Trends in access to water and sanitation in Malawi: progress and inequalities (1992–2017)

Alexandra Cassivi, Elizabeth Tilley, E. O. D. Waygood and Caetano Dorea IWA

ABSTRACT

Billions of people globally gained access to improved drinking water sources and sanitation in the last decades, following effort towards achieving the Millennium Development Goals. Global progress remains a general indicator as it is unclear if access is equitable across groups of the population. Agenda 2030 calling for `leaving no one behind', there is a need to focus on the variations of access in different groups of the population, especially in the context of low- and middle-income countries including Malawi. We analyzed data from Demographic Health Survey (DHS) and Multiple Indicator Cluster Survey (MICS) to describe emerging trends on progress and inequalities in water supply and sanitation services over a 25-year period (1992–2017), as well as to identify the most vulnerable populations in Malawi. Data were disaggregated with geographic and socio-economic characteristics including regions, urban and rural areas, wealth and education level. Analysis of available data revealed progress in access to water and sanitation among all groups of the population. The largest progress was generally observed in the groups that were further behind at the baseline year, which likely reflects good targeting in interventions/improvements to reduce the gap in the population. Overall, results demonstrated that some segments of the population – foremost poorest Southern rural populations – still have limited access to water and are forced to practise open defecation. Finally, we suggest including standardized indicators that address safely managed drinking water and sanitation services in future surveys and studies to increase the accuracy of national estimates.

Key words | drinking water, environmental health, Malawi, open defecation, Sustainable Development Goals (SDGs)

Alexandra Cassivi (corresponding author)
Caetano Dorea IWA
Department of Civil Engineering, Engineering and Computer Science (ECS) 304,
University of Victoria,
P.O. Box 1700 STN CSC, Victoria, BC V8 W 2Y2,
Canada
E-mail: *alexandracassivi@uvic.ca*

Elizabeth Tilley
Department of Environmental Health,
University of Malawi,
The Polytechnic,
Malawi
and
Eawag: Swiss Federal Institute of Aquatic Science and Technology,
Dübendorf,
Switzerland

E. O. D. Waygood
Polytechnique Montréal,
Montreal,
Canada

HIGHLIGHTS

- Lack of access to water and open defecation remain burden some worldwide.
- Trends on progress and inequalities vary in the different groups of the population.
- Available household surveys (DHS and MICS) were analyzed over a 25-year period.
- Interventions and improvements helped reduce the gaps in water and sanitation.
- Most vulnerable populations are still found in the same groups or areas.

INTRODUCTION

Access to safe water and basic sanitation is indispensable for human life and dignity and has been recognized as such through the Human Right to Water and Sanitation (UN Committee on Economic Social and Cultural Rights 2010). Efforts to improve access were accelerated as a result of the Millennium Development Goals (MDGs). Yet, the lack of access to safe drinking water and adequate sanitation remain widespread global issues, especially in low- and

doi: 10.2166/wh.2020.069

middle-income countries. According to the WHO and UNICEF Joint Monitoring Programme (JMP), in 2015, 663 million people were estimated to live without access to an improved water source and 2.4 billion people were still lacking access to improved sanitation facilities. Target 7C of the MDGs was to 'halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation' (i.e., improved water supply and sanitation services). Despite the MDG Target 7C achievement, 42.5% of the world's population did not have access to water on the premises and needed to fetch it (UNICEF/WHO 2015). For sanitation, the target was not achieved although significant improvements were observed. Open defecation (OD) continued to be practised by 13% of worldwide population among which, nine out of ten were living in rural areas (UNICEF/WHO 2015).

The apparent global progress in achieving the MDGs relative to drinking water masks the very limited progress in some demographics. Rapid urbanization worldwide has led to the necessity of improving urban services but has also exacerbated inequalities between urban and rural populations (Wolf *et al.* 2013; Bain *et al.* 2014a). At the end of the MDGs, further progress was called for through the inauguration of the Sustainable Development Goals (SDGs) with a 2030 horizon. The SDGs aim to: achieve equitable universal access to safe and affordable drinking water; achieve access to adequate and equitable sanitation and hygiene for all and end OD, paying special attention to the needs of women and girls and those in vulnerable situations (WHO/UNICEF 2017).

The population using safely managed drinking water services (i.e., an improved water source which is located on premises, available when needed and free from faecal and priority chemical contamination) and safely managed sanitation services (i.e., improved facilities which are not shared with other households and where excreta are safely disposed *in situ* or transported and treated off-site) were set as improved indicators used by the JMP to monitor progress towards the SDGs. This adjustment reduced the baseline percentage of the global population considered as having access to safe and affordable drinking water (from 91 to 71%) or adequate and equitable sanitation (from 68 to 39%) in comparison with the MDGs but is likely to increase the accuracy of the indicators (WHO/UNICEF 2017). The current population with access to safely managed drinking water can be further broken down to 85 and 55% in urban and rural areas, respectively. With regard to safely managed sanitation service, the proportion of the global urban and rural population with access was determined to be 43 and 35%, respectively (WHO/UNICEF 2017).

Agenda 2030 called for 'leaving no one behind' (WHO/UNICEF 2017), advocating for efforts aimed at reducing the service gaps and reaching the populations who are furthest behind (i.e., low income and rural). Households using unimproved drinking water sources including surface water and practising OD are the most likely to need assistance. As they are primarily responsible for households' water supply, sanitation and hygiene, women's and girls' lives are even further affected by a lack of access to basic services (Chipeta 2009; Graham *et al.* 2016).

Since access is usually greater in urban areas, global trends show that the service level of water and sanitation increases with the wealth of populations (Oageng & Mmopelwa 2014; Seyoum & Graham 2016; WHO/UNICEF 2017; Cassivi *et al.* 2018a). Factors such as climate change and population growth are expected to increase vulnerability to water stress and affect the adaptability of sanitation systems, especially for vulnerable populations in low resource contexts with limited coping strategies (Fulco *et al.* 2009; Sherpa *et al.* 2014).

Malawi is ranked among the poorest countries globally (GDP per capita = 389 US$) and relies greatly on official development assistance (World Bank 2018); it has experienced a significant population growth in the last decades. Water supply and sanitation facilities have improved following major investments in the sector; however, foreign aid interventions and allocations in water supply and sanitation services were not provided to the areas with the highest needs as most were implemented in settings with more and better existing infrastructure (Marty *et al.* 2017; Wayland 2017). The MDG water-related target was achieved, whereas moderate progress was made in sanitation (UNICEF/WHO 2015). In 2015, it was reported that 87% of the national population had access to an improved water source (i.e., piped water, boreholes or tubewells, protected dug wells, protected springs, rainwater and packaged or delivered water) and 41% had access to an improved sanitation facility (i.e., flush/pour flush to the piped sewer system, septic tanks or

pit latrines; ventilated improved pit latrines, composting toilets or pit latrines with slabs) (WHO/UNICEF 2018). As such, it is likely that these statistics were driven by the progress made in areas that did not have the greatest need (Adams 2018).

With regard to the SDGs, the number of people with safely managed drinking water and sanitation services in Malawi is expected to decrease from the old MDG-era improved/unimproved metric, when accounting for additional criteria of access (Cassivi *et al.* 2017, 2018b; Smiley 2017). Unfortunately, information on safely managed services in the country remains unknown due to data unavailability (e.g., water quality and contamination, excreta disposal and treatment). Significant inequalities are nevertheless expected to rise as in similar contexts where water quality is generally worse in rural areas (Bain *et al.* 2012, 2014a, 2014b). Furthermore, the use of improved water and sanitation facilities is greater in the wealthiest quintiles, confirming the necessity to target the most vulnerable populations (WHO/UNICEF 2017).

There is a need to focus on how the access to water and OD varies within and between the different geographic and socio-economic groups of the population using classification such as region, development type (urban/rural), wealth or education level (Galan *et al.* 2013; Hopewell & Graham 2014). However, research focusing on disaggregated data is limited, and the extent of such variations is not well known. Using the case study of Malawi, we compare the indicators of access to water and sanitation across those four categories from 1992 to 2017. Further, as individuals who have neither good water access nor good sanitation are those who should be first addressed as they are the furthest behind, we consider these two measures to identify where priority should be placed for interventions/improvements.

The objectives of this study are to describe emerging trends on progress and inequalities in water supply and sanitation services over a 25-year period (1992–2017) using household survey data and to identify areas where the proportion of the population without basic access to water and practising OD remains among the most vulnerable in Malawi. This is a timely exercise to identify and target groups that were left behind and help reach, by 2030, the targets set in the SDGs.

METHODS

This study was conducted using existing national surveys conducted in Malawi. Data sources including the UNICEF Multiple Indicator Cluster Surveys (MICS), USAID Demographic and Health Surveys (DHS) and Malaria Indicators Survey (DHS-MIS), all of which are harmonized household surveys. Household data for Malawi were downloaded and extracted for each year publicly available, which include data from 1992 to 2017 (see Supplementary Table S1; UNICEF 2019; USAID 2019). Appended datasets included a total sample of 154,603 Malawian households covering a period of 25 years. DHS and MICS are designed with a stratified, two-stage cluster design, which aims to provide representative estimates for the geographic regions, urban/rural areas and wealth quintiles. Random sampling and data privacy do not allow one to determine if households were repeatedly selected across years.

The use of longitudinal data required pre-processing, as MICS and DHS questionnaires have been modified and conducted in different rounds over time. All possible differences between years were taken into account, and data from each year were systematically recoded and categorized to ensure homogeneity of the variables prior to appending and analysis. The JMP methodology for compilation and classification was replicated to produce the most accurate estimates (WHO/UNICEF 2018). Household weights as reported by DHS and MICS (i.e., inverse of the household selection probability multiplied by the inverse of the household response rate in the stratum) were multiplied by the number of household members to calculate population weights (Croft *et al.* 2018; WHO/UNICEF 2018). Population weighting was used to produce estimates of coverage for access to water and OD at the individual level, as applied to monitor global progress in access to drinking water and sanitation services.

Data analysis

Relevant data on drinking water supply and sanitation, including the type of water source and sanitation facilities, were disaggregated to target the most vulnerable populations and emphasize the lingering lack of access (Eagin & Graham 2014). The principal indicators were reduced to

the following due to their availability and consistency across surveys over time: (1) the proportion of the population without access to an improved water source located within 30 min (i.e., basic access), (2) the proportion of the population practising OD and (3) the proportion of the population without access to an improved water source located within 30 min and practising OD.

Trends in access to water and OD were assessed using explanatory and grouping variables available in DHS and MICS including: source of drinking water ($n = 152{,}160$), round-trip time to collect water (minutes) ($n = 150{,}600$) and type of toilet facility ($n = 152{,}097$). The classification of improved and unimproved water technologies followed JMP classification for SDG monitoring. Therefore, ambiguous categories that were used in the first rounds of surveys (i.e., 1992, 2000 and 2004) were classified as follows: 'spring' and 'public well' as unimproved water technologies and 'traditional pit latrines' as unimproved sanitation technology. Analysis was conducted by grouping data in regions (i.e., Northern, Central and Southern), areas (i.e., urban/rural), wealth index which was a composite measure of a household's cumulative living standard as defined by DHS and MICS (i.e., poorest, poorer, middle, richer and richest) and education level of the head of the household (i.e., no education, primary education and secondary education and higher). According to the National Statistical Office, urban areas are Lilongwe, Blantyre, Mzuzu and Zomba. Analysis was limited to variables that were available across the datasets. In cases where data were missing, the households were excluded from specific analysis.

Descriptive statistics including measures of frequency (i.e., count, percent and frequency) and measures of variation (i.e., point difference and percent change) were used to summarize and assess progress and inequalities over time using disaggregated data. Analysis was conducted using Stata SE14.

RESULTS

Trends and progress

Drinking water

The proportion of the population without basic access to drinking water (i.e., improved water sources within 30 min) decreased from 1992 to 2017 reflecting considerable progress (Table 1). At the national level, the population without access to an improved water source within 30 min walking distance decreased from 57 to 22% representing a percentage change of 62%. The greatest improvement was observed between 2015 and 2017 where the proportion of the population without access considerably decreased at

Table 1 | Population without basic access to drinking water (1992–2017) (DHS, MICS)

		Population without basic access to water (%)											
		1992	2000	2004	2006	2010	2012	2013	2014	2015	2017	Percentage point difference	Percent change[a]
National		57	50	50	49	40	28	44	29	37	22	−35	−62
Region	Northern	60	45	48	40	34	30	37	33	34	31	−28	−48
	Central	60	53	52	49	43	31	41	31	39	23	−37	−62
	Southern	55	49	49	50	38	25	48	26	37	18	−37	−67
Areas	Rural	57	50	57	53	44	31	49	33	41	25	−38	−61
	Urban	63	56	16	21	20	11	15	10	13	5	−8	−63
Wealth Index	Poorest			66	59	52	43	54	37	46	25	−41	−63
	Poorer			61	56	46	31	51	38	42	27	−34	−56
	Middle			56	53	44	31	50	34	41	28	−28	−50
	Richer			50	48	37	28	46	30	38	21	−29	−59
	Richest			19	28	20	9	20	7	17	8	−11	−57
Education Level	None	64	59	58	55	45		50		42		−21	−33
	Primary	58	53	54	51	43		48		40		−18	−31
	Secondary	25	24	28	31	24		33		27		2	7

[a]From baseline year to end line year. First available value was used when year 1992 was not available.

the national level reflecting a similar change at the disaggregated level. Although household access was improved, the proportion of women who were responsible for fetching water remained roughly the same over time (varying between 84 and 87% from 2006 to 2014).

Progress towards providing basic access to water was greater in rural areas – where 83% of the Malawians live (World Bank 2018). In rural areas, the proportion of the population without access decreased from 63 to 25% over the 25-year period. Although the percentage point change from 1992 to 2017 was greater in rural areas, the change attributable to improving access in urban areas was higher with a decrease from 13 to 5%. The gap between urban and rural populations remains one of the greatest among all groups; persists as a relative percent change was similar over time.

Across regions, similar progress was made in the Central and Southern regions – where, respectively, 43 and 44% of the population live – as the proportion of the population without basic access was reduced by 37% in both regions (NSO Malawi 2008). Less progress was observed in the Northern Region where the population without basic access decreased from 60 to 31%. The proportion of the population without access remains the highest in this least populous region.

The greatest progress within the wealth quintiles was among the poorest group in which the percentage of the population without access was lower than in poor and middle upper wealth quintiles. Conversely, the richest group had the least progress in terms of percentage point change; explained by already high levels of service. Overall, the proportion of the population without access to an improved water source within 30 min was at least halved in all wealth quintiles.

Significant disparities were observed between education levels: the proportion of the population without basic access increased between 1992 and 2017 in households with secondary or a higher level of education. Although the percentage of the population without basic access was reduced by one third from 1992 to 2015 for all groups, it remained higher for the population without education. The difference in access to drinking water with regard to education illustrates the high inequalities among all groups.

Open defecation

Between 1992 and 2017, the number of people practising OD was reduced at the national scale (Table 2). Over the 25-year period, OD was reduced by 19% (a reduction from 25 to 6%). An important difference between rural and urban areas was observed in 1992, where 28 and 2% of the population were practising OD, respectively; this gap then narrowed in the following years. This progress may

Table 2 | Population practising OD (1992–2017) (DHS, MICS)

		Population practising OD (%)											
		1992	2000	2004	2006	2010	2012	2013	2014	2015	2017	Percentage point difference	Percent change[a]
National		25	16	14	12	10	13	5	11	5	6	−19	−76
Region	Northern	18	13	14	12	13	14	12	13	14	4	−15	−80
	Central	28	18	16	11	11	13	4	10	4	5	−23	−83
	Southern	24	16	13	13	8	14	6	9	6	8	−16	−68
Areas	Rural	28	19	16	14	11	15	6	13	6	7	−21	−75
	Urban	2	1	5	2	2	3	0	3	1	1	−1	−44
Wealth Index	Poorest			43	25	26	31	15	23	15	15	−28	−65
	Poorer			16	16	12	17	5	17	6	5	−11	−68
	Middle			8	11	7	11	3	12	3	7	0	−3
	Richer			5	7	4	7	1	5	2	2	−3	−66
	Richest			1	2	1	1	0	0	0	1	0	−20
Education Level	None	36	27	21	18	15	–	9	–	8	–	−27	−76
	Primary	22	15	15	12	10	–	5	–	6	–	−17	−74
	Secondary	4	3	4	4	3	–	2	–	2	–	−1	−38

[a]From baseline year to end line year. First available value was used when year 1992 was not available.

have been influenced by the establishment of the multi-party democracy in 1994, which could have been a politically motivated upgrade either internally or from foreign donors. It is possible that efforts were made towards improving access to sanitation in rural areas where most of the population lives. The percentage of the population practising OD was reduced by three quarters, dropping from 28 to 7% from 1992 to 2017. Although the proportion of people practising OD was already low in urban areas, it was nearly halved over the 25-year period reaching 1% of the urban population.

Progress was greater in the Central Region where OD occurrence was the highest at the baseline year with a percentage change of 83% (between 1992 and 2017). Lower progress was observed in the Southern Region which had the highest proportion of the population practising OD.

With regard to the wealth index quintiles, the proportion of the population practising OD was reduced by more than three quarters in all groups except the middle wealth group where the proportion was nearly halved. The gap between the poorest and richest quintile was reduced between 1992 and 2017. The most important percentage change was observed in the richest group reaching nearly 0% in 2017.

OD was reduced by three quarters in the population without education or with primary education, reaching fewer than 10% in 2015. Progress over the 25-year period was lower in households where in the household head had secondary or higher education.

Water and sanitation

The trends show that the proportion of the population without access to an improved water source within 30 min and practising OD was even more reduced than progress, respectively, in water and sanitation areas (Table 3). Nationally, the percentage of the population without basic access to water and practising OD decreased nearly 90% from 16 to 2% over the 25-year period. Results show important improvements in access for water and sanitation, separately and together, among the populations that were further behind.

Progress in the proportion of the population without access to water and practising OD was similar in all regions over the years. Improvements in rural areas led to a reduced gap of access between both areas although disparities remain. Most people without access to basic water and sanitation services were living in rural areas below the middle-income wealth quintiles.

As education levels increased, the proportion of the population without access to water and practising OD was reduced. Progress from 1992 to 2017 was similar in households without education and those with primary education as opposed to secondary level and higher where most of

Table 3 | Population without basic access to water and practising OD (1992–2017) (DHS, MICS)

		Population without basic access to water and practising OD (%)											
		1992	2000	2004	2006	2010	2012	2013	2014	2015	2017	Percentage point difference	Percent change[a]
National		16	10	9	7	5	4	3	5	2	2	−14	−89
Region	Northern	13	9	8	6	4	4	2	9	2	2	−11	−86
	Central	20	11	10	6	5	5	2	4	2	2	−18	−92
	Southern	14	9	8	9	4	4	4	3	3	2	−12	−86
Areas	Rural	18	12	10	9	5	5	3	5	3	2	−16	−89
	Urban	1	1	2	1	1	1	0	1	0	0	−1	−97
Wealth Index	Poorest			28	16	14	14	9	10	8	5	−24	−84
	Poorer			10	10	5	5	3	7	3	2	−8	−83
	Middle			4	6	3	2	2	5	1	2	−2	−47
	Richer			3	4	2	2	1	1	1	0	−2	−84
	Richest			0	1	0	0	0	0	0	0	0	−93
Education Level	None	23	17	14	11	7		5		4		−19	−81
	Primary	15	9	9	7	5		3		3		−12	−82
	Secondary	2	2	1	2	1		1		1		−1	−60

[a]From baseline year to end line year. First available value was used when year 1992 was not available.

the population already had higher levels of access to water and sanitation at the baseline year.

Population

Although improvements in terms of access to water and OD were generally observed between 1992 and 2017, important variations were noted between 2010 and 2017. The proportion of the population without access to an improved water source within 30 min and practising OD followed a decreasing trend from 1992 to 2010 and fluctuated until 2017 (see Supplementary Figure S1). Further analysis was conducted to investigate the impact of the type of survey data on trends and progress. The observed peaks (i.e., higher or lower recorded values) in data are likely attributable to the type of surveys as years 2012, 2014 and 2017 were conducted under DHS-MIS with smaller sample sizes. The proportion of the population without access to drinking water reached the lowest values during these years, while higher proportions of OD were observed. The DHS-MIS differed from the MICS and Standard DHS by the smaller sample size which implies potential sampling differences that explain fluctuations in estimates. Disaggregation of the DHS and MICS data highlights the discrepancy in the distribution of the sample among population groups (see Supplementary Table S2).

In order to explore representativeness, survey data were compared with national population data drawn from the Malawi National Statistics Office Census and the United Nations Population Division's World Urbanization. A comparison of the total rural/urban population ratio shows an important contrast with survey data particularly in the years where DHS-MIS was conducted (see Supplementary Figure S2). Trends with regard to the rural population in DHS and MICS across time ($R^2 = 0.1$) do not follow the distribution of the population as reported in the national census over the relevant years (1987–2017) ($R^2 = 0.9$). In 2017, the survey population living in rural areas was 60% compared with the actual population which was estimated to be 83%. The rural population in the sample for the years 2012, 2014 and 2017 was underestimated from 15 to 23% compared with the census population which likely explains the difference observed in the trends of access to drinking water and sanitation.

Variations in the distribution of the population across wealth between rural and urban areas were also observed in the survey sample. These variations are exacerbated in the years when the DHS-MIS was conducted. In urban areas, the richest group was more represented than the other groups which likely represents the actual distribution of the population (see Supplementary Figure S3a). The opposite pattern is observed in rural areas where the richest households represent a lower proportion of the population (see Supplementary Figure S3a). The other groups are similar in terms of distribution and generally follow the same trends across the years.

Finally, variations were also observed with respect to the distribution of the sample population in the three regions of Malawi (see Supplementary Figure S4). Data from the national population (NSO Census) show limited changes in the distributions of the population in the different regions of the country over the years. Data from the DHS and MICS generally follow the population reported in the national census as most inhabitants are located in the Central and Southern regions. Differences were, however, observed for the years 1992, 2014 and 2017 where the survey sample was equally distributed among the three regions. Such variations in the sample population do not represent the population in the country and likely influence the estimates at the country level.

Inequalities and vulnerability

Following the trend analysis, end line data were used to further study where a lack of access remains the most critical. Data from the 2015 DHS were used as the distribution of the sample data were shown to be more similar to the national global population than the 2017 DHS data. The larger sample size in 2015 also demonstrated a higher likelihood of following over last decades' national estimates.

Drinking water

Disaggregating the population without access to an improved water source located within 30 min shows the distribution of the population in the different groups and highlights the ones that are the most vulnerable (Figure 1(a)) The population without access is mostly within the Central

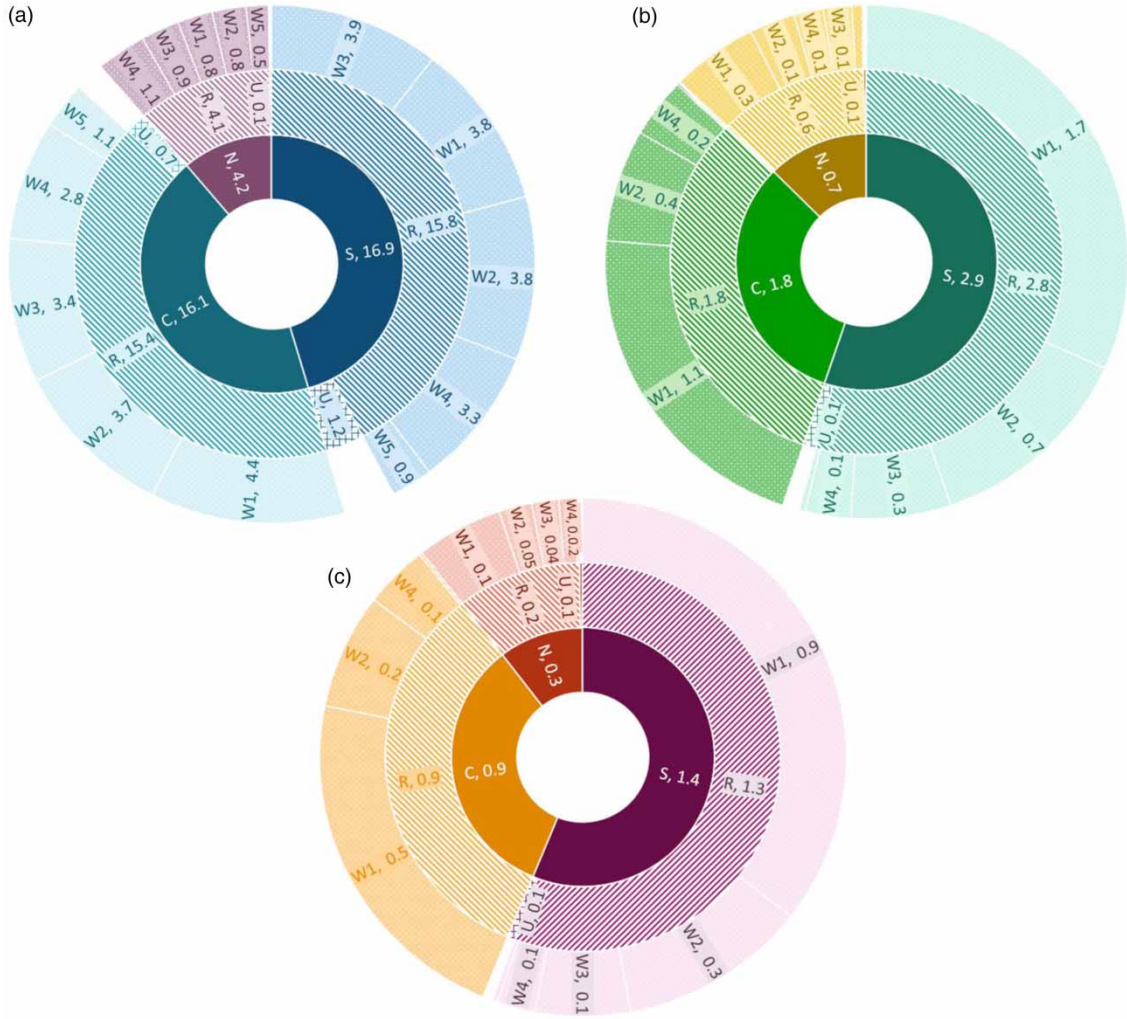

Figure 1 | Distribution of the population in 2015 (%): (a) without access to an improved water source located within 30 min (37.2%), (b) practising OD (5.4%) and (c) without access to basic drinking water services (improve within 30 min) and practising OD (2.6%). First level: Regions (N, Northern; C, Central; S, Southern); Second level: Areas (U, Urban; R, Rural); Third level: Wealth Quintile (W1, Poorest; W2, Poorer; W3, Middle; W4, Richer; W5, Richest).

and Southern regions, with a lower proportion in the Northern Region. More than three quarters of the people without access were living in the rural parts of the Central or Southern areas. Among all regions, most of the population lacking access lives in rural areas. Of note, the populations lacking access were mostly from richer households in the rural, Northern areas. The percentage of the population without access decreased as wealth increased in the Central Region. The population without access to basic drinking water was similar in all wealth groups of the Southern Region with the exception of the richest, where the proportion was the lowest.

Open defecation

In 2015, 5% of the national population was reported to practise OD. Despite significant progress in most of the groups, the distribution of the population practising OD was not uniform across groups (Figure 1(b)). Concentrated in the Central and Southern regions, most of the populations practising OD were living in rural areas. Overall, 54% of the population practising OD in Malawi was located in the rural part of the Southern Region, among which 31% were classified within the poorest wealth quintile. OD in 2015 was almost non-existent in the urban areas and the richest quintiles in rural areas.

Water and sanitation

In 2015, 2% of the population in Malawi did not have access to an improved drinking water source within 30 min of their household and were still practising OD (Figure 1(c)). A general negative association between OD and wealth is observed: the practice decreases as wealth increases. More than half of the people living without such access were located in the Southern Region and were mainly part of the poorest quintile of the population. Among all regions, the proportion of the population without access to basic water and sanitation supply was zero (or close to it) in the urban areas and the richer and upper quintiles in all areas.

DISCUSSION

General progress

Progress in access to water and sanitation in Malawi is observed in all groups of the population, including region, area, education level and wealth, over the 25-year period for which data were available. The greatest progress is generally observed in the groups that were furthest behind at the baseline year (e.g., rural, poorest and uneducated), which likely reflects good targeting. Although more people gained access in those groups, i.e., the largest segment of the population, the percentage of the population without access to water or practising OD continued to be the highest, which is consistent with trends in studies conducted in Peru and Ethiopia (Eagin & Graham 2014; Seyoum & Graham 2016). The low level reflects that most progress in terms of improving access was observed in the Central and Southern regions. Over time, these regions have narrowed the gap with the Northern Region where lower density, along with greater access at the baseline year, was reported. The difference in the regions could have been influenced, initially, by the establishment of the most important (Scottish) Missions in the Northern Region that benefited multiple water supply schemes and education projects in the last century (Thompson 2005; McCracken 2008; Kondowe 2015). Results demonstrated low regional inequalities in terms of access in the country, and this is consistent with Pullan *et al.* (2014) findings that relate to the same data.

Improvements in access to basic water and sanitation services in the country are likely attributable to the important investment in the sector over the last decades. Malawi received one of the largest per capita amounts of aid (ODA per capita = 1.07$) within the water sector between 2000 and 2010 (Bain *et al.* 2013). Galan *et al.* (2013) demonstrated a significant association between per capita aid disbursement for basic water and sanitation and the reduction in the proportion of the population practising OD. The higher proportion of the population lacking access to water and sanitation separately as opposed to both, shows that access was mostly improved for one service – namely water – but not necessarily for both of them. It is evident that improving access to both water and sanitation is indispensable to benefit the population (Bartram & Cairncross 2010).

The implementation of the Open Defecation Free (ODF) Malawi Strategy 2011 has raised awareness in the country by highlighting the need for involvement from several ministries (e.g., Agriculture, Irrigation and Water Development, Health and Education) in collaboration with development partners, NGOs, private sector and communities. Such efforts likely accelerated progress as important change is observed in the rural areas from 2012 onwards. Minimal progress was observed in reducing OD in urban areas and is not surprising considering that the ODF Malawi Strategy only focused on Community-Led Total Sanitation in rural areas and has not specifically tackled the most vulnerable and marginalized group of the population (e.g., people with disabilities, the elderly, women, children and youth) (Taulo *et al.* 2018).

Despite the fact that fewer people gained access in groups where access was the greatest at the beginning of the 25-year period, results demonstrated that the percentage change improvement still occurred over the years. However, the constant progress across the different parts of the population suggests the positive effect of recent underlying efforts to improve access to water and sanitation in Malawi. The remaining population (though a small percentage of the total) without access to an improved water source within 30 min and/or practising OD remains the hardest to reach and should be targeted in view of ensuring universal and equitable access for all by 2030.

Urban and rural areas

It is evident that the proportion of the population gaining access was larger in rural areas for both water and sanitation services. Different rates of progress in both groups led to a reduction in the gap between rural and urban areas. The population without access to an improved drinking water source within 30 min and/or practising OD was greatly reduced. It should be noted that access to water and sanitation was already greater in the urban areas at the beginning of the 25-year period which explains why fewer people gained access. Nevertheless, results demonstrated important progress and similar percentage changes in the urban areas supporting the broad range of targeted demographics.

Improvements in access in the urban areas were observed to follow slight urban population growth. Overcoming progress despite urbanization may suggest that people moving from rural to urban areas also obtained at least basic access to water and sanitation or that further efforts were put forward improving access for the vulnerable urban populations. Using aggregated global data, Bain *et al.* (2013) show that progress in urban household connections may be positively correlated with overall coverage in rural areas. Furthermore, important disparities that were observed between households with regards to education levels are likely explained by the fact that the latter are probably urban, while most programming targets uneducated, rural populations. Progress was mostly observed in groups without or lacking in education.

As improvements may become stagnant with urban population growth, addressing the needs of marginalized populations remains essential to reach universal access (Adams 2018). Previous studies shed light on the fact that some groups in urban areas, particularly those living in urban slums, may be even more vulnerable than the population in rural areas (Lungu *et al.* 2019). The lack of access to water and sanitation in urban areas is mainly a burden in peri-urban areas, and this has been documented in Blantyre and Mzuzu (Chipeta 2009; Wanda *et al.* 2012). The importance of targeting beyond the disadvantaged rural towards vulnerable urban population has previously been put forward (Chipeta 2009; Lungu *et al.* 2019) and is reinforced by the data presented here that show little progress in urban areas. Further disaggregation of urban populations, by taking into account peri-urban and informal settlements, would strengthen estimates (Bain *et al.* 2014a) as UN-Habitat (2013) estimated that nearly 70% of the urban population was living in informal settlements in Malawi.

Wealth and socio-economic status

Household wealth and education levels were also observed to influence trends in access to water and sanitation. Generally, a reduction in the proportion of the population without access to water and sanitation was greater in the lowest quintiles where baseline values were the highest. More people gained access to basic services in the lowest quintiles although the percentage change was similar across quintiles. Results highlight that the different rate changes across quintiles resulted in more equitable access to water across quintiles by narrowing the gap between the poorest and richest populations. Such findings are supported by previous studies that have found a significant association between socio-economic status and access to water and sanitation services (Eagin & Graham 2014; Seyoum & Graham 2016; Adams 2018).

Small variations in the percentage of the population without access to an improved water source were observed but greater inequalities with regard to practising OD were highlighted between each wealth quintile. In 2015, the percentage of the population lacking access to improved drinking water sources within 30 min in rural areas was almost the same across quintiles. In the Northern and Southern regions, a greater percentage of the population within the richer and middle quintiles were lacking access to an improved water source located within 30 min from their household.

The important difference between urban and rural population appears to further highlight inequalities than wealth in the country. These results confirm previous findings which have shown that rural and urban areas face the strongest inequities compared with other groups of the population (Seyoum & Graham 2016). Understanding the role of socio-economic status will be critical for designing policies targeting the most vulnerable households among the population (Adams 2018). No data are currently available to define the distribution of wealth across the country which limits further comparison with the population.

Leave no one behind

Results from this study demonstrated that although improvements have been made, significant parts of the population still have limited access to water and sanitation services and are forced to practise OD. Such findings highlight the need to target the most vulnerable and marginalized populations (Pullan *et al.* 2014). This finding is consistent with Mactaggart *et al.* (2018), revealing that people with disabilities had generally poorer access to water and sanitation services. Looking at wealth trends also draws attention to the need to reconsider disadvantaged rural thinking (Lungu *et al.* 2019). Women play a central role in water and sanitation as they continue to perform most of the water fetching. The time and energy associated with fetching water further exacerbates gender inequalities and reduces women's potential for empowerment by limiting opportunities (e.g., education, paid work, healthcare and childcare) and increasing the risk of injuries and exposure to abuse and violence (Curtis 1986; Geere 2015). Women and girls practising OD are also exposed to sexual exploitation and psychosocial stressors, which further compromise their dignity, health and well-being (Saleem *et al.* 2019). Improving access to water, sanitation and hygiene is a key driver to improve women's and girls' lives. Gender equity in terms of access to water and sanitation should be further investigated to address women's and girls' needs for empowerment. Acknowledging the different contexts between groups of the population (e.g., urban/rural) and targeting interventions to appropriate situations is essential to leave no one behind (Adams & Smiley 2018).

Data limitations

Certain limitations regarding data analysis must be stated. This study used readily available large-scale data collected as part of the MICS and DHS and is thus subject to data quality and accuracy controls. Indicators selected for this study were used because they were the most consistent across the years. OD is not the only intervention towards safely managed sanitation services and may be considered as the simplest reduction proxy to monitor access to sanitation.

Although the surveys are said to be nationally representative, a variation in data estimates with regards to the type of survey conducted by DHS was observed. The trends of access show a difference between the DHS standard and MIS which could be attributable to the use of a different sampling frame. This study had a descriptive aim and does not include measures of association. The relationship between access to water and sanitation and other explanatory factors should be further explored to establish causation.

It should also be noted that survey estimates are drawn from self-reported data which may introduce biases, such as social desirability response bias (e.g., conformity, sensitivity to OD and hope for better services), and compromise data reliability and validity (Guest *et al.* 2005; Van de Mortel 2008). Additionally, the differentiation between areas is based on the country's urban-rural definition. It remains unclear and important to define whether peri-urban informal settlements are considered as urban or rural areas and perhaps not even included in the sampling. The potential influence of the definition of urban and rural areas may have an impact on estimates especially if the definition were revised over time. It is not possible to compare the trends with the population growth and movement as most of the explanatory variables – regions, area and wealth quintiles – used in this analysis were also used to ensure the representativeness of the sample at the study design stage.

RECOMMENDATIONS

Findings from this study are explanatory and were subject to data availability. Further analysis using additional data sources and more exhaustive indicators and disaggregation factors would be necessary to direct interventions and efforts towards the groups of the population that are still left behind. It is clear that resources should be directed to those who lack minimum access to water and sanitation. In Malawi, such people are mostly found to be in the poorest rural Central and Southern regions.

In view of the SDGs, future surveys and studies should include indicators that address safely managed drinking water and sanitation services. A MICS along with a water quality module is currently (as of 2019–2020) underway in Malawi. The lack of water quality monitoring assessments in Malawi has previously been raised, and this lack highlights the needs to strengthen human and infrastructure capacity (Holm *et al.* 2018). The introduction of the first estimates of safely managed

drinking water services for the country will likely improve the accuracy of national estimates. Also, there is a need to monitor and study the effect of different climatic (e.g., droughts and floods) and political events (e.g., elections and resulting policies) on access to water and sanitation services.

CONCLUSIONS

Progress was made to improve access to drinking water and sanitation in Malawi for all parts of the population (in terms of area, regions, wealth and education). Overall, the proportion of the population without access to an improved drinking water source within 30 min and/or practising OD was more than halved between 1992 and 2017. However, results show that some segments of the population still lack access to basic water and sanitation services, and this highlights the need to evaluate coverage at different scales to improve global access and appropriately target WASH interventions. National data should be disaggregated to ensure the representativeness of the estimates and to better inform policy-making.

The analysis identified the most vulnerable parts of the population (as measured by having limited access and practising OD) as being the poorest, rural populations living in the Central and Southern regions of Malawi. Emerging trends on progress and inequalities in water supply and sanitation services show that efforts should be put towards improving access to basic services in the most vulnerable populations across all geographic and socio-economic groups of the population. Drawing attention to the people being left behind without at least basic access to water and sanitation service is necessary to reduce the gap within the population and ensure equitable access water and sanitation for all by 2030 with respect to the SDGs' agenda.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support of the Natural Sciences and Engineering Research Council of Canada (NSERC). The authors thank Dr Nathan Lachowsky who reviewed the first version of this manuscript and are also grateful for anonymous reviewers' comments which helped improve the final version of this manuscript.

CONFLICT OF INTEREST

The authors have no actual or potential conflict of interest to declare regarding this study.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

REFERENCES

Adams, E. A. 2018 Intra-urban inequalities in water access among households in Malawi's informal settlements: toward pro-poor urban water policies in Africa. *Environmental Development* **26**, 34–42.

Adams, E. A. & Smiley, S. 2018 Urban-rural water access inequalities in Malawi: implications for monitoring the Sustainable Development Goals. *Natural Resources Forum* **42** (4), 217–226.

Bain, R. E. S., Gundry, S. W., Wright, J. A., Yang, H., Pedley, S. & Bartram, J. K. 2012 Accounting for water quality in monitoring access to safe drinking-water as part of the Millennium Development Goals: lessons from five countries. *Bulletin of the World Health Organization* **90** (3), 228.

Bain, R., Rolf, L. & Bartram, J. 2013 *Universal Access to Drinking Water*. UNU-WIDER, Helsinki, Finland.

Bain, R. E. S., Wright, J. A., Christenson, E. & Bartram, J. K. 2014a Rural: urban inequalities in post 2015 targets and indicators for drinking-water. *Science of the Total Environment* **490**, 509–513

Bain, R., Cronk, R., Wright, J., Yang, H., Slaymaker, T. & Bartram, J. 2014b Fecal contamination of drinking-water in low- and middle-income countries: a systematic review and meta-analysis. *PLoS Medicine* **11** (5), e1001644.

Bartram, J. & Cairncross, S. 2010 Hygiene, sanitation, and water: forgotten foundations of health. *PLoS Medicine* **7** (11), e1000367.

Cassivi, A., Waygood, E. O. D. & Dorea, C. 2017 Quality of life impacts related to the time to access drinking water in Malawi. *Journal of Transport & Health* **5**, S15.

Cassivi, A., Waygood, E. O. D. & Dorea, C. 2018a Collection time inequalities: fetching water in Ethiopia. In: *41st WEDC International Conference*, Nakuru, Kenya.

Cassivi, A., Johnston, R., Waygood, E. O. D. & Dorea, C. 2018b Access to drinking water: time matters. *Journal of Water and Health* **16** (4), 661–666.

Chipeta, L. 2009 The water crisis in Blantyre city and its impact on women: the cases of Mabyani and Ntopwa, Malawi. *Journal of International Women's Studies* **10** (4), 17–33.

Croft, T. N., Marshall, A. M. J. & Allen, C. K. 2018 *Guide to DHS Statistics*. ICF, Rockville, MD.

Curtis, V. 1986 *Women and the Transport of Water*. Intermediate Technology Publications, London.

Eagin, B. & Graham, J. P. 2014 A study of water and sanitation access trends in Peru: where do inequities persist? *Journal of Water, Sanitation and Hygiene for Development* **4** (3), 499–508.

Fulco, L., Kabat, P., Hagemann, S. & Dorlandt, M. 2009 Impacts of climate variability and change on development and water security in Sub-Saharan Africa. *IOP Conference Series: Earth and Environmental Science* **6** (29), 292002.

Galan, D. I., Kim, S.-S. & Graham, J. P. 2013 Exploring changes in open defecation prevalence in sub-Saharan Africa based on national level indices. *BMC Public Health* **13** (1), 527.

Geere, J. 2015 Health impacts of water carriage. In: *Routledge Handbook of Water and Health* (J. Bartram, ed.). Routledge, London and New York, p. 732.

Graham, J., Hirai, M. & Kim, S.-S. 2016 An analysis of water collection labor among women and children in 24 sub-Saharan African countries. *PLoS One* **11** (6), e0155981.

Guest, G., Bunce, A., Johnson, L., Akumatey, B. & Adeokun, L. 2005 Fear, hope and social desirability bias among women at high risk for HIV in West Africa. *Journal of Family Planning and Reproductive Health Care* **31** (4), 285.

Holm, R. H., Kunkel, G. & Nyirenda, L. 2018 A thought leadership piece: where are the rural groundwater quality data for the assessment of health risks in northern Malawi? *Groundwater for Sustainable Development* **7**, 157–163.

Hopewell, M. R. & Graham, J. P. 2014 Trends in access to water supply and sanitation in 31 major sub-Saharan African cities: an analysis of DHS data from 2000 to 2012. *BMC Public Health* **14** (1), 208.

Kondowe, O. F. 2015 Issues and Challenges of Livingstonia Gravity Fed Water Supply Scheme.

Lungu, E. A., Biesma, R., Chirwa, M. & Darker, C. 2019 Is the urban child health advantage declining in Malawi? Evidence from demographic and health surveys and multiple indicator cluster surveys. *Journal of Urban Health* **96** (1), 131–143.

Mactaggart, I., Schmidt, W.-P., Bostoen, K., Chunga, J., Danquah, L., Halder, A. K., Parveen Jolly, S., Polack, S., Rahman, M., Snel, M., Kuper, H. & Biran, A. 2018 Access to water and sanitation among people with disabilities: results from cross-sectional surveys in Bangladesh, Cameroon, India and Malawi. *BMJ Open* **8** (6), e020077.

Marty, R., Dolan, C. B., Leu, M. & Runfola, D. 2017 Taking the health aid debate to the subnational level: the impact and allocation of foreign health aid in Malawi. *BMJ Global Health* **2** (1), e000129.

McCracken, J. 2008 *Politics and Christianity in Malawi, 1875–1940: The Impact of the Livingstonia Mission in the Northern Province*. African Books Collective, Cambridge University Press.

NSO Malawi 2008 *Population and Housing Census 2008 – Main Report*.

Oageng, I. & Mmopelwa, G. P. 2014 Water consumption patterns in a rural setting in Ngamiland district, Botswana: the case of Boro village. *Journal of Water Sanitation and Hygiene for Development* **4** (4), 720–726.

Pullan, R. L., Freeman, M. C., Gething, P. W. & Brooker, S. J. 2014 Geographical inequalities in use of improved drinking water supply and sanitation across sub-Saharan Africa: mapping and spatial analysis of cross-sectional survey data. *PLoS Medicine* **11** (4), e1001626.

Saleem, M., Burdett, T. & Heaslip, V. 2019 Health and social impacts of open defecation on women: a systematic review. *BMC Public Health* **19** (1), 158–158.

Seyoum, S. & Graham, J. P. 2016 Equity in access to water supply and sanitation in Ethiopia: an analysis of EDHS data (2000–2011). *Journal of Water Sanitation and Hygiene for Development* **6** (2), 320–330.

Sherpa, A. M., Koottatep, T., Zurbrügg, C. & Cissé, G. 2014 Vulnerability and adaptability of sanitation systems to climate change. *Journal of Water and Climate Change* **5** (4), 487–495.

Smiley, S. L. 2017 Quality matters: incorporating water quality into water access monitoring in rural Malawi. *Water International* **42** (5), 585–598.

Taulo, S., Kambala, C., Kumwenda, S. & Morse, T. 2018 *Review Report of the National Open Defecation Free (ODF) and Hand Washing with Soap (HWWS) Strategies*.

Thompson, T. J. 2005 Presbyterians and politics in Malawi: a century of interaction. *The Round Table* **94** (382), 575–587.

UN Committee on Economic Social and Cultural Rights 2010 *General Comment No. 15: The Right to Water*. United Nations General Assembly, ed. *Resolution A/RES/64/292*. New York.

UN-Habitat 2013 *State of the World's Cities 2012/2013: Prosperity of Cities*. Routledge, Nairobi, Kenya.

UNICEF 2019 *Multiple Indicator Cluster Surveys*.

UNICEF/WHO 2015 *Progress on Sanitation and Drinking Water*. 2015 Update and MDG Assessment.

USAID 2019 *The DHS Program*.

Van de Mortel, T. F. 2008 Faking it: social desirability response bias in self-report research. *Australian Journal of Advanced Nursing* **25** (4), 40.

Wanda, E. M. M., Gulula, L. C. & Phiri, G. 2012 An appraisal of public water supply and coverage in Mzuzu City, northern Malawi. *Physics and Chemistry of the Earth* **50–52**, 175–178.

Wayland, J. 2017 Constraints on aid effectiveness in the water, sanitation, and hygiene (WASH) sector: evidence from Malawi. *African Geographical Review* **38** (2), 140–156.

WHO/UNICEF 2017 *Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines*.

WHO/UNICEF 2018 *JMP Methodology*. 2017 Update & SDG Baselines.

Wolf, J., Bonjour, S. & Pruss-Ustun, A. 2013 An exploration of multilevel modeling for estimating access to drinking-water and sanitation. *Journal of Water and Health* **11** (1), 64–77.

World Bank 2018 *World Bank Open Data*.

First received 2 March 2020; accepted in revised form 12 August 2020. Available online 21 September 2020