). Among private tubewell users, shallower wells and open defecation were significantly associated with the presence of *E. coli*. The results show that self-supply is capable of providing a safely managed water service and can contribute to efforts to achieve Sustainable Development Goal 6. However, targeted support should be directed towards disadvantaged households to safeguard water quality and strengthen service reliability. In particular, programmes that support the installation of deeper tubewells, prevent open defecation and promote household water treatment may bring water quality benefits in areas where self-supply is practised.

1. Introduction

Self-supply is a widespread model of water service delivery in South Asia, with around one third of the population—or almost 600 million people—relying on private wells for their drinking water [1]. Typically owned and managed by individual households, self-supply systems can be a stop-gap or intermediate stepping stone along a household's pathway towards a safely managed water service [2]. However, because self-supply typically means water is accessible on the premises, it has the potential to provide a safely managed water service in its own right. To be considered safely managed for the purposes of Sustainable Development Goal 6 (SDG 6), a water service must be from an improved source, free from contamination, available in sufficient quantities when needed and accessible on the premises [3]. Self-supply's potential to provide a safely managed water service therefore hinges on the extent to which it can provide water that is free from contamination and available when needed, and the extent to which it can provide such services to those who are most disadvantaged or hardest to reach.

Despite the ubiquity of self-supply in low- and middle-income countries (LMICs), significant evidence gaps remain in relation to its performance against the safely managed water service criteria. The governance, social and environmental aspects involved in operating and maintaining a water supply system may differ between private and communal systems, which may in turn lead to differences in operational performance.

Such differences might also be predicted by the broader theory of common-pool resources, which views the proprietary-rights system as an important factor that can influence outcomes [4, 5]. Yet there has been little documented on the performance of self-supply in comparison with communal systems, notwithstanding a handful of recent studies focused on reliability [6–8]. In terms of water quality, a recent systematic review of self-supply in LMICs found contamination levels similar to those of groundwater sources generally [9]. Although the associated meta-analyses found groundwater self-supply to be more frequently contaminated than piped supply, a lack of studies prevented any conclusive comparison of self-supply with communal water points [9]. The importance of this evidence gap is underscored by the fact that the majority of the rural population in low- and lower-middle income countries globally rely on non-piped improved sources for their drinking water [10].

A strengthened understanding of how service levels for self-supply vary across different sub-populations is also critical for advancing equity and inclusion, principles which are fundamental to SDG 6. While inequities in access to improved or safely managed water services are well documented [11, 12], how these inequities manifest in self-supply contexts remains unclear. Disadvantaged households may lack the resources needed to ensure adequate construction quality and effective maintenance, potentially resulting in poorer service outcomes; however, empirical evidence to evaluate this hypothesis has been lacking to date.

Environmental and infrastructural factors that influence service levels for self-supply systems also remain unexplored. Although there have been a large number of studies focused on predictors of water quality for groundwater sources in LMICs, particularly through sanitary inspections [13], these have tended to focus on community water systems. Likewise, there have been numerous investigations into predictors of reliability or functionality for communal water systems [14–16]. In contrast, very few assessments have focused on predictors of water quality or availability for self-supply systems [6, 7, 17, 18].

One cannot assume that the findings from studies of communal systems directly translate to self-supply contexts. Compared with self-supply, communal water systems may be constructed to different standards, may use different pump technologies, and are often situated in public areas at greater distance from private premises and domestic activities, where faecal sources such as sanitation systems and animal pens are often located. There are other inherent differences between private and communal water sources that could lead to disparities in service reliability and associated predictors. These include the likelihood of collective action (given different user group sizes and dynamics) and access to government support such as funding or technical expertise in the event of a major breakdown.

Addressing the evidence gaps on self-supply's comparative performance and associated predictors will be important for water policy-makers and practitioners across LMICs, including Nepal. Private tubewells supply drinking water to around 8.5 million people in rural Nepal, equivalent to 38% of the rural population [1]. Self-supply has long constituted a substantial component of Nepal's rural water service landscape. Household investment in private tubewells alongside community tubewells dates back decades [19], and dependence on private tubewells continues to grow [1]. The overwhelming majority of self-supplying households in Nepal reside in the low-lying Terai region, where the government estimates that more than a million private tubewells have been installed [20]. Policies and plans aimed at achieving SDG 6 must therefore engage with self-supply as an issue—even more so given previous evidence of comparatively poor construction standards [19] and the risk of elevated arsenic concentrations in groundwater in the Terai region [21]. Decision-makers need to carefully consider if, when and how self-supply should be encouraged (or discouraged), supported (or prevented), and regulated (or ignored). Addressing these issues requires a robust understanding of how self-supply service levels compare to communal systems, the equity of these service levels, and the factors that influence them.

This study therefore aims to (a) comparatively assess the performance of self-supply against communal water supply in terms of water quality and water availability; (b) comparatively assess the service levels provided by self-supply across different sub-populations (female-headed households, households with a disability, households from a lower caste); and (c) identify predictors of water quality and availability for self-supply systems. The analysis is based on data collected during a survey of 1289 tubewells in Sarlahi district, which captured information relating to their sanitary conditions and operational performance and included testing of water samples for the presence of *E. coli* and arsenic.

2. Methods

2.1. Study site

This study took place in Sarlahi District in the Terai region of Nepal (figure 1), a largely rural district with a population of 862 470 at the time of the 2021 census [22]. Groundwater use is common in Sarlahi, with around two thirds of the population relying on hand pumped tubewells [22], including both private tubewells and community tubewells [23]. Sarlahi was the selected study site due to the initiation of a

Figure 1. Map of study site.

programme to support rural water supply improvements in the district. The project 'Beyond the Finish Line—Inclusive and sustainable rural water supply services' was implemented by SNV, an international non-government organisation with funding support from the Australian Department of Foreign Affairs and Trade (Water for Women Fund).

2.2. Data collection

The analysis in this paper drew on data collected during a survey of tubewells carried out by SNV to assess baseline conditions in terms of water supply functionality, water quality, sustainability and service models. The survey, which was carried out during August 2021, captured data for 1289 tubewells in Sarlahi. Tubewells were selected on a random basis from lists provided by four rural municipalities. In total, 6% of the tubewells on these lists were sampled for the survey, and these included community tubewells, private tubewells, and tubewells serving schools and healthcare facilities. Ethics approval for this study was obtained from the UTS Human Research Ethics Committee.

A questionnaire was developed to collect key information about each water source and its surrounding environment. This included a range of questions covering sanitary conditions, potential sources of faecal contamination, and operational performance in terms of breakdown and repair times. The questionnaire design was informed by a review of standard sanitary inspection forms [24], as well as a review of the literature on risk factors for faecal contamination of groundwater sources. Questions were asked about the distance between the tubewell and potential faecal sources, with distances estimated by an enumerator counting the number of steps between two points (with each step estimated to be two feet in length). For households using private tubewells, additional information was collected on whether there were household members with a disability, as well as information on the sex and caste of the household head. The survey was administered using a digital questionnaire on the AKVO Flow platform.

Water samples were also collected at each tubewell and subsequently tested for *E. coli* and arsenic, with two samples collected per well (one for *E. coli* testing, one for arsenic testing). The collected water samples were transported to a lab within 8 h. For arsenic, samples were tested using HiMedia's rapid Arsenic testing kit, a colour comparator test with a range of 0.05–3.0 mg l^{-1} [25]. Samples were tested for *E. coli* using the Hygiena MicroSnap system which included the following steps:

- Sample collected in a sterile vial (100 ml)
- Sample transported to the laboratory within 8 h of collection
- Membrane filtration and inoculate the filter in an enrichment broth
- Incubate 100 ml at 37 °C for 8 h then transferred to the detection kit
- Detection kit further incubated at 37 °C for 10 min
- Result displayed in RLU (Relative Light Unit) within 15 s
- Result in RLU is converted to CFU according to a chart provided by the manufacturer

2.3. Analysis

First, descriptive analysis was carried out to summarise the key characteristics of private and community tubewells included in the survey, as well as the status of households using private tubewells in terms disability, caste and sex of household head. To identify statistically significant differences between private and community tubewells, Pearson chi square tests were applied to assess dichotomous variables, and Mann Whitney U tests were applied to assess continuous variables. The same tests were applied to assess any differences between households in terms of disability, caste and sex of household head. The threshold for statistically significant results was based on an alpha of 0.05.

Table 1. Characteristics of private tubewells and community tubewells.

	Community tubewells ($n = 72$)	Private tubewells ($n = 1128$)	p-value
Concrete apron			
Concrete apron present	72.2%	67.4%	0.394
Stagnant water			
No stagnant water within 10 feet	88.9%	93.9%	0.094
Fence			
Fence present	12.5%	44.3%	**<0.001**
Priming			
No pump priming required	50%	76.9%	**<0.001**
Open defecation			
No open defecation within 33 feet	72.2%	89.6%	**<0.001**
Animal dung pit			
No Animal dung pit within 33 feet	86.1%	93.8%	**0.01**

Note: p-values relate to pearson chi square tests. Bold values indicate statistically significant result.

Logistic regression analyses were then carried out to identify (i) significant differences in service levels between private and community tubewells, (ii) significant differences in service levels between households with/without a disability, from a lower/other caste, and with a female/male head, and (iii) significant predictors of private tubewell water being free from *E. coli* and operating for a 12 month period without a breakdown of more than 12 h (by way of a full multivariable model). The specific outcome variables analysed for (i) and (ii) were *E. coli* not detected, arsenic not detected, no breakdown exceeding 12 h in the previous 12 months (self-reported by users), and sufficient water available for domestic needs (self-reported by users). Because well depth may influence all of those outcomes, additional regression analyses were performed that adjusted results for well depth, thereby revealing whether observed differences were simply due to differences in well depth or some other characteristic associated with the private or communal nature of tubewell management and ownership. The regression models were in the form of generalized estimating equations (GEEs), which were adjusted for intra-cluster correlation at an administrative level corresponding to the former Village Development Committees. The rationale for the selection of predictor variables is detailed in Supplementary Material. Again, the threshold for statistically significant results was based on an alpha of 0.05. All analyses were performed with SPSS v27.

3. Results

3.1. Tubewell characteristics

Compared with community tubewells, private tubewells were significantly more likely to be protected by a fence, significantly less likely to require priming, and significantly less likely to, have open defecation or an animal dung pit nearby (table 1). Results of the Mann Whitney U test showed private tubewells were significantly shallower and situated closer to sanitation facilities than community tubewells (figure 2).

3.2. Performance of private tubewells vs community tubewells

Compared with community tubewells, private tubewells were significantly less likely to experience a breakdown exceeding 12 h, less likely to have arsenic detected, and more likely to supply water that was both free from contamination and available in sufficient quantities when needed (table 2). When running logistic regression GEEs that adjusted for intra-cluster correlation, private tubewells had significantly higher odds of arsenic non-detection, significantly higher odds of operating without a breakdown of more than 12 h, and significantly higher odds of supplying water that was both free from contamination and available in sufficient quantities when needed (table 3). These results held when adjusting analysis for well depth, suggesting that the observed associations were not simply a function of the differences in well depth between private and community tubewells.

3.3. Equity of service levels for private tubewells

Logistic regression GEEs assessing relationships between forms of household disadvantage and tubewell service levels found mixed results (table 4). Dalits and disadvantaged ethnic groups had significantly higher odds of arsenic not being detected in their tubewell water, but overall had significantly lower odds of water that was both free from contamination and available in sufficient quantities when needed. The odds of reporting sufficient water for domestic needs were significantly lower for female-headed households as

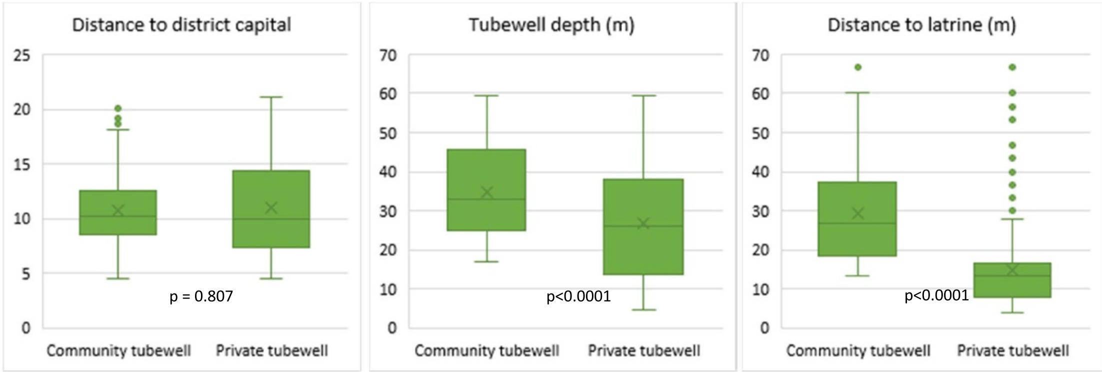

Figure 2. Box plots of continuous variables for private vs community tubewells.
Note: p-values represent results from Mann–Whitney U test.

Table 2. Performance against safely managed water service criteria: community tubewells vs private tubewells.

	Community tubewells ($n = 72$)	Private tubewells ($n = 1128$)	p-value
E. coli not detected	65.3%	68.1%	0.621
Arsenic not detected	84.7%	92.8%	**0.012**
No breakdown > 12 h	93.1%	99.3%	**<0.001**
Sufficient water for domestic needs	94.4%	92.1%	0.469
Free from contamination and available in sufficient quantities when needed	41.7%	56.4%	**0.015**

Note: p-values relate to Pearson Chi-Square tests. Bold values indicate statistically significant result.

compared to male headed households, but this did not translate into a significant relationship with a safely managed service more broadly.

3.4. Predictors of private tubewell service levels

Multivariable logistic regression GEEs assessing predictors of private tubewell service levels identified only two significant factors. Deeper tubewells and an absence of open defecation were both significantly associated with water that was free from *E. coli* (table 5). No significant predictors were identified for tubewells operating throughout a one-year period without a breakdown exceeding 12 h (table 6).

4. Discussion

The results reveal several insights of importance for policy makers and practitioners. First, private tubewells outperformed community tubewells in terms of providing water that was both free from contamination and available when needed. Second, among households with a private tubewell Dalits and disadvantaged ethnic groups were less likely to enjoy a water service that was both free from contamination and available when needed, as compared to households from other castes. Third, shallower tubewells and open defecation were significantly associated with the presence of *E. coli*. The results therefore show that self-supply is capable of providing a safely managed water service for those households that are willing and able invest in their own tubewell; however, these benefits are not shared equally, with disadvantaged households less likely to self-supply a safely managed service.

The results varied when the ‘safely managed’ criteria were broken down into their individual components. Private tubewells significantly outperformed community tubewells in some service level dimensions but not others. Private tubewells showed superior performance in terms of continuous operation (no breakdowns greater than 12 h) and non-detection of arsenic. However, when it came to being free from *E. coli* and having sufficient water for domestic needs, no statistically significant difference was observed between private and community tubewells. Water quality is often the foremost concern when it comes to self-supply versus other water service modalities; however, there is no evidence from this study to suggest that self-supply in Sarlahi gives rise to increased water quality risks relative to community-based supplies.

Table 3. Association between ownership and safely managed water service criteria adjusting for intra-cluster correlation.

	E. coli not detected		Arsenic not detected		No breakdown >12 h		Sufficient water for domestic needs		Free from contamination & available when needed	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Private ownership (vs community)	1.20 (0.60–2.44)	0.613	**3.08 (1.43–6.66)**	**0.022**	**10.50 (4.27–25.83)**	**<0.001**	0.97 (0.34–2.78)	0.952	**2.12 (1.19–3.77)**	**0.011**

Note: Bold values indicate statistically significant result.

Table 4. Associations between household sub-groups and attainment of safely managed water service criteria amongst private tubewell users.

	E. coli not detected		Arsenic not detected		No breakdown > 12 h		Sufficient water for domestic needs		Free from contamination & available when needed	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Lower caste	0.81 (0.63–1.03)	0.093	**1.52 (1.06–2.17)**	**0.020**	1.49 (0.25–9.09)	0.667	0.93 (0.74–1.18)	0.561	**0.68 (0.54–0.85)**	**<0.001**
Disability in household	1.15 (0.69–1.92)	0.582	0.61 (0.32–1.15)	0.122	0.5 (0.07–3.57)	0.488	0.66 (0.3–1.45)	0.300	1 (0.63–1.59)	0.996
Female-headed household	1.67 (0.83–3.33)	0.153	0.73 (0.37–1.43)	0.360	—	—	**0.43 (0.27–0.66)**	**<0.001**	1.12 (0.68–1.89)	0.647

Note: Bold values indicate statistically significant result. There were no breakdowns > 12 h amongst 61 female headed households. Results adjusted for intra-cluster correlation. Lower caste defined as 'vulnerable group', 'minority group', 'deprived group', 'dalit'. Non-lower caste included 'Brahmin, Chhetri, Thakuri, Sanyasi, Janajati and other (Yadav, Das, Rauniyar, Sudi, Teli, Mandal, Kalwar).

Table 5. Predictors of private tubewell water being free from *E.* coli.

	Unadjusted or (95% CI)	p value	Adjusted OR (95% CI)	p value
Concrete apron				
Concrete apron (no cracks)	Ref		Ref	
Concrete apron (cracks)	0.87 (0.64–1.19)	0.397	0.93 (0.68–1.30)	0.698
No concrete apron	0.96 (0.74–1.24)	0.735	0.96 (0.75–1.23)	0.750
Stagnant water				
No stagnant water within 10 feet	Ref		Ref	
Stagnant water within 10 feet	0.99 (0.58–1.70)	0.982	1.16 (0.70–1.92)	0.574
Fence				
Fence present	Ref		Ref	
Fence absent	0.97 (0.75–1.25)	0.816	0.93 (0.72–1.19)	0.554
Priming				
No pump priming required	Ref		Ref	
Pump priming required	0.98 (0.69–1.38)	0.906	1.00 (0.70–1.45)	0.988
Open defecation				
No open defecation within 33 feet	Ref		Ref	
Open defecation within 33 feet	0.67 (0.42–1.07)	0.097	**0.63 (0.40–0.97)**	**0.037**
Animal dung pit				
No Animal dung pit within 33 feet	Ref		Ref	
Animal dung pit within 33 feet	0.88 (1.61–0.49)	0.688	1.04 (0.58–1.85)	0.885
Depth	**1.01 (1.00–1.02)**	**0.021**	**1.01 (1.00–1.02)**	**0.003**
Distance to nearest latrine	1.00 (0.99–1.01)	0.450	1 (0.99–1.00)	0.388

Note: Bold values indicate statistically significant result. Results adjusted for intra-cluster correlation.

Table 6. Predictors of private tubewells operating without a breakdown of >12 h in the last 12 months.

	Unadjusted OR (95% CI)	*p* value	Adjusted OR (95% CI)	*p* value
Depth (m)	1.04 (0.98–1.11)	0.159	1.00 (0.94–1.06)	0.901
No. 6 pump or equivalent	0.16 (0.02–1.34)	0.092	0.27 (0.03–2.41)	0.239
Distance to district capital (km)	**0.86 (0.76–0.98)**	**0.019**	0.90 (0.77–1.05)	0.899

Note: Bold values indicate statistically significant result. Results adjusted for intra-cluster correlation.

The results show that private tubewells in Sarlahi provide a highly reliable service, with less than 1% of the systems experiencing a breakdown of more than 12 h over a one-year period. In comparison, the odds of experiencing a breakdown of more than 12 h was 10.5 times higher for community tubewells. This indicates that private tubewells either tend to breakdown less often (due to lower usage levels) or are repaired more quickly (due to ease of collective action). This result aligns with evidence from Cambodia and Vanuatu, where water sources owned privately by households were found to provide a more reliable water supply than community water systems [6, 7]. The reliability of water from private tubewells suggests that groundwater availability is not currently a major constraint on domestic use. However, a combination of trends, such as population growth and the increased use of electric pumps—particularly for agricultural purposes—may intensify groundwater abstraction in the future.

The notion that self-supply can deliver a safely managed service runs counter to an often-held assumption that a piped supply is the only means for securing the level of service commensurate with SDG 6 aspirations[26]. Although self-supply clearly presents a regulatory challenge, particularly in terms of safeguarding water quality, the persistence of self-supply in rural areas of high-income countries highlights its potential as a medium- or even long-term solution to gaps in public service delivery [1, 2]. Yet, despite it being both widespread and capable of delivering safely managed water, policies and plans in Nepal and elsewhere in Asia remain relatively silent on self-supply. Exactly why self-supply remains outside the policy gaze of governments requires further interrogation. The high prevalence of self-supply means that strategies that strive to achieve SDG 6 in South Asia must acknowledge self-supply and engage in the issues it presents. These might be opportunities to support or facilitate self-supply where the benefits outweigh the risks, opportunities to strengthen or improve self-supply where it already exists, or deter self-supply where its risks outweigh the benefits. Weighing these options is not straightforward, as they necessarily implicate an array of economic, social and hydrogeological considerations.

The results on predictors of water quality are consistent with previous research on communal groundwater sources in some respects, and inconsistent with others. Though the association between tubewell depth and *E. coli* detection was statistically significant, the effect size was modest: with each metre in tubewell depth, the adjusted odds of *E.coli* being detected decreased by just 1%. The relationship between shallower well depths and the presence of *E. coli* aligns with meta-analysis that found higher contamination levels in (shallow) dug wells relative to drilled wells, although in the meta-analysis the effect of shallow groundwater was not isolated from the possible effect of a large diameter that typically characterises dug wells. Notably, a more analogous study that focused on private tubewells in Bangladesh did not find any relationship between tubewell depth and *E. coli* presence [17], while a study on private boreholes in Indonesia did observe an association between *E. coli* concentration and shallow depth [27]. The observed relationship between open defecation and *E. coli* lends support to ongoing efforts to end open defecation globally, and highlights the interactions between water and sanitation. The adjusted odds of water being free from *E. coli* was 37% lower when open defecation was practiced in close proximity to the tubewell. Previous evidence linking open defecation and water quality from groundwater sources is, however, somewhat mixed [28–30]. More generally, the lack of significant associations between water quality and a number of the potential sanitary risks is in keeping with groundwater quality studies broadly [31], as well as studies from Bangladesh focused on private tubewells specifically [17, 18].

The study has a number of limitations. First, due to the lack of piped systems in rural Sarlahi, the comparative analysis was limited to tubewells. It is unclear whether piped supplies would likely provide a better or worse service level. While a systematic review found piped supply was less likely to contain *E. coli* than self-supply [9], this advantage would not necessarily carry through to a safely managed service given the importance of the 'availability' criterion. Second, the cross-sectional nature of the study means that the associations observed cannot be construed as causal and the results may be affected by omitted variable bias. Experimental studies could potentially strengthen the evidence on any causal relationships, though to our knowledge a randomized approach to water service delivery models has never been attempted in LMICs. A deeper understanding of the factors and dynamics that may result in differential outcomes between private and community tubewells could also be aided through a longitudinal study design that incorporates qualitative methods. Third, some of the dichotomous predictor variables were premised on threshold distances to the tubewells (e.g. stagnant water and animal dung pit), and the cut-offs chosen may not accurately reflect the distances *E. coli* may or may not be transported via runoff or subsurface flow. Fourth, the results may be influenced by recall bias. In particular, the ability of a respondent to accurately recall the frequency and duration of breakdowns over a 12 month lookback requires further validation. Future research could also overcome this issue with longitudinal, high frequency data collection. Fifth, *E. coli* is a faecal indicator bacteria, and its presence or absence does not necessarily equate to the presence or absence of faecal pathogens.

5. Conclusion

The results of this study show that self-supply, when in the form of private tubewells, can deliver a safely managed water service and provide a safer and more reliable water supply than community tubewells. This finding has significant implications for policy makers in South Asia in particular, where more than 600 million people self-supply their drinking water. The catch is that those who benefit from safely managed self-supply are those households that are willing and able to invest in their own tubewell, and disadvantaged households are less likely to self-supply a service that attains a safely managed standard. Given that self-supply is so widely practiced in Nepal and Asia more broadly, private household investment in water sources has had a significant but underappreciated influence on progress towards Sustainable Development Goal 6, and will continue to do so over the next decade. Self-supply's importance is further heightened by the fact it draws on the financial resources of households, and hence is not reliant on funding from governments and development partners. Governments in South Asia and other regions where self-supply is common need to carefully consider policy responses in order to harness the opportunities self-supply presents, minimise the risks it poses, and address inequities in both access and service levels.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary information files).

Acknowledgment

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Conflict of interest

At the time of the study, authors S L and R B were employed by SNV, an international non-profit organisation that implements water and sanitation programmes in Nepal, including in Sarlahi District where this research took place. Authors T F and J K were employed at the University of Technology Sydney, which was sub-contracted by SNV to carry out the research. The study was funded by the Australian Department of Foreign Affairs and Trade (DFAT) under the Water for Women Fund. The authors have no other financial or non-financial interests to disclose.

Ethics statement

The study was carried out under a learning partnership between SNV Netherlands Development Organisation and the University of Technology Sydney (UTS), for which ethical approval was obtained from the UTS Human Research Ethics Committee. All participants (survey respondents) were adults aged 18 or over. All participants provided verbal consent prior to participating.

Author contributions

All authors provided inputs into the research design and development of data collection tools. R B and S L oversaw the data collection. T F analysed the data and drafted the manuscript with inputs from all authors.

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