Appendix A: Data sources and assumptions for groundwater use calculations

Findings on the proportions of households using groundwater as their primary source of drinking water are displayed in Figures 1 and 2 for urban and rural areas respectively. Data sources underpinning calculations are detailed below for each case study country. The results of calculations are described in terms of 'best estimates' and 'minimum and maximum values'. Best estimates reflect conservative calculations to avoid overstating groundwater reliance, and minimum and maximum values are shown in this Appendix for selected cases to indicate particular uncertainties due to e.g. the existence of multiple baseline datasets.

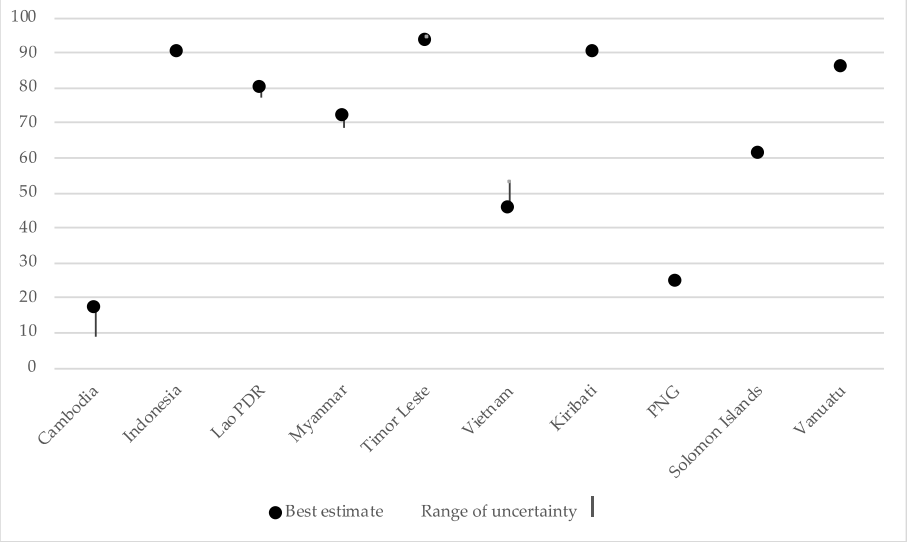

Figure 1: Proportion of urban households that are groundwater-reliant, indicating best estimates and ranges of uncertainty

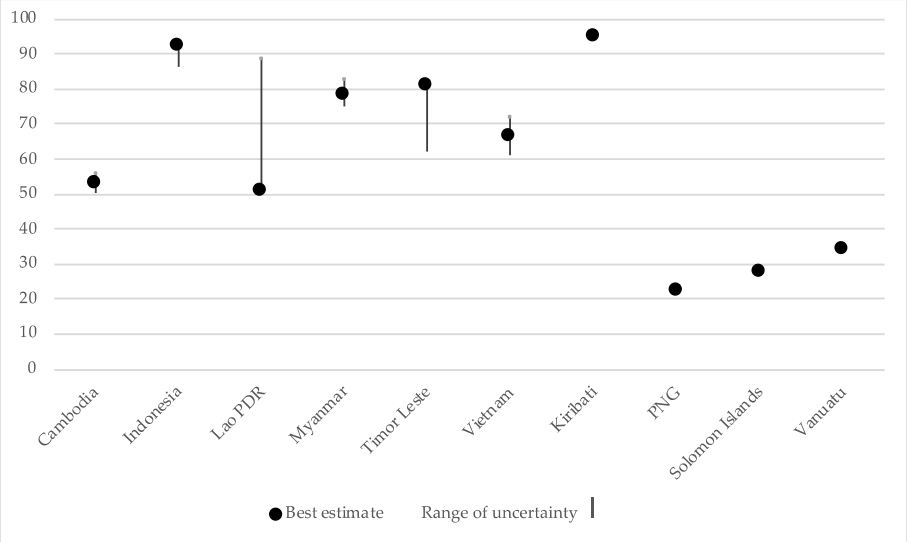

Figure 2: Proportion of rural households that are groundwater-reliant, indicating best estimates and ranges of uncertainty

Cambodia

Socio-Economic Survey (SES) 2015 data the basis for breakdown of facilities used (sourced from JMP country file). Note that SES 2015 (administered by Ministry of Planning) asked for the household's main source of drinking water for the whole year, in contrast with previous SESs which asked for the main source during wet and dry seasons separately.

Urban

Best estimate: Using SES 2015 data as basis, a calculated 17% of urban households use groundwater as their primary source of drinking water. This is based on information from a review of Cambodia's water sector [1], which identifies sources used by piped schemes in all provincial capitals (excluding Phnom Penh) and the number of households served. From this, a calculated 30% of urban households outside of Phnom Penh use tap water sourced from groundwater. Phnom Penh information was added to this, with surface water the source used by Phnom Penh Water Supply Authority (PPWA) (accessed 12 Oct 2018) which serves 96% of households in Phnom Penh (Ministry of Planning 2016). Including Phnom Penh, the calculated proportion of urban households whose tap water is sourced from groundwater is 5%.

Packaged water is excluded based on Phnom Penh Post report (accessed 12 Oct 2018) that almost all bottled water is siphoned from rivers or supplied by PPWA (which uses surface water as described above).

Minimum and maximum values: A minimum value (9%) is reported to reflect uncertainty associated with the baseline uses the same assumptions and calculations but takes NBADWQ 2015 data (assessment of urban household microbial quality of drinking water at point of consumption, sourced from JMP) as the baseline. NBADWQ has 6% of urban households using point source groundwater, 50% using tap water and 20% using packaged water (in contrast with SES 2015 respective figures of 13%, 74% and 2%).

Rural

Best estimate: Rural best estimate (53%) based on literature [2][3] noting these figures are cited as relevant for the dry season and are based on point source groundwater use only. Taken as a reasonable estimate based on similarity with SES 2015 data on point source groundwater use (50%) and expert advice that piped systems commonly use surface water.

Minimum and maximum values: Minimum and maximum values are included to provide reference points from the SES 2015 survey as complement to the best estimate figure derived from literature. Minimum value shows SES 2015 point source groundwater use (50%). Maximum value (56%) takes point source groundwater as a baseline and adds a half of the 12% tap water, indicating uncertainty given lack of available data on sources used for piped systems.

Indonesia

National socio-economic survey (SUS) 2016 data the basis for breakdown of facilities used (sourced from JMP country file).

Urban

Best estimate: calculated 90% includes point source groundwater (38%) and packaged water (46%), based on information that Danone Aqua, identified as the leading brand in a 2018 Euromonitor International market report (accessed 16 November 2018), is sourced from groundwater (company information, accessed 16 November 2018). A rapid scan of selected other brands (using a snowballing approach from media sources citing brand names) was also undertaken to verify groundwater as the typical source of packaged water. 39% of tap water included based on data that water supplied by utilities in Indonesia is 61% sourced from surface water, 16% from springs and 23% from groundwater (information based on 2016-2017 data from Perpamsi, the Association of Indonesian Water Supply Utilities). This assumes supply for different sectors (domestic, commercial, industrial) follows the same ratio as abstraction.

Rural

Best estimate: Calculation of 92% includes point source groundwater (71%) and packaged water (16%) based on information as above about the source of packaged water. 90% of tap water is also included based on information from data on sources used for piped schemes constructed under the Water and Sanitation for Low Income Communities Project (PAMSIMAS) (accessed 30 October 2018).

Minimum and maximum values: A minimum value (86%) excludes tap water to reflect that schemes built under PAMSIMAS (used as the basis for estimating the proportion of tap water sourced from groundwater) may not be representative of schemes across Indonesia.

Lao PDR

2015 census data the basis for breakdown of facilities used (sourced from JMP country file).

Urban

Best estimate: Calculated 77% includes point source groundwater (13%) and packaged water (64%) based on literature reporting that all bottled water is groundwater sourced [4]. Of households using tap water, 17% are included based on research which found that that 10 of 60 townships have groundwater-sourced piped water [4].

Minimum and maximum values: A minimum value (77%) excludes tap water given lack of information about the relative size of served populations in the 10 of 60 households using groundwater-sourced tap water [4].

Rural

Best estimate: based on literature reporting an agricultural survey [5], which identifies rural groundwater reliance as 51%. This figure is reasonably consistent with 2015 census data (55%) including those using point source groundwater and packaged water (assuming all packaged water is groundwater as described above).

Minimum and maximum values: A maximum value based on census 2015 data shows a substantial increase in proportion of households using groundwater, arising from the inclusion of 34% of households using 'other' facilities described in survey notes as 'mountain sourced' (which are assumed to be spring sourced).

Myanmar

Demographic and Health Survey (DHS) 2016 data the basis for breakdown of facilities used (sourced from JMP country file).

Urban

Best estimate: Calculated 72% includes point source groundwater (34%) and packaged water (34%) based on company information that Alpine, the brand leader in bottled water, uses groundwater and sector expert advice that packaged water is all groundwater-sourced.

Calculations for tap water are based on analysis of Myanmar's two largest cities, Yangon and Mandalay, which together represent about half of the total urban population and reflect geographic diversity, with Mandalay located in the dry zone. Yangon City Development Corporation (YCDC) supplies water to 58% of Yangon's ~4.5 million population, and as of 2014 an estimated 12.5% was sourced from groundwater [6]. Mandalay, Myanmar's second largest city, has a reticulated supply which is 90% sourced from groundwater [7] and reaches an estimated 50% of the ~1.2 million

population [8]. From these figures, the proportion of those served by tap water sourced from groundwater is calculated to be 27%.

Minimum and maximum values: A minimum value (61%) excludes tap water given lack of information about the relative size of served populations and sources of water in cities beyond Yangon and Mandalay. While we know that at least some tap water is sourced from groundwater, including the minimum value is also indicative of uncertainty related to sources of packaged water, with best estimate value based on information from one brand.

Rural

Best estimate: Calculated 78% includes point source (75%) and packaged water (4%), based on information that Alpine, the brand leader in bottled water, uses groundwater and sector expert advice that packaged water is all groundwater-sourced. Tap water is conservatively excluded given lack of data on sources used for piped systems.

Minimum and maximum values: A minimum value (75%) excludes packaged water given uncertainty beyond the leading brand. A maximum value (83%) includes half of the 7% that is tap water, reflecting that some rural piped schemes use groundwater, for example [7] describes a mix of surface and groundwater sourced piped systems in the dry zone.

Timor-Leste

Census 2010 data the basis for breakdown of facilities used (sourced from JMP country file).

Urban

Best estimate: Calculated 93% includes point source groundwater (28%) and tap water (65%) based on literature confirming that piped systems in Dili [9] and Bacau [10] use groundwater.

Minimum and maximum values: A maximum value (95%) adds packaged water. Information on the sources of packaged water was not readily available, however expert advice suggests at least one company based in Timor-Leste sources water from groundwater and much bottled water is imported from Indonesia where (as above) it is typically groundwater-sourced.

Rural

Best estimate: Calculated 81% includes point source groundwater and tap water based on advice from sector experts that villages with taps tend to be spring or aquifer sourced.

Minimum and maximum values: A minimum value (62%) includes only half the tap water, reflecting the lack of data and literature to validate expert advice and based on information that motorized pumps are used to supply water to approximately ~150,000 rural dwellers [11], which is approximately half those using tap water. Though it should be noted that this figure would exclude gravity-based spring-sourced piped systems which (according to expert advice) are common in rural areas.

Vietnam

Multiple Indicator Cluster Survey (MICS) 2014 data the basis for breakdown of facilities used (sourced from JMP country file).

Urban

Best estimate: 46% based on calculations of proportions of tap water and bottled water sourced from groundwater.

Calculation for tap water based on utility benchmarking data (accessed 2 June 2018) which has a proportional breakdown of source of water abstracted by utilities. This assumes supply for different sectors (domestic, commercial, industrial) follows the same ratio as abstraction.

Calculation for packaged water based on review of the four dominant brands of La Vie (Nestlé), Aquafina (PepsiCo), Vinh Hao (Vital), and Dasani (Coca-Cola Vietnam), which account for around 80% of sales according to a VietnamNet 2015 article. Also information from a Vietnam Investment Review 2017 article which places Aquafina market share at 40% and La Vie at 30%. Reviewed company websites or market and media reports to identify the water source for each major brand: Aquafina uses treated tap water; La Vie uses groundwater; Vital uses groundwater and Dasani uses groundwater. All sites accessed 12 Oct 2018. Tap water used for Aquafina (which has 40% market share) was conservatively assumed to be not from groundwater, though if sourced from Hanoi or Ho Chi Minh City water supplies it could be groundwater. Remaining market share assumed to use groundwater given La Vie (with 30% market share) and other market leaders use groundwater. From this analysis, a calculated total of 60% of packaged water is sourced from groundwater.

Minimum and maximum values: A maximum value (54%) includes Aquafina bottled water (from tap water) as likely originally sourced from groundwater.

Rural

Best estimate: 66% based on calculations of proportions of tap water and bottled water sourced from groundwater.

Calculation for tap water assumes 50% of tap water is sourced from groundwater. This is a conservative estimate informed by: (i) a World Bank Technical Assessment [12] focused on the northern mountainous and central highlands regions, which indicates 75% of piped schemes are groundwater or spring sourced; and (ii) research in six communes spanning three provinces in the Red River Delta and two provinces in the Mekong Delta [13,14] which found a roughly equal mix, with northern piped schemes typically sourced from surface water, and southern schemes sourced from groundwater. This calculation, while based on limited data sources, does not make a substantial difference to the overall finding given that tap water is only used by 11% of the rural population.

Calculation for packaged water uses the assumed 60% sourced from groundwater as described above for urban areas.

Minimum and maximum values: Reflecting the lack of data and related uncertainty about sources of tap water in rural areas across Vietnam, a minimum value excludes tap water and a maximum value includes an additional proportion of packaged water (in alignment with the urban calculated maximum value above).

Kiribati

Census 2010 data the basis for breakdown of facilities used (sourced from JMP country file).

Urban

Best estimate: 90% includes point-source groundwater (23%) and tap water (67%). Tap water is included based on information that the reticulated system in South Tarawa (Kiribati's only urban centre) is wholly reliant on rainfall-fed groundwater lenses [15].

Rural

Best estimate: 95% includes point source groundwater (89%) and tap water (6%). Piped water systems are mainly located on North Tarawa [16] which is reliant on shallow groundwater [17].

Papua New Guinea

Household Income and Expenditure Survey (HIS) 2010 data the basis for breakdown of facilities used (sourced from JMP country file).

Urban

Best estimate: 25% includes point source groundwater (5%) and a calculated 28% of the 71% using tap water as groundwater sourced. Calculations based on information from Water PNG (accessed 16 July 2018), a State Owned Enterprise responsible for water supply and sewerage services in urban areas, with water sources for different urban areas weighted by population.

Rural

Best estimate: 22% includes only point source groundwater use (22%). Tap water (16%) excluded based on sector expert advice that piped water in rural areas is almost exclusively from gravity fed systems, from a dammed stream.

Solomon Islands

Census 2009 data the basis for breakdown of facilities used for urban areas, and Solomon Islands Rural WASH Program data 2016 the basis for breakdown of facilities used for rural areas (sourced from JMP country file).

Urban

Best estimate: 61% includes point source groundwater (3%) plus 94% of those using tap water. Tap water calculations are based on expert advice and reports [18,19] on resources used by Solomon Water to supply Solomon Island's four largest cities (Honiara, Auki, Noro and Tulagi) with piped water. Honiara and Auki piped water supplies are sourced from groundwater, while Noro and Tulagi are sourced from surface catchments. Honiara and Auki are home to 94% of the population of these four cities (based on 2009 census data).

Rural

Best estimate: 28% includes only point source groundwater use (28%). Tap water (used by 38%) is excluded given information that most rural communities, other than those on small outlying coral atoll islands, use abundant surface water or rain water [20].

Vanuatu

Vanuatu 2016 Mini-Census data the basis for breakdown of facilities used (sourced from Vanuatu National Statistics Office). The Mini-Census was used instead of Vanuatu Demographic and Health Survey (VDHS) 2013 data (which is the most recent data included in the JMP country file) given it is more recent and involved a full population enumeration.

Urban

Best estimate: 83% includes point source groundwater (2%), tap water (83%) and packaged water (1%). Tap water included based on information that water supplied by UNELCO (concessionaire) to Port Vila is groundwater sourced, and water supplied by the Public Works Department (Ministry of Public Utilities and Infrastructure) to Luganville is spring sourced [21]. The National Water Strategy 2006-2018 [22] notes that six private suppliers also supply piped water in urban areas, and that no information is available on sources used by these operators. However, given Vanuatu's two largest urban settlements use groundwater it is assumed these providers also supply groundwater.

Packaged water included as the leading brand of bottled water, Azure Pure Water, uses groundwater (sourced from the largest aquifer on Efate island, which sits under the farm lands surrounding Bauerfield Airport).

Rural

Best estimate: 34% based on 2017 waterpoint inventory data [23] which identifies sources for community supplies. This calculation is the sum of population using groundwater as a proportion of total population.

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