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Self-supplied drinking water in low- and middle-income countries in the Asia-Pacific

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There is increasing awareness of household self-supply and the role it can play in securing water for domestic needs in low- and middle-income countries (LMICs), but its scale across the Asia-Pacific has not previously been quantified. This study analysed 77 datasets from 26 countries to estimate the prevalence of self-supplied drinking water, and its associated trends in LMICs in South Asia, Southeast Asia and the Pacific. When factoring in temporal trends, results suggest that >760 million people—or 31% of the population—relied on self-supply for their drinking water in these regions in 2018, with the number of users increasing by >9 million each year. Reliance on self-supply for drinking water is greater in rural areas than in urban areas (37% of rural population vs 20% of urban population), though results vary considerably between countries. Groundwater sources constitute the most common form of self-supply in South Asia and Southeast Asia, while rainwater collection is dominant in the Pacific. The results confirm the significance of self-supply in the Asia-Pacific and suggest that households are a major but often overlooked source of financing within the water sector. The findings raise important questions about how policy and practice should respond to this widespread phenomenon.

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INTRODUCTION

There is growing recognition that self-supply plays an important role in providing water for households in low- and middle-income countries (LMICs). Household self-supply commonly refers to water sources—typically in the form of wells, boreholes or rainwater collection systems—that are privately owned, financed and managed by individual households or families. An emerging body of literature has focused on self-supply in urban and rural sub-Saharan Africa[1–4]; however, the phenomenon has remained relatively unexamined in Asia and the Pacific. This is despite evidence that private water sources are common in some countries throughout the region[5–11]. The potential extent of household self-supply in LMICs in the Asia-Pacific could be substantial—while 93% of households used an improved drinking water source in 2017, only 37% used a piped source[12].

Self-supply emerges in a range of contexts. It can be found alongside municipal piped water services in densely populated cities[13,14], in unplanned urban areas unserved by piped systems[15], alongside communal water sources in rural settings[7,9], and in remote areas where public water sources are entirely absent[1]. Depending on the context, self-supply might be a luxury only the wealthy can afford[16], or an option of last resort for the poor. It can act as a primary or sole source of drinking water, or it can be reserved for other domestic purposes[8]. Self-supply can therefore complement public water services or substitute for them entirely, with this varying role reflective of a reality where households use multiple water sources for different reasons and at different times of the year[17]. Within these differing contexts, the precise reasons for adopting self-supply (e.g., perceived level of safety, reliability, organoleptic properties, convenience, and cost) may also vary.

A clearer understanding of how reliant households are on self-supply, along with an evidence-based characterisation of source types and trends, is of critical consequence to water policy, sector financing and public health. Owing to the private nature of self-supply, it is often overlooked by policy and regulation. Though there are examples of self-supply being formally supported or recognised by governments in LMICs[18], this remains the exception rather than the norm. Increased monitoring of financial flows within the water sector has highlighted the need to track household investment in self-supply[19]. Yet in the most recent UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water report, only one country in the Asia-Pacific—namely Bangladesh—was able to provide an estimate on household investment in water sources[20]. While households investing in private water sources may increase the overall pool of funds spent on water infrastructure, it may also lead to inefficient use of resources across the sector more broadly[9]. Likewise, a diversion of funds away from public water service providers may negatively impact their financial and operational performance[13]

Clarifying the extent and modalities of self-supply is important from a public health perspective. Water quality remains a prime concern in relation to self-supply, yet these sources typically fall outside the remit of routine testing of drinking water quality, which instead focuses on utility-operated piped services. The prominence of self-supply could therefore have ramifications for how to interpret and support progress towards Sustainable Development Goal target 6.1. Having water supplied on the premises is a key criterion for a water service to be considered safely managed, and self-supply generally complies with this requirement. The degree to which self-supply attains the other two safely managed service criteria—being free from contamination and available in sufficient quantities when needed—is a fundamental but as yet unanswered question. How self-supply might or might not support the human right to water also in part hinges on these issues[21].

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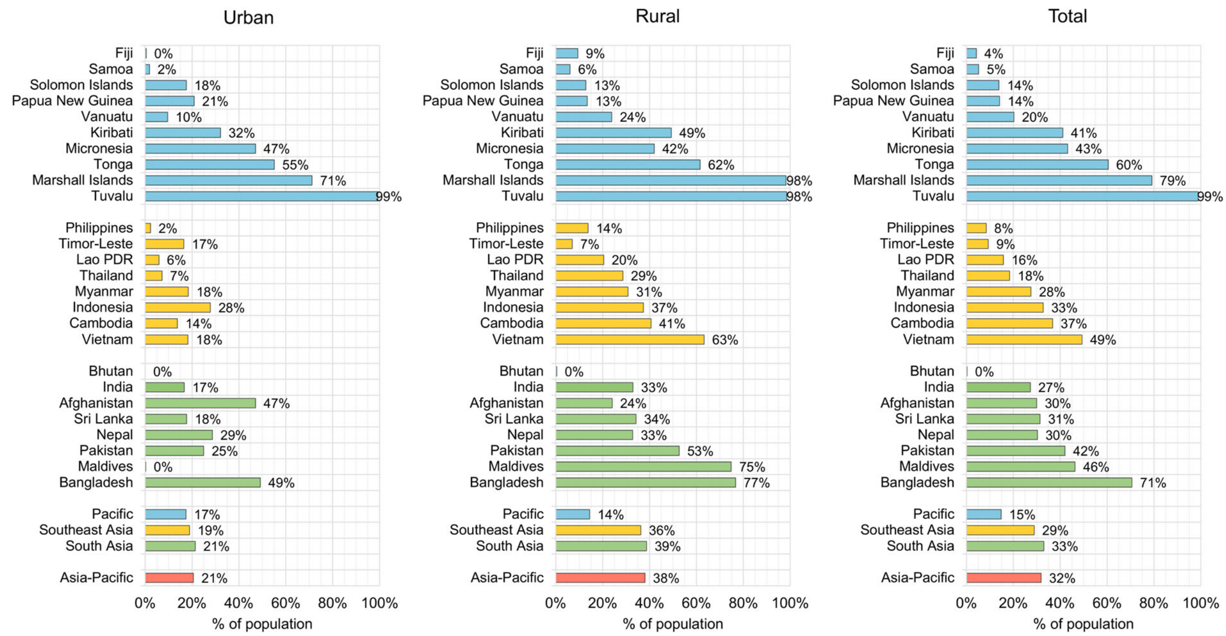

Fig. 1 Proportion of population using self-supply as a main drinking water source. Proportions are based on most recent data from national surveys and censuses. Blue coloured bars represent countries in the Pacific, orange coloured bars represent countries in Southeast Asia, green coloured bars represent countries in South Asia and red bars represent Asia-Pacific (all countries combined). These crude estimates, which do not factor in temporal trends, suggest 32% of the population (~780 million people) in the Asia-Pacific used self-supply as their main drinking water source in 2018. Self-supply is more common in rural areas (38% of the rural population) than in urban areas (21% of the urban population).

To understand the prominence and policy implications of self-supply in LMICs in the Asia-Pacific region, this study sought to (i) estimate the prevalence of self-supply in 2018, (ii) characterise the types of self-supply that are practiced across different countries and (iii) describe the trends in adoption of self-supply. The analysis drew on 77 national datasets from 26 LMICs across Southeast Asia, South Asia and the Pacific.

RESULTS

Prevalence

Across Southeast Asia, South Asia and the Pacific, most recent data suggest ~32% of the population self-supplied their drinking water in 2018 (Fig. 1 and Table 1). This is equivalent to ~780 million people using self-supply as a main drinking water source. Reliance on self-supplied drinking water was greatest in South Asia (33%), followed by Southeast Asia (29%). Self-supply was less common in Pacific Island countries (15%). It is important to note the influence of India and Papua New Guinea on these estimates, as they constituted 75 and 78% of their respective regional populations. When excluding India, the prevalence of self-supply in South Asia increased from 33 to 50%, while prevalence in the Pacific increased from 15 to 17%, when excluding Papua New Guinea. Country-level prevalence varied substantially: self-supply is ubiquitous in Bangladesh (71%) and the Marshall Islands (79%), but seemingly uncommon in Bhutan (0%) and Fiji (4%). India, Bangladesh, Pakistan and Indonesia collectively contributed 85% of self-supply users across all countries assessed.

Overall, self-supply prevalence in 2018 was higher in rural areas than in urban areas (38% vs 21%), and this disparity was evident in both South Asia (39% vs 21%) and Southeast Asia (36% vs 19%). However, the opposite was the case in the Pacific (14% rural vs 17% urban). In only four countries was use of self-supply substantially greater in urban areas than in rural areas: Papua New Guinea, Solomon Islands, Micronesia and Afghanistan.

Self-supply estimates for Southeast Asia increased significantly when considering households using bottled water for drinking, but self-supply for other (non-drinking) domestic needs (Fig. 2). For six countries with available data in Southeast Asia, use of self-supplied water increased from 30 to 45% of the population (equivalent to an additional 70 million people) when considering self-supply of non-drinking water among households relying on bottled water for drinking. This issue was most marked in urban areas, where the use of self-supply in conjunction with bottled water was almost as common as use of self-supply as a main source of drinking water. Indonesia presents the most striking example of this, where 28% of the urban population self-supplied their drinking water (~41 million people), and an additional 29% drank bottled water but used self-supply for non-drinking purposes (~43 million people).

Information on secondary water sources—irrespective of bottled water use—was also available for some Pacific Island countries (Fig. 3). These data show an opposing pattern to that observed in Southeast Asia, with households in the Pacific being less inclined to use private rainwater tanks for other (non-drinking) domestic needs.

Cambodia is the only country analysed that has routinely collected information on main drinking water source across both wet and dry season (Fig. 4). These data show a marked shift in self-supply reliance between wet and dry season (61% vs 36%), a dynamic that is largely driven by an increase in rainwater collection in rural areas during the wet season.

Source types

Tubewells/boreholes were the most common form of self-supply across the Asia-Pacific region in 2018, with this self-supply source type accessed by almost a quarter of the population (Fig. 5). This result was heavily influenced by the large population of South Asia, where private tubewells are common. Southeast Asia exhibited a more even spread across boreholes/tubewells (12%), protected wells (9%) and rainwater collection systems (5%). In contrast, self-supply in the Pacific was predominantly in the form of private rainwater tanks. Importantly, among all households using self-supply, 95% relied on a source type that the Joint

Table 1. Crude estimates for population using self-supply as a main drinking water source in 2018 (based on most recent data).

	Proportion of population with self-supply as main drinking water source	Total population in 2018	Crude estimate of population with self-supply as main drinking water source in 2018
Pacific			
Fiji	4%	883,483	37,556
Kiribati	41%	115,847	47,660
Marshall Isl.[a]	79%	58,413	46,205
Micronesia	43%	112,640	48,660
PNG	14%	8,606,316	1,217,275
Samoa	5%	196,130	10,262
Solomon Isl.	14%	652,858	90,633
Tonga[a]	60%	103,197	62,417
Tuvalu	99%	11,508	11,377
Vanuatu	20%	292,680	59,373
Sub-total	15%	11,033,072	1,631,418
Southeast Asia			
Cambodia	37%	16,249,798	5,974,521
Indonesia	33%	267,663,435	87,578,639
Lao PDR	16%	7,061,507	1,112,191
Myanmar	28%	53,708,395	14,787,616
Philippines	8%	106,651,922	9,029,040
Thailand	18%	69,428,524	12,806,874
Timor-Leste	9%	1,267,972	117,964
Vietnam	49%	95,540,395	47,104,794
Sub-total	29%	617,571,948	178,511,639
South Asia			
Afghanistan	30%	37,172,386	11,142,335
Bangladesh	71%	161,356,039	113,957,274
Bhutan	<1%	754,394	2,056
India	27%	1,352,617,328	368,952,399
Maldives	46%	515,696	239,025
Nepal	30%	28,087,871	8,500,120
Pakistan	42%	212,215,030	89,246,056
Sri Lanka[b]	31%	21,670,000	6,804,328
Sub-total	33%	1,814,388,744	598,843,593
Grand total	32%	2,442,993,764	778,986,650

[a]Data constraints prevented inclusion of groundwater-based self-supply for Tonga and Marshall Islands.
[b]Data constraints prevented inclusion of rainwater-based self-supply for Sri Lanka.

Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) defines as improved.

Trends

Twenty of 26 countries had multiple datasets that allowed for assessment of temporal trends, and overall these data suggest reliance on self-supply as a main drinking water source has been increasing in absolute terms, but has remained relatively stable as a proportion of the population (Fig. 6). The absolute increase in self-supply usage was evident in both urban and rural areas. In total, an additional 9.4 million people have been turning to self-supply every year (Table S3 in Supplementary Information). This increase comprises 2 million people per year in urban areas and 7.4 million people per year in rural areas. The stability in the proportion of the population using self-supply has been underpinned by divergent trends whereby the proportion of the population relying on self-supply has been increasing in rural areas, but decreasing in urban areas. Self-supply as a main drinking source has been increasing in some countries by >0.5% points per year (e.g., Bangladesh, Cambodia, Nepal and Vanuatu), while it has been declining by >1% point per year in others (Thailand, Tonga, Vietnam and Indonesia; Fig. 7).

When factoring in these temporal trends, the overall prevalence estimate for self-supply in 2018 was adjusted to 31%, equivalent to 760 million people (Table 2). This adjusted prevalence was 37% in rural areas (equivalent to 575 million people) and 20% in urban areas (equivalent to 185 million people). In the adjusted analysis, the higher prevalence of self-supply in rural areas was again evident in South Asia (38% of the rural population vs 22% of the urban population) and Southeast Asia (36% of the rural population vs 18% of the urban population), but not in the Pacific (15% of the rural population vs 17% of the urban population).

DISCUSSION

The results reveal the extensive nature of self-supply throughout the Asia-Pacific region, with around one in three households relying on this form of water service delivery. The ongoing growth of self-supply indicates it will continue to play a major role in securing water for households for many years to come. Though considerable in magnitude, the estimates likely understate the true dependence on self-supply because tens of millions more households rely on self-supply for non-drinking purposes; and this study could only examine this issue for households relying on bottled water as their main drinking source. Self-supply may also have flow on effects not reflected in these estimates because households with their own private water source may share it with other surrounding households[22]. While these neighbouring households are using 'off-premises' water sources, they are still end-users of self-supply. Few surveys and censuses enquire about water source ownership or reliance on non-drinking sources (except for households drinking bottled water)[17] and so estimating the true extent of self-supply is difficult.

A critical question is how governments should respond to this phenomenon. On the one hand, self-supply presents an opportunity: it unlocks an additional source of funding[19], allows for a scale and unit of management (the family or household) which is potentially more amenable to collective action than communal systems[7], and reflects an endogenously driven form of development. This latter point is important as it underscores the agency of households in charting their own development pathway, rather than being subject to the external decisions and priorities of governments and development partners. On the downside, self-supply is difficult to monitor and regulate, meaning water quality risks may be significant, and it may thwart the economies of scale that could be achieved if household investments were pooled and channelled towards shared or centralised systems[9]. It also presents challenges to regulation of groundwater extraction and use more generally[23]. Policy makers need to weigh up these considerations, and find a way to harness the upsides and minimise the risks.

It is clear that self-supply is unleashing significant amounts of funding for water supply improvements throughout the Asia-Pacific, yet these financial flows are largely invisible and unaccounted for in sector plans and monitoring efforts. Of the countries included in this analysis, only Bangladesh has been able to provide an estimate on the amount households invest in water services improvements[20]. A key constraint is that data on household investment in water supplies is not routinely collected by water ministries. This is not to say that estimating the value of household investments is impossible. For example, data from national Household Income and Expenditure Surveys may shed light on household investments in water supply, while some censuses for Pacific Island countries

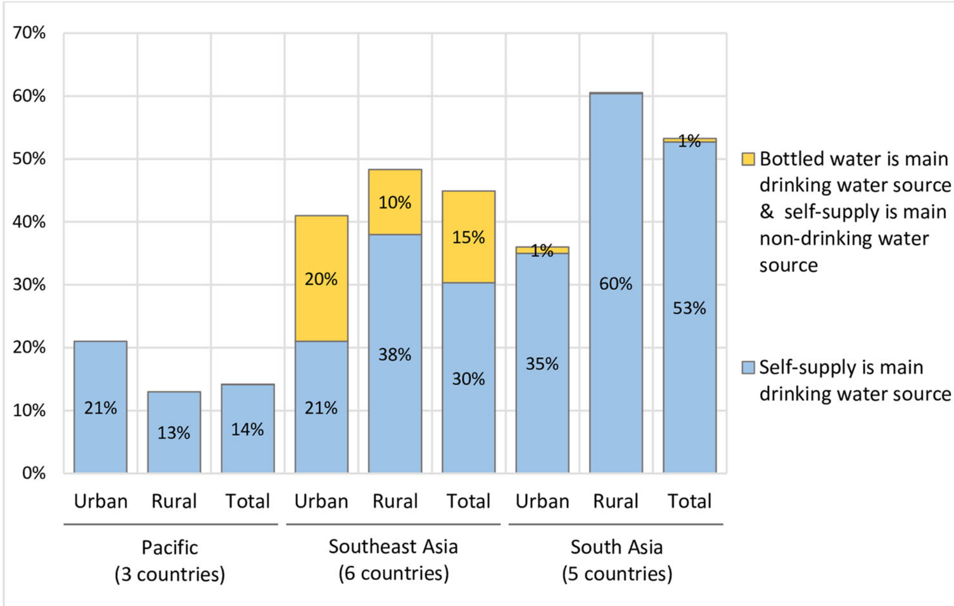

Fig. 2 Proportion of population relying on self-supply when including non-drinking use in conjunction with bottled water. Analysis is based on data from 14 countries with surveys that ask about non-drinking water sources for households that use bottled water as a main drinking water source. This includes three countries in the Pacific (Kiribati, Papua New Guinea and Vanuatu), six countries in Southeast Asia (Indonesia, Lao PDR, Philippines, Thailand, Timor-Leste and Vietnam) and five countries in South Asia (Bangladesh, Bhutan, Maldives, Nepal and Pakistan).

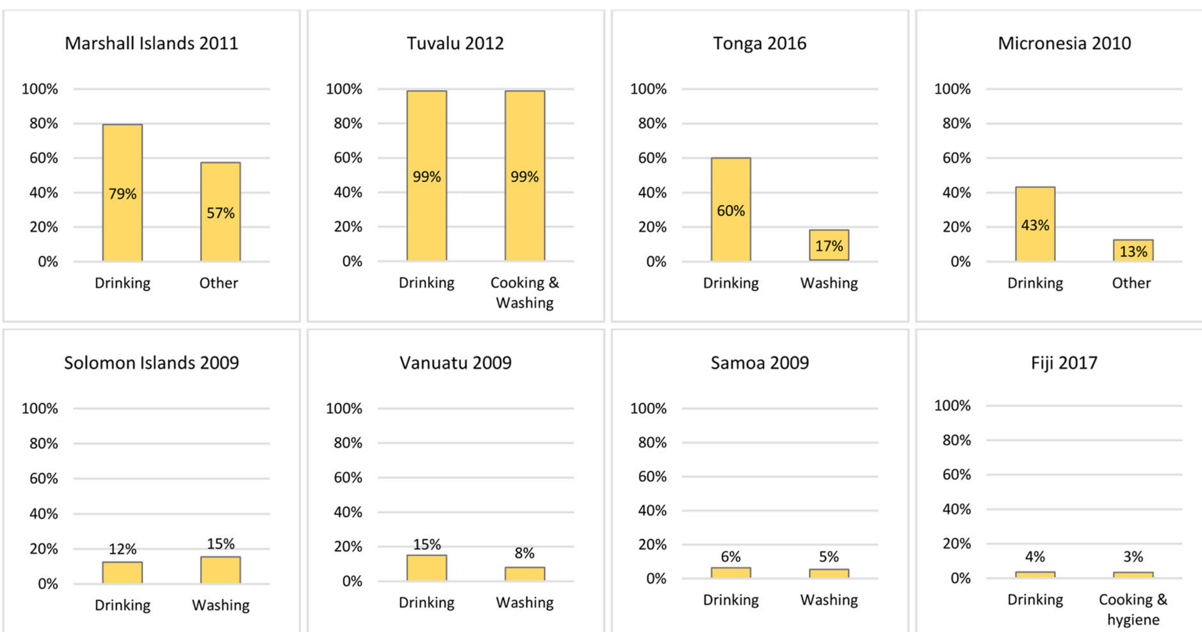

Fig. 3 Proportion of population using private rainwater tanks for drinking and other domestic purposes in the Pacific. Self-supply in the Pacific is more commonly used for drinking than non-drinking purposes, with the exception of Solomon Islands.

also capture detailed information on the number and size of rainwater tanks that could form the basis of an estimate. Moreover, the type of data used in this study could be combined with standardised costs for wells or rainwater tanks to arrive at annual estimates. To illustrate the point, if it is assumed that low-cost wells and rainwater collection systems cost between USD 100–200 per unit, each year there would be USD 250–650 million of household investment in self-supply across South Asia, Southeast Asia and the Pacific. A key limitation to this approach is that it assumes on-premises supplies are fully funded by the households themselves, and this might not always be the case[7,24].

Fundamental evidence gaps remain around the extent to which self-supplied water can be considered 'safely managed' for the purposes of SDG 6.1. Though there is some evidence that self-supply can provide more reliable water services than communal systems in rural areas[7], the chief concern is in relation to water quality. Studies from the region have shown self-supply is often susceptible to microbial and chemical contamination[15,25–27], but

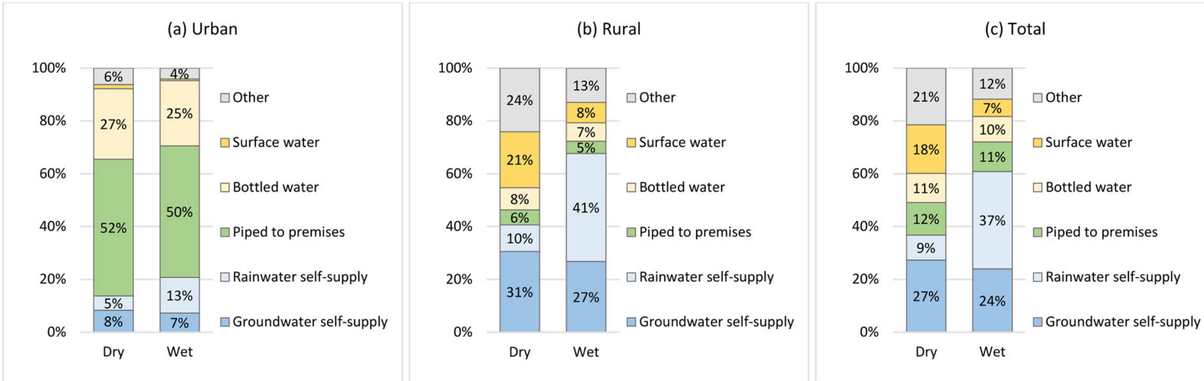

Fig. 4 Proportion of population using self-supply as a main drinking water source by season in Cambodia, 2014. In Cambodia, wet season coincides with an increase in the use of self-supply. In 2014, this seasonal shift in self-supply use was evident in **a** urban areas (20% in wet season vs 13% in dry season), **b** in rural areas (68% in wet season vs 41% in dry season), and **c** overall (61% in wet season vs 36% in dry season). 'Other' sources comprise public borehole/tubewells, public protected wells, public unprotected wells, tanker truck and cart with small tank.

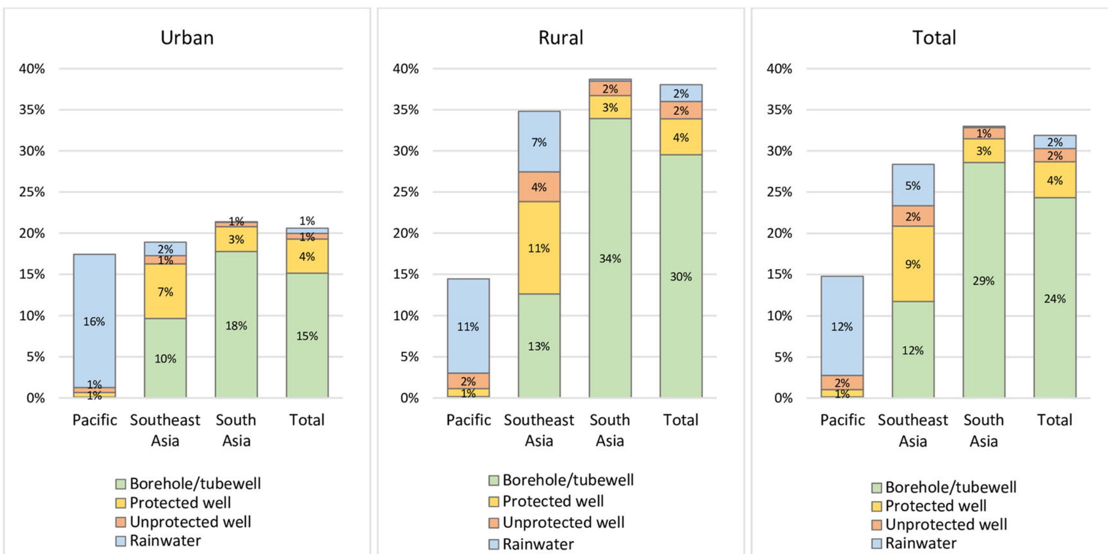

Fig. 5 Proportion of population using self-supply as a main drinking water source by source type and region. Boreholes/tubewells are the most common form of self-supply in Southeast Asia and South Asia, while rainwater collection is the dominant form of self-supply in the Pacific.

how these contamination risks compare to those associated with centralised or communal water systems remains unclear. Self-supplied groundwater in urban areas is of particular concern given the dense populations and proximity to on-site sanitation systems, which are often poorly constructed and managed[28]. Even rainwater collection systems in rural areas pose potential problems—although they are defined as an inherently 'improved' source type, evidence from Cambodia and Vanuatu suggests a high proportion of rainwater collection systems lack proper protection[29,30]. Incorporation of water quality testing into nationally representative surveys (e.g., Multiple Indicator Cluster Surveys; MICS) will help shed new light on the safety of self-supplied drinking water, though this may only provide a partial 'snapshot' that fails to capture temporal variability.

A related question is how the safety of self-supplied water can be monitored and safeguarded. The ultra-decentralised nature of self-supply makes monitoring a complex and expensive task. Governments may also be reluctant to intervene in this way as it encroaches on the private domain. By contrast, the centralised and public nature of large urban water systems are far easier to monitor and regulate. This has implications for SDG 6.1. Data on water quality from utilities and regulators commonly underpin the 'free from contamination' estimate derived by JMP; yet this has little relevance to the hundreds of millions of people in urban areas of the Asia-Pacific drawing drinking water from their own well or borehole. Incorporation of water quality testing into major household surveys will be crucial for addressing this issue[31].

The resilience of self-supply in relation to climate change also warrants closer examination. While climate change poses a risk to water supplies irrespective of service delivery model, self-supplying households may be particularly vulnerable. For example, deepening a borehole in response to prolonged drought or protecting a well from extreme flooding is likely to be more challenging for individual households than for a utility or service provider with adequate financial resources. Self-supply in the form of rainwater harvesting is especially vulnerable to a future climate, where rainfall is likely to be more variable. This is particularly relevant for the 1.3 million people in LMICs in the Pacific who rely

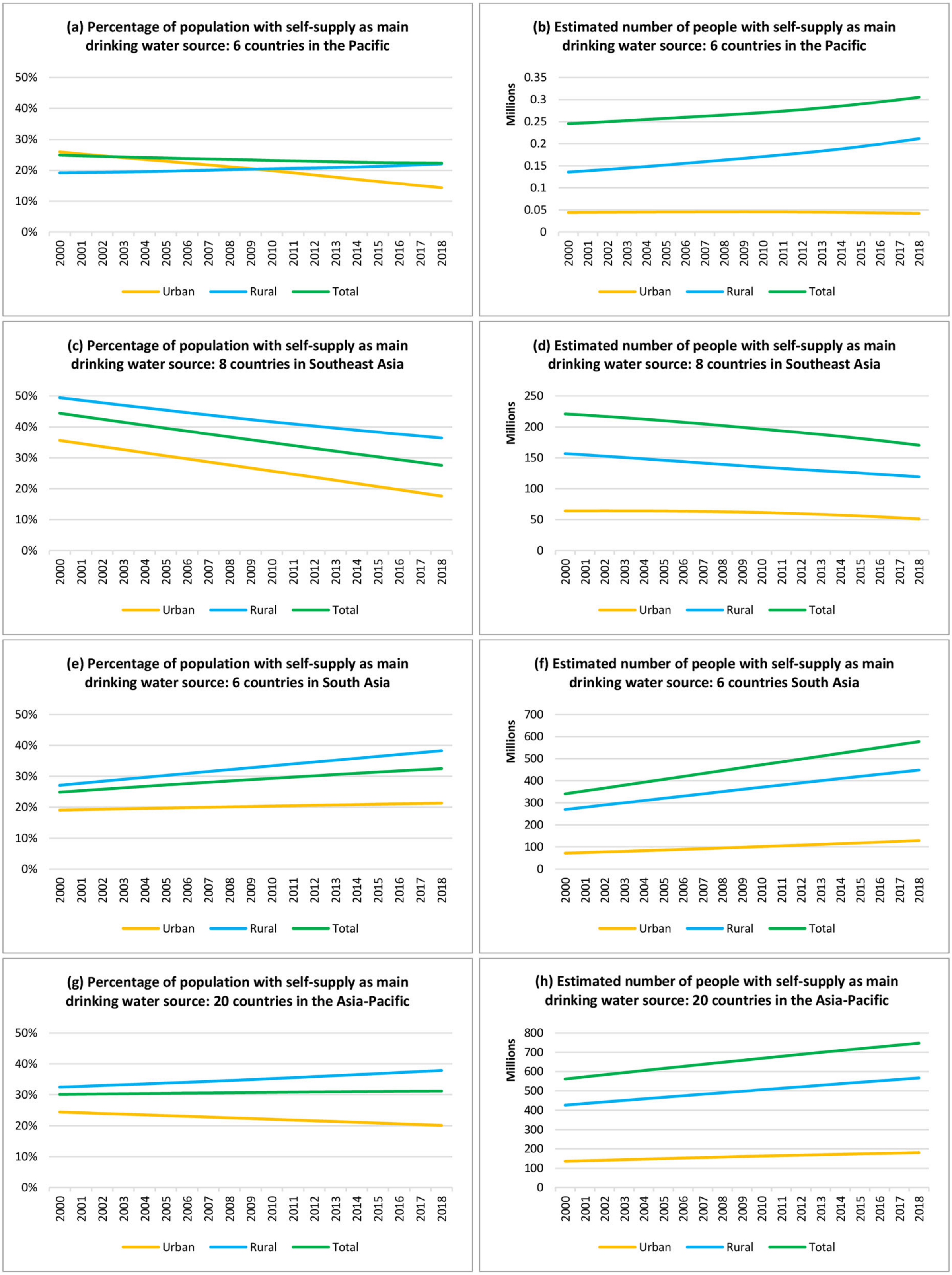

Fig. 6 Temporal trends in use of self-supply as a main drinking water source across the Asia-Pacific. Estimates in **a** and **b** are based on data from six countries in the Pacific (Micronesia, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu). Data for Micronesia could not be disaggregated by urban–rural, and hence is only included in 'total'. Estimates in **c** and **d** are based on data from eight countries in Southeast Asia (Cambodia, Indonesia, Lao PDR, Myanmar, Philippines, Thailand, Timor-Leste and Vietnam). Estimates in **e** and **f** are based on data from six countries in South Asia (Bangladesh, India, Maldives, Nepal, Pakistan and Sri Lanka). Estimates in **g** and **h** are based on data from all aforementioned 20 countries (6 countries from South Asia, 8 countries from Southeast Asia and 6 countries from the Pacific).

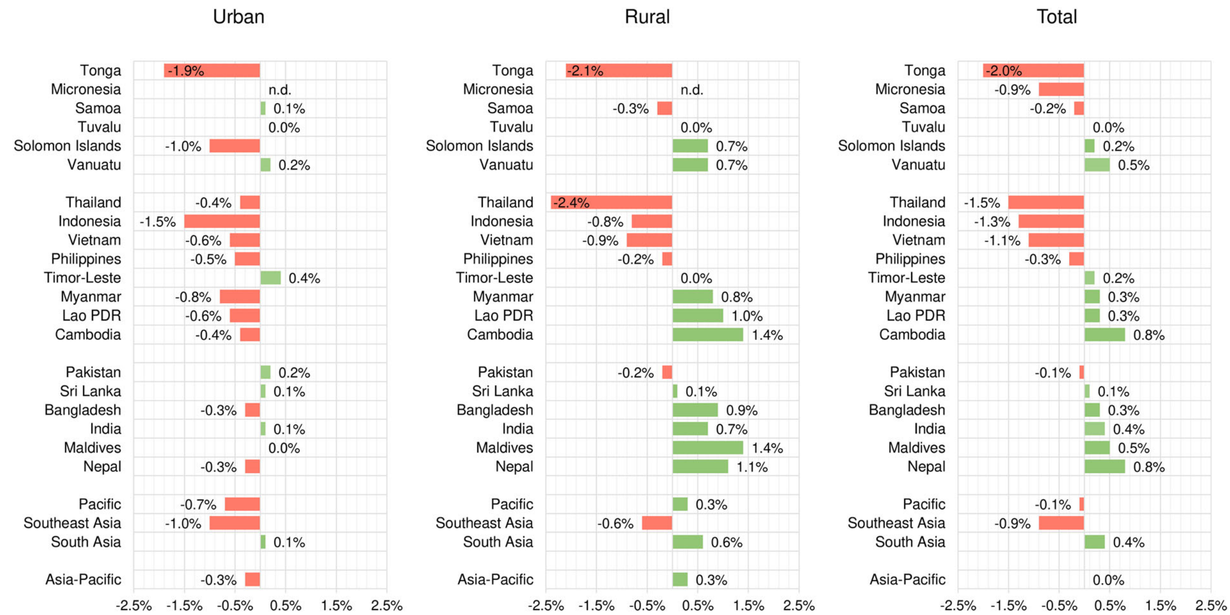

Fig. 7 Estimated annual change in proportion of population using self-supply as a main drinking water source in 2018. Changes are presented in terms of percentage points. Red bars indicate a reduction in the proportion of population using self-supply, while green bars indicate an increase in the proportion of population using of self-supply.

on private rainwater tanks for drinking water. Climate risks may also exacerbate socio-economic inequalities among self-supply users. For example, poorer self-supply users may depend more heavily on shallow wells that are less resilient to drought and flood, or have to make do with smaller rainwater tanks that rapidly become depleted during dry spells.

Further work is needed to understand the equity implications of self-supply more generally. Building a better understanding of who benefits and who loses out will be important for ensuring self-supply can address rather than exacerbate existing inequalities. For example, it remains unclear how widely used self-supply is among the poorest households, and the degree to which their forms of self-supply are higher risk than wealthier households. This also links to a need to better understand the drivers and barriers that shape household investment in private water sources across and within communities and neighbourhoods. Further investigation is needed to clarify the extent to which adoption of self-supply is driven by socio-economic factors (e.g., wealth and education) as compared to environmental factors (e.g., groundwater or climatic conditions), market conditions (e.g., private sector supply chain of low-cost pumps or storage tanks) or the wider water service landscape (complete absence of formal water services vs dissatisfaction with quality, reliability or accessibility of these services). These questions have important implications for how self-supply might be framed: is it a triumph for households who are increasingly becoming self-sufficient and masters of their own destiny or is it symptomatic of widespread service delivery failings and widening socio-economic inequalities?

Characterising the true extent of self-supply is constrained by the limited number of water-related variables typically collected in national censuses and nationally representative surveys. The use of self-supply as a secondary water source could only be examined for households using bottled water as a primary drinking water source. This is because national surveys, such as Demographic and Health Surveys (DHS) and MICS do not routinely capture information about water sources other than the main drinking water source, except when bottled water is the main drinking water source[17]. The degree to which households use self-supply as a secondary source as a complement to a piped supply or communal source therefore remains unclear. Clarifying this issue would provide a more nuanced understanding of the role self-supply plays in supplementing public water supplies and in strengthening water security and resilience more broadly. In addition, self-supplied water might be shared with neighbours[22] and that too would ideally be included in estimates of reliance; however, the surveys and census available for this analysis did not capture this information. If data were more widely available on the use of self-supply as a secondary water source and the use of a neighbour's private water source, the estimated proportion of the population depending on self-supply would undoubtedly increase. But the magnitude by which it would increase remains an unanswered question.

Although the extent of self-supply reliance in the Asia-Pacific may be unparalleled globally, this form of water service delivery is not unique to LMICs in the Asia-Pacific. For example, self-supply is expanding in urban Africa[2], and has been observed in various countries in Central America[32,33], South America[34] and the Middle East[35–37]. In both the United States and Canada, an estimated 11% of the population rely on private wells[38,39], while in Australia more than a quarter of the population use a private rainwater tank[40]. Further examination of global experiences might yield insights into how governments might support and nurture 'beneficial' self-supply, while avoiding or remedying 'detrimental' self-supply.

Self-supply of drinking water is clearly a widespread phenomenon in LMICs throughout the Asia-Pacific, notwithstanding variability between countries and across urban/rural divides. While governments and development partners are directing significant amounts of funding towards centralised, networked or communal water systems, households continue to invest heavily in their own water supplies. The degree to which drinking water is self-supplied in the Asia-Pacific may in part reflect failings in service delivery; but it also reflects the reality that households in LMICs are masters of their own destiny rather than passive recipients of development assistance. Self-supply presents both opportunities and risks, and policy makers need to navigate the best way to balance these factors. To aid this decision making, further research is needed to characterise the costs and benefits of self-supply, understand the drivers behind its continued growth in different contexts and evaluate policy interventions that are best able to maximise the opportunities whilst minimising the risks.

Table 2. Adjusted estimates for population using self-supply as a main drinking water source in 2018 (factoring in temporal trends).

	Percentage of population with self-supply as main drinking water source in 2018 (%)			Estimated population with self-supply as main drinking water source in 2018		
	Urban	Rural	Total	Urban	Rural	Total
Pacific						
Fiji[a]	<1	9	4	2215	36,477	38,692
Kiribati[a]	32	49	40	20,161	26,231	46,392
Marshall Isl.[a,b]	71	98	77	32,037	13,175	45,212
Micronesia[c]	50	44	45	12,669	38,463	51,132
PNG[a]	21	13	14	237,144	1,003,767	1,240,911
Samoa	2	5	5	712	8784	9496
Solomon Isl.	10	19	17	15,379	96,595	111,974
Tonga[b]	51	56	55	12,105	44,695	56,800
Tuvalu	100	100	100	7179	4329	11,508
Vanuatu	10	26	22	7102	57,386	64,488
Sub-total	17	15	15	346,703	1,329,902	1,676,605
Southeast Asia						
Cambodia	12	45	37	447,146	5,582,765	6,029,911
Indonesia	25	37	30	36,367,943	43,917,229	80,285,172
Lao PDR	5	23	17	134,892	1,073,494	1,208,386
Myanmar	16	33	28	2,697,744	12,227,635	14,925,379
Philippines	3	15	9	1,379,936	8,697,638	10,077,574
Thailand	9	28	17	3,283,698	9,881,422	13,165,120
Timor-Leste	17	7	10	67,396	61,603	128,999
Vietnam	20	62	47	6,770,635	37,804,773	44,575,408
Sub-total	18	36	28	51,149,390	119,246,559	170,395,949
South Asia						
Afghanistan[a]	47	24	30	4,466,337	6,658,052	11,124,389
Bangladesh	50	76	67	29,627,069	77,969,970	107,597,039
Bhutan[a]	0	<1	<1	0	1722	1722
India	17	32	27	79,368,827	284,831,885	364,200,712
Maldives	<1	85	51	0	263,404	263,404
Nepal	26	38	35	1,469,033	8,472,107	9,941,140
Pakistan	23	52	42	18,165,260	70,051,876	88,217,136
Sri Lanka[d]	15	35	31	581,119	6,224,327	6,805,446
Sub-total	22	38	32	133,677,645	454,473,343	588,150,988
Grand total	20	37	31	185,173,738	575,049,804	760,223,542

[a]Temporal trends could not be calculated for these countries due to a lack of data across multiple time points.
[b]Data constraints prevented inclusion of groundwater-based self-supply for Tonga and Marshall Islands.
[c]Data constraints precluded best-fit regression lines specific to urban and rural areas, hence the proportion of self-supply users from urban and rural areas is assumed to remain the same as most recent data.
[d]Data constraints prevented inclusion of rainwater-based self-supply for Sri Lanka.

METHODS

Datasets

The study was based upon national datasets that contained information on household water sources, and either their ownership status or their location relative to respondents' premises. A search of eligible datasets was conducted for LMICS in South Asia, Southeast Asia and Oceania. The World Bank classification of country income levels was used to determine which countries would be included[41]. The data search included both nationally representative surveys and national censuses. Relevant datasets were identified by reviewing individual country files from the JMP[12]. Data were then obtained from a range of online repositories, including national statistics agencies, DHS, MICS, and The Pacific Community (SPC) Statistics for Development Division (see Table S1 in Supplementary Information). Where possible, the data were extracted and analysed; otherwise reports with summarised results were reviewed. For the purposes of the analysis, self-supply was defined as a groundwater or rainwater source that was either (a) located on the respondent's premises, or (b) denoted as belonging to a household, based on the wording of the source category or the explanatory notes in the survey or census documentation. In total, 77 datasets were identified covering 26 LMICs across South Asia, Southeast Asia and Oceania. Relevant data could not be sourced for one LMIC in Southeast Asia (Malaysia). Overall, the 26 countries for which relevant data could be found constituted 98.7% of the population of all LMICs in the Pacific, Southeast Asia and South Asia.

Analysis

Analyses of individual datasets were conducted using SPSS (v26) and performed with sample weights. Self-supply source types were aligned to four categories used by the JMP: borehole/tubewell, protected well, unprotected well and rainwater collection. Prevalence estimates were calculated at both country- and regional-level based on the proportion of the population relying on self-supply, as a main drinking water source.

Datasets for some countries did not clearly or consistently delineate between on/off-premises or private/communal for groundwater (Solomon Islands, Vanuatu, Fiji, Marshall Islands and Tonga) or rainwater sources (Sri Lanka). Where possible, a ratio for on-premises (private) vs off-premises (communal) was derived from an earlier dataset (from the same country) or from a neighbouring country. Further details on how this issue was addressed can be found in Supplementary Information. Additional prevalence analysis by season (wet vs dry), for non-drinking uses and by source type were conducted where datasets allowed. Countries with more than one relevant dataset since 2000 were used to assess temporal trends in self-supply prevalence.

Two methods were used to estimate self-supply prevalence for each country, with estimates calculated for urban areas, rural areas and at a national level (urban and rural combined). First (method 1), the proportion of the population self-supplying their drinking water was estimated for each country based on the most recent available dataset. These proportions were then applied to 2018 population figures to derive a crude estimate for the number of people self-supplying their drinking water. Regional estimates were calculated for the Pacific, Southeast Asia and South Asia by summing the number of people using self-supply in each country, and then dividing by the total population in that region. Second (method 2), adjusted prevalence estimates were calculated by applying best-fit regression lines to countries with multiple data points across different years, with regression lines fitted to data for urban and rural areas separately. These best-fit regression lines were used to estimate the proportion of the population self-supplying their drinking water in 2018 for each country. These proportions were then applied to 2018 population figures to derive an estimate of the number of people self-supplying their drinking water. For the six countries where best-fit regression lines could not been ascertained, the most recent prevalence estimates were used instead. Regional estimates for method 2 were calculated in the same way as method 1. Overall, method 1 was the cruder of the two approaches; however, it was possible to apply to more countries (26 for method 1 vs 20 for method 2), and it was also more conducive to disaggregation by source type. Method 2 likely produced a more robust estimate of the true prevalence of self-supply.

DATA AVAILABILITY

The datasets analysed in this study are available from the following online repositories: https://dhsprogram.com, https://mics.unicef.org/surveys, https://pacificdata.org, https://washdata.org/data/downloads, https://www.statistics.gov.sb, https://vnso.gov.vu, https://www.censusindia.gov.in, http://sis.statistics.gov.lk and https://www.nis.gov.kh (see Table S1 in Supplementary Information for a full list of data sources).

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AUTHOR CONTRIBUTIONS

T.F. analysed the data and drafted the manuscript. T.F., C.P., K.K.K., M.O., E.R. and J.W. conceived of the idea and revised the manuscript.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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