



Who is being left behind in water security, where do they live, and why are they left behind towards the achievement of the 2030 agenda?

Rose Ingutia¹

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Abstract

The study focuses on sustainable development goal (SDG) 6, target 6.1.1 examining the proportion of the population using safely managed drinking water (SM). The SDGs aim to leave no one behind (LNOB) in development by 2030, this paper investigates if anyone is being left behind in accessing SM. We use world regions, countries globally, and 23 countries identified globally as critically water insecure (CWIC). The results indicate none of the CWIC had over 50% of the population accessing SM, but had over 50% using improved water, and over 10% using surface water. Sub-Saharan Africa had the lowest percentages using SM, and the highest using surface water in 2020. Pre-primary schools lag behind primary and secondary schools in accessing basic water services. Tanzania, Burundi, Papua New Guinea, and the Solomon Islands have below 50% of pre-primary schools with basic water. Households and schools using unimproved water sources are mostly from low-income and low climate resilience countries, fragile countries, and rural areas of CWICs characterized by high levels of poverty, food insecurity and illiterate women; subsequently exacerbating stunting and child mortality rates. These negative outcomes are largely consequences of poor institutional quality common to CWICs. Previous studies failed to highlight good governance, rigorously examine CWICs, and NOLB in water -health-food insecurity nexus. The stakeholders of the 2030 Agenda on water security can use these findings to accelerate the progress of leaving no one behind.

Keywords Water security · Sustainable development goals · Critically water insecure countries · Education · Health · Nutrition

Introduction

UN Member States in 2015 adopted Sustainable Development Goals (SDGs) pledging to “leave no one behind” within and between nations, peoples, and segments of society; endeavoring to reach the furthest behind first (UN 2015). The concept of leave no one behind (LNOB) implies no individual, group of people, country, or region should be left behind in the quest to achieve the SDGs. Out of the 17 SDGs, this paper’s investigation is on SDG 6 whose task is to ensure availability and sustainable management of water and sanitation for all. The study focuses on target 6.1.1 “Proportion of population using safely managed drinking water services” (UNstats 2023). The present study applies

the UN-Water (2013) definition of water security as “The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability”. The definition implies water security is attained if all people everywhere can access adequate good quality water to sustain good health, income, and socio-economic development activities; and that used water is treated to prevent pollution and disease; and to boost resilience against floods and droughts; and good governance to resolve any disputes. This study examines the questions of who is being left behind in water security, where they live, and why they are left behind.

Water resources play a critical role because firstly, about 71% of the earth’s surface is covered by water, however, only 0.5% of the total water found in rivers, lakes, streams, aquifers, rainfall, and reservoirs can be usable by humans. Whereas a large portion of the rest of the water is salty and a

✉ Rose Ingutia
rose.ingutia@helsinki.fi

¹ Department of Economics and Management, Faculty of Agriculture and Forestry, University of Helsinki, Latokartanonkaari 5, P.O. Box 27, 00014 Helsinki, Finland

small portion is frozen freshwater (Arora and Mishra 2022; Visbeck 2018). Secondly, on average, the adult human body contains approximately 67.85% of water distributed evenly to 70% of all major body organs (Munteau et al. 2021). Lastly, water sustains all life including humans, animals, and plants, and human development. However, water is affected by human activities including land use change and pollution that contribute to climate change effects that exacerbate floods, drought, and water-related conflicts (Falkenmark 2020).

According to the Sustainable Development Goals Report (SDG 2022), as of 2020 the proportion of the global population with access to safely managed drinking water services was 74%, nonetheless, 2 billion people lacked access to these services. Whereas 1.2 billion lacked access to basic water services. The report predicts that at the present rate of progress by 2030, 81% will be covered globally, and 1.6 billion will be left behind without access to safely managed drinking water services. Meeting the target of LNOB by 2030 asks for a fourfold increase in the present rate of progress. About 72% of the world's population reside in water-insecure countries, while 8% in critically water-insecure countries (MacAlister et al. 2023). UNICEF (2021) reported that 1.42 billion people including 450 million children reside in regions exposed to high or extremely high water vulnerability. According to the UN-Water (2023) report, water use has been increasing yearly by about 1% globally since 40 years ago, and this same rate is likely to remain through 2050 due to population growth, socio-economic development, and changing consumption patterns. During the 2000–2019 period, floods caused US\$ 650 billion in economic losses, affected 1.65 billion people contributing to over 100,000 deaths. At the same time, droughts influenced 1.43 billion people with economic losses of about US\$130 billion. Floods and droughts comprise over 75% of natural disasters (CRED/UNDRR 2020).

The achievement of water security (goal 6) is a determinant factor in meeting the targets of the 2030 agenda in SDGs including poverty (1), zero hunger (2), health (3), education (4), gender (5), energy (7), work (8), inequality (10), communities (11), and peace and security goal 16 (UN-Water 2016; Adeel 2017). Furthermore, a study by Taka et al. (2021) assessed the synergies and trade-off of enhanced water security in meeting the targets of the 2030 agenda; and found that water security contributes positively to all the SDGs particularly good health and zero hunger.

No child should be left behind in accessing and completing education; access to basic water services in schools is indispensable. Unsafe drinking water largely contributes to diseases such as hepatitis, typhoid, cholera, dysentery, diarrhea, malaria, polio, and trachoma (WHO 2022). About half a million deaths in low- and middle-income countries are associated with diarrhea a majority of the victims being

children under 5 (WHO 2019; Levallois and Villanueva 2019). Access to clean water nurtures good health and well-being and reduces waterborne diseases. Water security facilitates food production leading to food security and reduction of malnutrition. Water fosters socio-economic development through food production, food processing, transformation and preparation subsequently generating income, which in turn enables economic access to food. Whereas constraint access to safe drinking water and sanitation services compromises nutritional status via water-borne diseases and incurable intestinal infections (HLPE 2015; Miller et al 2021; Larson et al. 2020; Young et al. 2021). Schools characterized by unimproved water sources, lack handwashing facilities, and have high person-to-person contact are risky environments for children and staff for they exacerbate susceptibility to environmental health hazards particularly waterborne diseases.

Poor health is a huge burden on children's education; it contributes to absenteeism from school and poor school grade performance (Sharma and Adhikari 2022; UNICEF 2021). Unprotected water sources deliver unsafe water for it contains neurotoxins or other chemicals that tend to affect brain development from prenatal throughout childhood with severe irreversible consequences affecting motor function, learning, and behavior. Stunted neurodevelopment contributes to lower school grades leading to decreased lifetime earnings and increased crime (Silbergeld 2016; Bondy and Campell 2017). Another path where lack of safe water affects children's health is by exacerbating malnutrition and stunting which also affects cognitive development. Water scarcity is known to cause children to be absent from school either because of water-borne diseases or to collect water; it triggers child labour, migration, and conflicts (UNICEF 2021). Sufficient drinking water quantity boosts students' education performance through the influence of hydration on attentiveness, focusing, and short-term memory (Chard et al. 2019; Hunter et al 2014).

The study's objectives are (1a) to investigate if anyone is being left behind in water security across world regions and income groups in the quest to achieve the 2030 agenda. (1b) To focus on critically water insecure countries (CWIC) in finding answers (i) to who is being left behind in water security, (ii) where they live, and (iii) why they are left behind. (2) To investigate the countries 'being left behind' in accessing drinking water in schools, where the schools left behind are located and why they are left behind. (3) Examine the interactions across water security, health, and food insecurity.

This study fills the gap of what is missing from previous studies for instance, UNICEF and WHO joint project on water issues have carried studies including (a) UNICEF and WHO (2019) assessed the progress in reducing inequalities with the help of national, regional, and global estimates for WASH in households to identify the population at risk of being 'left

behind'. (b) UNICEF and WHO (2021) investigated the probability for attaining the SDGs targets using the current trends to determine the acceleration required to meet the universal coverage by 2030. (c) UNICEF and WHO (2023), examined the progress of household drinking water, sanitation, and hygiene during the period 2000–2022 aiming to realize gender equality and empower women and girls. Several other studies including Correa-Porcel et al. (2021), Chen et al. (2019) and Morales-Garcia and Rubio (2023) have investigated the water-energy-food nexus. To our knowledge, we are among the first to carry out a study on NOLB on the water-health-food insecurity nexus in terms of the 2030 agenda.

Moreover, it is not enough to examine the inequalities in water security and the acceleration rate required to meet the 2030 target without addressing governance issues. For instance, governance effectiveness, and regulatory quality are crucial in the formulation and implementation of effective policies and regulations needed to ensure no one is 'left behind' in water security. This study fills this gap by examining the state of governance indicators in the 23 countries that are critically water insecure globally. Furthermore, the CWIC that risks being 'left behind' are rigorously examined unlike in precedent studies.

Given the critical role water security plays, the investigation of anyone being left behind in water security in households and schools across world regions, income groups, countries and within countries, followed by a focus on critically water insecure countries with interactions across water security, health, and food insecurity is very important. Water insecurity issues have repercussions on health and food security contributing to child mortality rates and poor education outcomes, among others. Poor quality governance as a key factor to leaving people behind is also investigated. This paper highlights those left behind in accessing water security to enable more knowledge exchange on this set of people who generally are deprived of other SDGs given that water security is interlinked to several SDGs. Thus, the paper contributes directly to the ongoing research on water security issues and indirectly to the SDGs linked to water issues. We are not simply identifying those left behind in accessing safely managed water, but are also indicating where they live and why they are being left behind. The findings are very insightful to the policymakers, for the paper presents a well-founded basis to guide policymakers on who, where, why, and how to prioritize in the design and the implementation of the policies to resolve water security issues common to those furthest at the back (CWIC) in the hope of bringing everyone on board of water security. This paper does not only address household water security issues but complements previous research, by also examining water security issues in pre-primary, primary, and secondary schools.

Data and methods

Data source

The study uses secondary data from numerous sources including Our World in Data (2023), a data portal produced by the Oxford Martin Programme on Global Development at the University of Oxford, the data we have used from this source was originally sourced from the WHO/UNICEF joint program. Moreover, we have directly used data from WHO/UNICEF (2022). We have also used secondary data from World Bank (2023) governance indicators and Demographic Health Surveys (2023) datasets. These data sources gather data from internationally renowned sources including national statistical agencies, central banks, and custom services that have used household survey methods to collect data. They standardize the data to enable suggestive comparisons across countries.

Method

- (1a) To investigate if anyone is being left behind in accessing water security across world regions and income groups in the quest to achieve the 2030 agenda. The study areas are (i) Regions- Central and South Asia, East and South East Asia, Latin America and the Caribbean, North America and Europe, West Asia and North Africa, Sub-Saharan Africa and the World. (ii) Countries grouped in income levels- Lower Middle-income, Low-income, Upper middle-income, and high-income. (iii) Least developed countries. (iv) Land-locked developing countries. (v) Fragile countries.
- (1b) To focus on critically water insecure countries (CWIC) in finding answers to (i) who is being left behind in water security, (ii) where they live, and (iii) why they are left behind. The CWIC examined are 23 in number, this study has adapted the 23 countries from MacAlister et al. (2023) a study that assessed global water security in 2023. The criteria for classifying these countries as critically water insecure is based on MacAlister et al. (2023) investigation of 186 countries with sufficient data to access 10 components of water security that were covered notwithstanding their size, population, or geography. The 10 components of water are drinking water, sanitation, good health, water quality, water availability, water value, water governance, human safety, economic safety, and water source stability. The components were assessed using the most recent national SDG indicator data (2020). Each water security component was evaluated

and individual countries received a score ranging from 0–10. Country scores were compared globally, while the overall national water security score was a result of the sum of the 10 components of a maximum score being 100. National scores were classified as water secure (75 and over), moderately secure (65–74), insecure (41–64), and critically insecure (40 or below). The present study uses 23 countries in the critically insecure group identified by MacAlister et al. (2023) to represent nations left far behind in achieving the 2030 agenda of water security for all. The list of the names of the countries is found in Table 3. It is noteworthy that the present study's objectives are different from those of MacAlister et al. (2023).

The study uses WHO/UNICEF's definitions of the drinking water ladder as follows 'Safely managed' drinking water is an improved source located on premises, available at all times, and free from contamination. 'Basic' drinking water source' is an improved source within 30 min of round trip collection time. 'Limited' drinking water source is an improved source over 30 min' round trip collection time. 'Unimproved' drinking water source connotes water from unprotected dug wells or unprotected springs against contamination. An improved water source implies access to piped water, tube wells, boreholes, protected dug wells, springs, and rainwater collection. While 'surface water' is water directly from a river, dam, lake, pond stream, or canal (Ritchie and Roser 2021).

- (2) To investigate the countries 'being left behind' in accessing drinking water in schools, where the schools left behind are located and why they are left behind, the data applied is for 2021 and is derived from UNICEF/WHO. The WHO and UNICEF have Joint Monitoring Program (JMP) for Water Supply, Sanitation, and Hygiene; globally since 1990. The JMP global database is a leading source as well as a 'gold standard' of comparable data estimates indicating the progress of rural and urban service coverage at national, regional, and global levels. JMP compiles household-level data from national census, household survey, and administrative datasets. The water security indicator is defined as the provision of basic to safely managed drinking water. Given most countries have data on basic water services as compared to safely managed water services this definition allows the inclusion of the maximum number of countries. However, data availability is a limitation particularly access to unfamiliar water sources excluded from the water security assessment (MacAlister et al. 2023). JMP global database estimates are reliable because JMP provides guidance and tools to support countries in data collection, analysis, and reporting. JMP draws

a line of best fit between all available data points using a simple linear regression least squares method to minimize the variability of data points estimating the proportion of the population using improved, unimproved, basic, and safely managed water services, country estimates are included if the data covers at least 50% of the population (JMP 2024).

Countries whose schools have more than 99% access to basic water are not included. Some countries are not included because of missing data during the period in question. The study uses a quartile classification of countries worldwide in terms of their performance in providing drinking water to pre-primary, primary school, and secondary/high schools. Countries' performance in providing water services to schools under basic or improved water services, limited water services and no water services or unimproved water services are indicated in ascending order the first quartile, the second quartile, the third quartile and the fourth quartile, the first being the worst performer and the fourth being the best performer under respective drinking water ladders.

We use governance indicators to gauge the impact of institutional quality on water security and other variables of interest in critical water-insecure countries. The World Governance Indicators (WGI) data reflects diverse views on governance by numerous survey respondents worldwide including public, private and Non-government sector experts. The WGI criteria for selecting data is that it should be from credible organizations, comparable across countries, and regularly updated. The procedure of data collection is systematic entailing data source identification, extraction, filtering, validation, and organization. The WGI uses an Unobserved Components Model to aggregate multiple sources of governance data into a single composite indicator for each of the six dimensions. The Unobserved Components model distinguishes between representative and non-representative indicators. Representative indicators are those that have similarities in many countries in terms of governance thus giving a global picture of the kind of governance that is common. Therefore, the representative indicators are preferred over the non-representative indicators. The assumption of representativeness gives ground for the belief of the common distribution for governance across different sources of data. The respective data sources are standardized to a mean of zero and a standard deviation of one to generate comparable indicators across countries (for detailed information about the Unobserved Components Model please see Kaufmann et al. 2010). Table 6 presents governance indicators of 23 countries that are critically insecure

in water. The columns display normalized estimates ranging from -2.5 to 2.5 , higher values connote better governance outcomes; standard errors from the estimates reflect the variability around the point estimate of governance; and the country percentile rank among over 200 countries ranging from 0—lowest to 100—highest (Kaufmann and Kraay 2023; Handoyo 2023; Gallego-Álvarez et al. 2021; Kaufmann et al. 2010).

WGI's methodology of aggregating multiple and various data sources into a single combined indicator raises validity and reliability issues. Independent sources have different methods of data collection and face diverse limitations. Given the structural challenges in measuring governance, the WGI reports margins of errors (the standard errors columns) of respective countries' estimates. Taking into consideration the margins of error, the WGI enables purposeful relevant cross-country comparisons. However, it is noteworthy that the practice of standardizing governance into quantifiable measures for comparison purposes is only suggestive given that it has not taken into consideration country context-specific social, cultural, and political issues.

To examine the impact of water security on health, we compare countries' percentages of households with lack of access to improved water services and the countries' under-five child mortality rates (U5MR) as an indicator of a country's health status, Miladinov (2020) and Boachie et al. (2020) used U5MR in examining health status. In general the choice of statistical analysis method to be applied depends on research objectives. The present study examines the questions of who is being left behind in water security, where they live, and why they are left behind. To reach out to those left behind in water security, policymakers have to know who they are, where they live, and why they are left behind; descriptive statistical analysis methods serves the aim of this manuscript. We apply the methods commonly used in descriptive statistics research. This study assumes the Central Limit Theorem of normal distribution and therefore employs both the mean and standard deviation. The standard deviation is normally used to measure data description, test hypothesis and establish the relationships of the variables (Cooksey 2020). Table 1 presents the summary of descriptive statistics of water security globally, in critically water insecure countries (CWIC) and in schools globally, the quantitative variables are presented in terms of mean and standard deviation.

The study uses either tabular or graphical presentations as is befitting to present results indicating the countries, regions, and income groups with those left behind, their geographical locations and factors con-

tributing to their being left behind in water security. Tabular and graphical tools compress large information in a meaningful way for interpretation purposes that can be put to use in bringing on board those left behind in water security.

Results

Who is being left behind in accessing water security?

We investigate who is being left behind in water security by examining the drinking water ladder in terms of percentages of the population accessing safely managed water (SM), basic water, limited water, unimproved water, and surface water.

Who is left behind in water security across world regions and income groups?

Table 2 compares the drinking water ladder across world regions, across world income groups, and between periods to gauge who is left behind in water security. Table 2 indicates that North America and Europe were at the top with the highest percentages (90.1%) of the populations accessing safely managed water (SM), and 0% of the population using surface water during the 2000 and 2020 periods. While Sub-Saharan Africa (SSA) in 2000 had only 17.1% of the population, using SM, and 18.7% using surface water, in 2020, the percentage of the population using SM rose to 30 and surface water fell to 6.8%. The SSA region had the highest percentage (15.6%) of the population using unimproved water in 2020; however was a significant improvement from 27.5% in 2000. Furthermore, SSA had the highest percentage of the population with limited water access in both 2000 (9%) and 2020 (12.9%).

In 2020, 97.6% of the population in high-income countries were using SM water sources, while in low-income countries was 28.8%. In the same period, 0.1% of the population in high-income countries had limited access to water, while in low-income countries 17.8% of the population suffered from limited access to drinking water. In high-income countries, 0.2% of the population used unimproved water sources in 2020, while in the same period, 17.1% of the population in low-income countries used unimproved water sources. In 2020, the high-income countries had 0% of the population using surface water for drinking, while in the same period, 5.9% of the population in low-income countries used surface water for drinking purposes.

Figure 1 on disaggregated water security across regions and income groups in 2020 vividly confirms the discussions of Table 2.

Table 1 Summary of descriptive statistics of water security in households in CWIC and in schools globally

Critically insecure water countries		Average	SD
Lowest 20%	Urban	3.54	3.14
	Rural	28.00	4.99
Highest 20%	Urban	57.20	17.22
	Rural	5.52	4.34
Women	<i>No education</i>		
	Urban	25.25	17.06
	Rural	51.69	23.01
Men	<i>No education</i>		
	Urban	12.22	9.16
	Rural	28.74	15.46
Women	<i>Primary</i>		
	Urban	6.49	3.04
	Rural	6.11	3.47
Men	<i>Primary</i>		
	Urban	6.39	3.46
	Rural	8.67	3.53
Women	<i>Secondary/high school</i>		
	Urban	51.53	16.14
	Rural	20.21	13.39
Men	<i>Secondary/high school</i>		
	Urban	67.82	10.39
	Rural	38.54	9.16
Improved water	% pop. using improved	70.52	16.32
Diarrhea	% diarrhea among under 5	18.00	7.47
Immunization, DPT	% of 12–23 months immunized	73.52	17.70
Mortality rate	Under-5 mortality per 1000 live births	58.04	33.82
Basic water	% of pop. using basic water	67.89	17.79
Basic water	% of rural pop. using basic water	54.95	19.17
Basic water	% of urban pop. using basic water	84.98	8.79
Food insecurity	% of pop. prevalence food insecurity	56.98	24.15
Stunting	Prevalence of stunting of under 5 (%)	33.40	7.99
Undernourishment	% of pop. undernourished	27.59	14.84
Globally			
Safely managed water	% of global pop. with access to SM	56.21	25.31
Basic water	% of global pop. with access to basic water	21.97	9.96
Limited water	% of global pop. having limited water	5.34	5.06
Unimproved water source	% of global pop. using unimproved water	10.89	8.91
Surface water	% of global pop. using surface water	4.90	5.55
Pre-primary school			
Basic water	% of pre-primary schools globally with basic water	62.63	17.91
Limited water	% of pre-prim. improved not available water	12.14	10.13
No water or unimproved	% of pre-pri. with no water or unimproved	30.76	19.69
Primary school			
Basic water	% pri. with basic water or improved and available	62.67	20.63
Limited water	% of pri. with improved, not available water	14.94	11.27
No water or unimproved	% of pri. without water or unimproved	30.06	22.62
Secondary/high school			
Basic water	% of sec/high with improved and available water	75.86	17.91
Limited water	% of sec/high with improved water, not available	15.93	11.96
No water or unimproved	% of sec/high without water or unimproved	20.91	19.33

The number of countries with data in 2021 and had below 99% schools with access to basic water globally under respective schools and water ladder are as follows: Pre-primary school-basic water 17, limited water 16, no water 36. Primary school-basic water 65, limited water 57, no water 54. Secondary/high school-basic water 54, limited water 33, no water 51

Table 2 Comparison of drinking water ladder across world regions, income groups and between time-period (%)

Entity	2000 wat_s	2020 wat_s	2000 wat_bas	2020 wat_bas	2000 wat_li	2020 wat_li	2000 wat_u	2020 wat_u	2000 wat_s	2020 wat_s
Regions										
Cent. & S. Asia	46.1	62.4	36.2	28.9	3.4	4.1	11.9	3.7	2.5	0.9
E. and SE Asia					1.0	0.9	14.3	4.2	3.3	0.6
L. Ame & Car	71.7	75.4	18.8	22.0	0.9	0.4	5.9	1.4	2.7	0.9
N.Amer& Euro	90.1	95.6	8.5	3.6	0.3	0.4	1.1	0.4	0.1	0.0
Sub-Sah Africa	17.1	30.0	27.8	34.6	9.0	12.9	27.5	15.6	18.7	6.8
W Asia & N Afri	67.9	78.7	15.9	13.3	4.6	5.6	9.3	1.3	2.3	1.1
World	61.7	74.3	20.0	15.8	2.5	3.6	11.8	4.7	4.1	1.6
Income levels										
Lower-mid inc.	43.1	58.1	34.1	29.9	4.3	4.6	13.1	5.1	5.4	2.3
Low income	18.8	28.8	22.7	30.4	10.1	17.8	31.4	17.1	17.1	5.9
Upper-mid. Inc	68.8	76.8	15.7	18.6	0.8	0.8	12.1	3.3	2.6	0.5
High income	95.2	97.6	3.7	2.2	0.1	0.1	1.0	0.2	0.1	0.0
Least D C	25.0	37.1	25.7	29.7	8.8	13.4	26.0	14.0	14.6	5.9
Other										
Fragile	37.5	42.5	23.4	31.7	6.8	9.4	19.1	11.0	13.2	5.4
L.locked Dev. C.	26.1	35.5	25.7	32.3	8.1	15.0	25.3	13.1	14.8	4.2

First, Second, Third, Fourth, Fifth, Sixth - First is the best performer, while sixth is the worst performer.

wat_s water safely managed; wat_bas_ basic water; wat_li limited water; wat_unimp unimproved water source; wat_s surface water; Cent. & S. Asia Central and South Asia; E. and SE Asia East and South East Asia; L. Ame & Car Latin America and the Caribbean; N. Amer & Euro North America and Europe; W Asia & N Afri West Asia and North Africa; Lower-mid inc lower middle income countries; Upper-mid. Inc upper middle-income countries; Least DC least developed countries; L. locked Dev. C. land locked developing countries

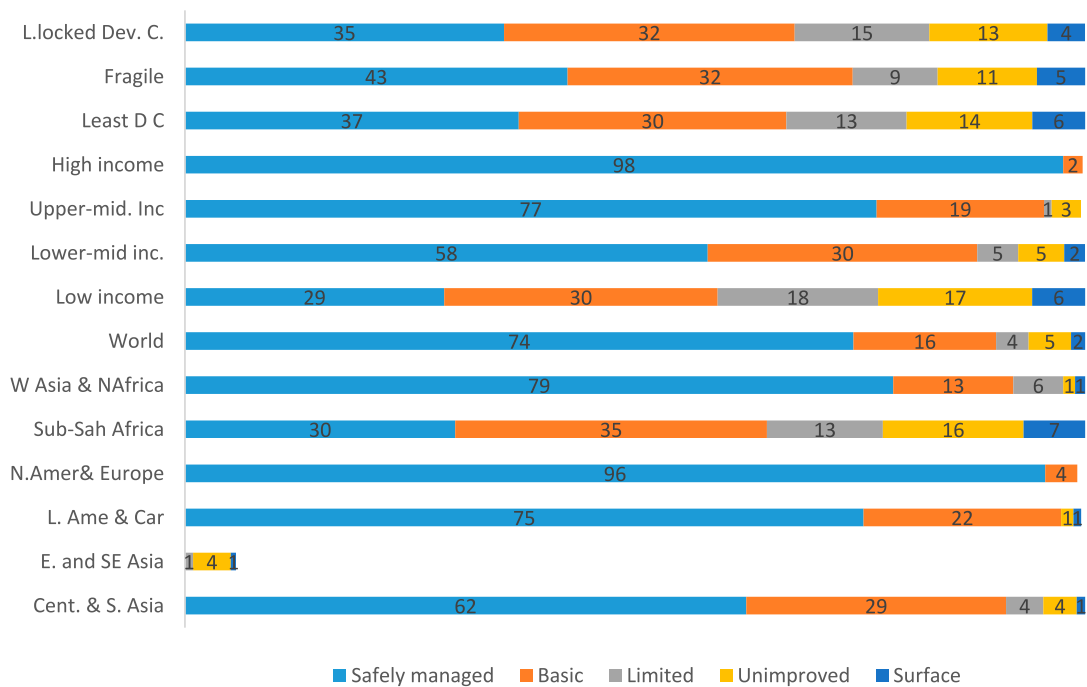


Fig. 1 Disaggregated water security in percentages across regions and income groups in 2020 (%). Comparisons of access to safely managed water across regions and income groups globally in 2020

Who is being left behind in water security across critically water insecure countries?

Table 3 on critically water insecure countries (CWIC) indicates that out of the 23 CWIC, only six countries had information on the percentages of people that had access to safely managed and basic water in 2020. None of the CWIC had over 50% of the population accessing SM; Pakistan had the highest percentage (36) while Chad had the lowest percentage (5). Pakistan and Sierra Leone had over 50% of their populations with access to basic water, while Madagascar had the lowest percentage of the population accessing basic water (33). CWIC in 2020 with over 20% of the population grouped as limited access to water were South Sudan (37%), Yemen (29%), Somalia (28%), Ethiopia (27%), Sudan (27%), and Niger (22%). CWICs with over 20% unimproved water sources are Chad (32%), Madagascar (32%), Niger (27%), Haiti (23%), Papua New Guinea (22%), and Solomon Islands (21%). In 2020, 30% of Papua New Guinea's population used surface water, while in Madagascar, Sierra Leone, and Liberia were 12% respectively. The rest of CWIC had below 10% of their populations using surface water.

In addition, Table 3 compares the percentages of the population with access to an improved water source (piped water, tube wells, boreholes, protected dug wells, springs, and rainwater collection) in CWIC between 2000 and 2020. Table 3 shows all countries had positive percentage changes except Solomon Islands (−14%), Comoros (−12%), and South Sudan (−1%). The percentage of the Ethiopian population with access to improved water sources was 19% in 2000, but has performed well by increasing the population to 50% in 2020 a 174 percentage increase. Other countries with improved performance are Afghanistan from 28% in 2000 to 76% in 2020 a 167 percentage change and Somalia from 24% in 2000 to 56% in 2020 a 139 percentage change. In terms of the population having access to an improved water source Table 3 suggests that all the CWIC had over 50% of their populations using improved water sources in 2020, except South Sudan (40%), Papua New Guinea (45%), Chad (46%) and Niger (47%).

Table 3 Percentage of people across drinking water ladder in critically insecure water countries (CIWC)

	SM 2020	Basic 2020	Limited 2020	Unimpr 2020	Surface 2020	Water 2000	Water 2020	Absolu change	Relative change
Afghan	28	48	1	14	9	28	76	47	167
Chad	5	40	15	32	8	40	46	7	17
Comoro						90	80	2	−12
Djibouti			15	7	2	75	76	1	1
Eritrea						47	52	5	11
Ethiopia	12	37	27	19	5	19	50	32	174
Haiti			10	23		56	67	1	19
Liberia			9	3	12	62	75	14	22
Libya				0		84	100	16	19
Madag	20	33	3	32	12	36	53	17	47
Micron						85	88	3	4
Niger			22	27	4	37	47	2	27
Pakistan	36	54	4	4	2	87	90	3	3
P. Guinea			2	22	30	33	45	12	37
S. Leone	10	53	9	16	12	40	64	23	57
Sol. Islands			6	21	6	79	67	11	−14
Somalia			28	13	2	24	56	33	139
S. Sudan			37	14	9	41	40	0	−1
Sri Lanka			1	5	2	80	92	12	15
Sudan			27	4	9	43	60	17	39
Vanua			1	0	8	82	91	9	11
Yemen			29	8	3	41	61	20	48

Afghan Afghanistan; *Ethiopi* Ethiopia; *Madag* Madagascar; *Micron* Micronesia; *Pakista* Pakistan; *P. Guine* Papua New Guinea; *S. Leon* Sierra Leone; *Sol. Islands* Solomon Islands; *S. Suda* South Sudan; *Sri Lank* Sri Lanka; *Vanua* Vanuatu

Where are those left behind in water security found in CWIC?

There is no disaggregated data on the drinking water ladder (safely managed water, basic water, limited water, unimproved water, and surface water) showing the geographical location of people in CWIC, therefore we use disaggregated data on improved water sources to locate people left behind in water security. Table 4 presents the percentage of people using improved water services in rural areas as a percentage of the rural population and the percentage of people using improved water services in urban areas as a percentage of the urban population in CWIC in 2020. Afghanistan had 100% of the urban population using improved water, while only 66% of the rural population used improved water sources. Sri Lanka had 100% urban and 91% rural, while Vanuatu had 100% urban and 88% rural. All the CWIC countries had more than 50% of the urban population with access to improved water sources.

Out of the 19 countries that reported to have above 50% of the urban population with access to improved water sources, nine of them reported to have below 50% of the rural population with access to improved water sources. People left behind in accessing at least an improved water

source are mostly found in rural areas including South Sudan (34%), Somalia (37%), Madagascar (36%), Chad (38%), Niger (39%), Papua New Guinea (39%), Ethiopia (40%), Haiti (43%), and Djibouti (47%).

Why are people left behind in water security in CWIC?

Our findings in Table 2 and Fig. 1 indicated that in 2020 97.6% of the population in high-income countries had access to SM while in low-income countries only 28.8% had access to SM. This has intrigued us to probe wealth quintiles of CWIC, but due to missing data, Table 10 and Fig. 2 portray wealth quartiles in rural and urban areas of 13 countries out of the 23 countries. Countries with over 50% of the 20% of top wealth quartile include Afghanistan with 73% of the top wealth quartile in urban areas and 3% in the rural areas, Chad (81%, 2%), Ethiopia (62%, 5%), Madagascar (66%, 10%), Niger (86%, 5%), Papua New Guinea (71%, 14%) and Yemen (55%, 4%). The lowest 20% wealth quartile in rural Liberia is 39%, in Sierra Leone is 34%, in Haiti is 33%, and in Eritrea is 31%.

Gender roles in developing countries assign women as domestic water managers for drinking, cooking, and

Table 4 U5MR, access to water, food insecurity and undernourishment in CIWC

Year 2020	U5MR %	Water total %	Rural %	Urban %	Food insecurity %	Undernourishment %
Afghanistan	0.58	75	66	100	70	30
Chad	1.11	46	38	74	–	33
Como	0.51	80	77	88	80	–
Djibouti	0.56	76	47	84	49	14
Eritrea	0.39	–	–	–	–	–
Ethiopia	0.49	50	40	84	56	25
Haiti	0.61	67	43	85	83	47
Liberia	0.78	75	64	86	81	38
Libya	0.11	100	–	–	39	–
Madagascar	0.66	53	36	80	61	49
Micronesia	0.26	88	–	–	–	–
Niger	1.16	47	39	86	56	–
Pakistan	0.66	90	89	93	33	17
Papua N. Guinea	0.44	45	39	86	–	22
Sierra Leone	1.09	64	53	78	87	27
Solomon Islands	0.19	67	59	91	–	18
Somalia	1.15	56	37	79	77	53
South Sudan	0.99	41	34	70	86	–
Sri Lanka	0.07	92	91	100	10	3
St. Kitts & Nevis	0.15	–	–	–	27	–
Sudan	0.57	60	53	74	51	13
Vanuatu	0.24	91	88	100	23	12
Yemen	0.60	61	51	77	–	41

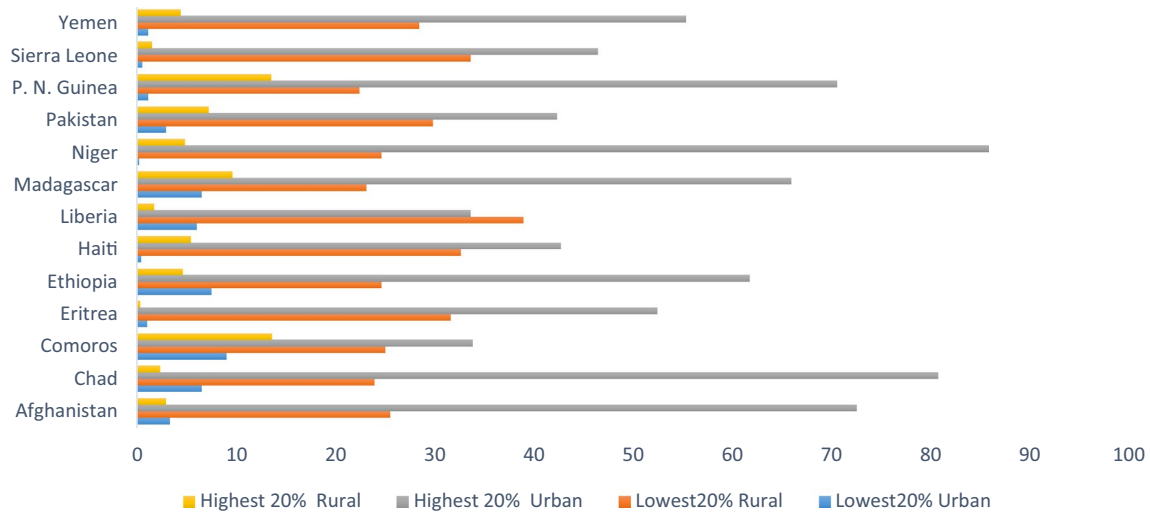


Fig. 2 Comparison of wealth quartile of CWIC across rural and urban areas (%). Water insecurity in CWIC is highest in rural areas and lowest in the wealth quartile

hygiene purposes. Educated women are more aware of the benefits of accessing improved water sources and the consequences of drinking unimproved water. Furthermore, women are the main caregivers of sick family members, thus educated women with awareness of waterborne diseases are most likely to avoid the use of unimproved water sources (Omidakhsh and von Ehrenstein 2021; Ingutia 2017). Table 5 on female versus male education status in the context of urban versus rural in the CWIC indicates that in 2020 the 12 countries with data, six countries had over 50% women without education. The countries with the lowest percentage of women without education were Madagascar (6% urban and 19% rural), and Haiti (6%

urban, 20% rural). Percentages of women with secondary or high school education under 10% are found in rural areas including Afghanistan (5), Chad (8), Eritrea (4) and Niger (9).

World Bank classifies fragile and conflict-affected countries as those with high levels of institutional and social fragility, and countries affected by violent conflict. We note in Table 2 that fragile and conflict countries in 2020 had only 42.5% of their population using SM, while 11% used unimproved water and 5.4% used water surface.

In Table 6, governance indicators indicate that none of CWIC had positive governance indicators above one; the indicators range from -2.5 to 2.5 in ascending order with

Table 5 Female vs. male education status in the context of urban vs. rural in CIWC

	Wom		Men		Wom		Men		Wom		Men	
	No ed		No ed		Pri		Pri		Sec/hi		Sec/hi	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
	67	89	31	56	3	2	7	6	20	5	46	27
Chad	42	69	20	43	7	4	4	8	37	8	63	26
Como	19	37	11	19	5	7	8	12	67	41	69	49
Eritre	23	71			4	1			41	4		
Ethiop	25	48			9	5			34	10		
Haiti	6	20	3	13	8	10	6	8	72	43	80	49
Liberi	21	47	7	22	3	4	1	5	61	21	76	45
Mada	6	19	5	16	6	9	5	7	71	33	72	35
Niger	33	75			8	5			47	9		
Pakist	28	62	14	33	12	11	11	13	56	22	68	45
P. Gui	7	25	4	14	11	11	12	14	52	23	60	31
S. Leo	28	61	15	42	3	4	4	4	62	23	75	41

Afgha Afghanistan; *Como* Comoros; *Eritre* Eritrea; *Ethiop* Ethiopia; *Liberi* Liberia; *Mada* Madagascar; *Pakist* Pakistan; *P. Gui* P. Guinea; *S. Leo* Sierra Leone

Table 6 Governance indicators in critical insecure water countries

	Voice and accountability			Political stability			Government effectiveness			Regulatory quality			Rule of law			Control of corruption		
	Est	StdErr	Rank	Est	StdErr	Rank	Est	StdErr	Rank	Est	StdErr	Rank	Est	StdErr	Rank	Estimate	StdErr	Rank
Afghanistan	-1.08	0.13	20	-2.70	0.24	0	-1.61	0.28	5	-1.39	0.21	8	-1.83	0.16	2	-1.49	0.16	5
Chad	-1.40	0.13	11	-1.26	0.25	11	-1.51	0.21	6	-1.13	0.19	11	-1.33	0.15	7	-1.42	0.16	6
Comoros	-0.76	0.14	27	-0.29	0.28	36	-1.64	0.26	5	-1.26	0.22	10	-1.28	0.24	9	-1.21	0.21	11
Djibouti	-1.41	0.13	11	-0.45	0.25	30	-0.76	0.22	21	-0.86	0.19	19	-1.04	0.15	15	-0.75	0.17	25
Eritrea	-2.06	0.13	0	-0.99	0.25	15	-1.64	0.22	4				-1.49	0.15	5	-1.34	0.17	9
Ethiopia	-1.04	0.12	21	-1.75	0.23	6	-0.59	0.21	30	-0.98	0.17	14	-0.41	0.14	38	-0.39	0.14	40
Haiti	-0.84	0.13	25	-1.03	0.24	14	-2.11	0.26	1	-1.26	0.22	10	-1.03	0.16	16	-1.35	0.16	8
Liberia	-0.07	0.12	43	-0.31	0.21	35	-1.46	0.21	8	-1.04	0.17	12	-1.04	0.14	16	-0.91	0.14	20
Libya	-1.36	0.13	12	-2.46	0.24	2	-1.86	0.25	2	-2.22	0.25	1	-1.88	0.17	2	-1.58	0.18	3
Madagascar	-0.26	0.12	38	-0.51	0.23	26	-1.05	0.21	13	-0.81	0.17	21	-0.88	0.14	20	-1.01	0.14	17
Micronesia	1.13	0.23	87	1.12	0.25	88	0.36	0.43	65	-0.89	0.34	17	0.19	0.36	56	0.88	0.30	80
Niger	-0.49	0.13	34	-1.67	0.24	7	-0.66	0.21	28	-0.80	0.18	22	-0.58	0.15	31	-0.67	0.15	28
Pakistan	-0.88	0.13	24	-1.79	0.23	5	-0.57	0.24	32	-0.76	0.20	24	-0.71	0.15	25	-0.86	0.14	22
P. Guinea	0.03	0.13	47	-0.65	0.22	23	-0.83	0.27	19	-0.68	0.22	27	-0.71	0.16	26	-0.60	0.17	30
Sierra Leone	-0.09	0.12	42	-0.30	0.23	36	-1.06	0.21	13	-0.90	0.17	16	-0.79	0.14	23	-0.40	0.14	40
Solomon Islands	0.45	0.20	60	0.56	0.25	65	-0.69	0.43	27	-0.83	0.34	20	-0.04	0.34	53	0.07	0.26	59
Somalia	-1.84	0.13	2	-2.58	0.24	1	-2.13	0.22	1	-1.95	0.19	3	-2.31	0.15	0	-1.69	0.17	2
South Sudan	-1.81	0.15	2	-2.19	0.28	3	-2.32	0.25	0	-2.01	0.21	2	-1.97	0.23	1	-1.94	0.19	0
Sri Lanka	-0.05	0.13	44	-0.09	0.23	45	-0.08	0.26	50	-0.23	0.21	43	-0.01	0.16	54	-0.33	0.15	44
St. Kitts & Nevis	0.81	0.21	72	0.93	0.27	80	0.63	0.49	73	0.51	0.37	69	0.48	0.34	66	0.34	0.25	62
Sudan	-1.43	0.13	10	-1.66	0.24	8	-1.54	0.21	6	-1.57	0.18	5	-1.09	0.15	14	-1.42	0.15	7
Vanuatu	0.65	0.20	68	0.88	0.29	76	-0.38	0.40	39	-0.38	0.31	39	0.30	0.33	61	-0.17	0.23	47
Yemen, Rep	-1.76	0.13	4	-2.65	0.24	1	-2.36	0.24	0	-1.86	0.23	4	-1.78	0.16	4	-1.71	0.16	1

Est. is the estimate of governance varies from -2.5 (weak) to 2.5 (strong). StdErr is standard error reflecting the variability around the point estimate of governance. Rank is the percentile rank among over 200 countries ranging from 0 (lowest) to 100 (highest) as investigated by the World Bank

2.5 being the best score. Governance effectiveness and regulatory quality capture water governance in terms of the ability of the government to formulate and implement effective policies and regulations, and implement them, and the credibility of the government’s commitment to its stated policies. We note that out of the 23 CWIC, only Micronesia (0.2), Sri Lanka (0.0) and St. Kitts and Nevis (0.7) had positive but insignificant governance effectiveness. Only St. Kitts and Nevis had a positive regulatory quality indicator of 0.5, the rest of the CWIC had negative indicators. These findings apply to the rest of the governance indicators including corruption, political stability, the rule of law, and voice and accountability.

People being left behind in water security are most likely to be found in countries vulnerable to climate change for it affects water security through droughts and floods. A World Congress on Disaster Risk Reduction (DRR) held in Sendai, Japan in 2015, came up with a framework called Sendai to enable countries to have good governance in handling DRR. Figure 6 in Appendix points to country scores in the adoption and implementation of the DRR strategies in line with the Sendai Framework. Figure six is a Pareto chart indicating individual country values in descending order. Countries to the right of the chart after the Pareto line intersects with Egypt, Kazakhstan, and Namibia starting with Papua New Guinea have low scores in the adoption of DRR(poor governance).

Which countries are being left behind in accessing drinking water in schools?

Table 7 depicts pre-primary schools with unimproved, limited, or basic water services in percentages globally in 2020, countries are disaggregated in quartiles, countries with over 99% of the population accessing basic water services are excluded, other countries are not included because of missing data, this explanation applies to Tables 7 and 8. Countries with over 50% of pre-primary schools using unimproved water sources are Equatorial Guinea (75%), Vanuatu (65%), Eritrea (59%), and Papua New Guinea (58%). Countries with less than 50% of pre-primary schools with access to basic water sources include Tanzania (49%), Burundi (48%), Papua New Guinea (34%), and Solomon Islands (26%).

Countries with over 50% primary schools using unimproved water sources include Niger (83%), Central African Republic (81%), Ethiopia (80%), Equatorial Guinea (74%), Chad (70%), Madagascar (63%), Guinea (63%), Democratic Republic of Congo (58%), Cote d’Ivoire (56%), Vanuatu (51%) and Burundi (50%).

Table 9 depicts secondary or high school water services, countries with less than 50% of their schools without basic water services are Syria (49%), Nigeria (49%), Niger (48%), Philippines (46%), Burkina Faso (46%), Panama (41%), and Ethiopia (22%). Countries with over 50% of their secondary or high schools using unimproved water sources include

Table 7 Quartile classification of countries’ pre-primary schools with unimproved, limited, or basic water services in percentages

No water service or unimproved				Li mited water services				Basic water	
E. Guinea	75	Guinea	33	Cambodia	<1	Ecuador	91		
Vanuatu	65	Burkina F.	29	Sierra L.	<1	Fiji	90		
Eritrea	59	Indonesia	27	Solomon Islands	30	Ghana	79		
P.N. Guinea	58	Brazil	21	Mexico	29	Peru	76		
C.A.R	49	Gabon	17	Gabon	24	Uzbekistan	76		
Burundi	49	Senegal	16	Uzbekistan	16	Indonesia	70		
D. R. Congo	44	Peru	14	Tanzania	14	Romania	67		
Solomon Island	43	S. Sudan	11	Ghana	12	Cambodia	62		
Côte d’Ivoire	42	Mexico	10	Peru	10	Mexico	61		
Sierra Leone	41	Ghana	9	Papua New Guinea	8	Gabon	59		
Chad	41	Uzbekistan	8	Fiji	4	Sierra Leone	58		
Lebanon	40	Ecuador	7	Burundi	3	Lebanon	57		
Cameroon	39	Fiji	6	Lebanon	3	Tanzania	49		
S.T.Principe	39	El Salvador	6	Ecuador	3	Burundi	48		
Gambia	38	Costa Rica	2	Indonesia	2	P N. Guinea	34		
Cambodia	38	Iraq	2			Solom Islan	26		
Tanzania	37								

Note: First quartile; Second quartile; Third quartile; and Fourth quartile

Table 8 Quartile classification of countries' primary schools with unimproved, limited, or basic water services in percentages

Basic water services or improved			Limited water services			No water service or unimproved			
Armenia	99	Rwanda	59	Syria	48	Niger	83	Algeria	15
Tonga	98	Gabon	59	Benin	39	C.A.R.	81	Cambodia	14
Viet Nam	96	Afghanistan	58	Philippines	29	Ethiopia	80	Tunisia	13
Malaysia	95	Lao P.D Republic	56	Zimbabwe	29	Equatorial Guinea	74	Gambia	13
British V.Is	94	Albania	56	Mali	28	Chad	70	Fiji	12
Jamaica	93	Congo	54	India	26	Madagascar	63	Costa Rica	11
Uzbekistan	90	Sierra Leone	52	Solomon Islands	25	Guinea	63	Ghana	11
Malawi	87	South Sudan	51	Tuvalu	25	D.R. Congo	58	Zimbabwe	11
Fiji	87	Mauritania	51	Mongolia	24	Côte d'Ivoire	56	Ecuador	10
Costa Rica	86	Tanzania	50	Uganda	23	Vanuatu	51	S.T. Principe	10
Algeria	85	Syria	49	Nigeria	23	Burundi	50	Djibouti	9
Palau	84	P.N.Guinea	46	Tanzania	22	Haiti	48	Malawi	7
Cambodia	83	Philippines	45	Sudan	20	P. N. Guinea	48	India	7
Sri Lanka	82	Burundi	45	Cameroon	20	Sierra Leone	47	Bangladesh	6
Ecuador	82	Liberia	44	Afganstan	17	Nigeria	46	Uganda	4
El Salvador	80	Sudan	43	El Salvador	16	Somalia	46	El Salvador	4
Bangladesh	80	Solomon Islands	43	Bangladesh	15	Cameroon	43	Mongolia	3
Zambia	78	Benin	43	Gabon	14	South Sudan	40	Ukraine	3
Ghana	78	Nepal	39	Ghana	12	Lebanon	37	Syria	2
Peru	77	Guinea	37	Lao P. Republic	11	Pakistan	37	Mali	2
Honduras	76	Cameroon	37	South Sudan	9	Sudan	36		
Morocco	75	Madagascar	37	Indonesia	8	Eritrea	35		
Tuvalu	75	Togo	33	Ecuador	8	Burkina Faso	33		
Myanmar	74	Nigeria	31	Peru	7	Lao P.D. Republic	33		
Uganda	73	Chad	30	P. N. Guinea	6	Solomon Islands	32		
Mongolia	73	Panama	27	British Virgin Islands	6	Tanzania	28		
Indonesia	72	C.A.R	16	Ethiopia	6	Gabon	27		
Timor-Lest	71	Ethiopia	15	Burundi	6	Philippines	26		
Mali	70			Malawi	6	Afgansta	25		
Marshall Is.	68			Burkina Faso	5	Senegal	21		
Kiribati	67			Malaysia	5	Indonesia	20		
India	67			Cambodia	4	Iraq	19		
Romania	64			Zambia	3	Benin	19		
Pakistan	63			Lebanon	3	Zambia	18		
Burkina F.	62			Costa Rica	3	Eswatini	17		
Zimbabwe	60			C.A.R	3	Brazil	16		
Lebanon	60			Fiji	2	Peru	15		

Note: First quartile; Second quartile; Third quartile; and Fourth quartile

Madagascar (74%), Haiti (63%), Vanuatu (58%), Central African Republic (58%) and Chad (50%).

Where are the schools left behind located and why are they left behind?

Figure 3 answers this question by disaggregating access to drinking water in schools by income group and geographical location in 2021. Figure 3 indicates that in high-income countries 100% of primary and secondary schools have access to basic water services. Whereas in upper-middle-income countries, 98% of secondary schools and 96% of primary schools have access to basic water services. Lower middle-income countries have 75% of secondary schools with access to basic water, while primary schools is 63%.

Under this income group, the urban areas' schools with access to basic services are 71%, while rural areas' schools are 65%. As concerns low-income countries, 39% of pre-primary, 45% of primary schools, and 47% of secondary schools have basic water services.

The interactions across water security, health, and food security.

Figure 4 depicts the impact of water security on health (U5MR), CWIC with low percentages of their populations with access to improved water sources have the highest numbers of under-five child mortality rates. The high percentages of child mortality rates are concentrated where the percentage of households with access to improved water services

Table 9 Quartile classification of countries' secondary/high schools with unimproved, limited, or basic water services in percentages

Basic services or improved & available		Limited water services		No water services or unimproved					
Malaysia	99	Mongolia	73	Syria	49	Madagascar	74	Eswatini	10
Saint Vincent	99	Albania	73	Burundi	39	Haiti	63	Brazil	9
Tonga	99	Honduras	71	Ethiopia	31	Vanuatu	58	Burundi	9
Grenada	99	Tanzania	70	Gabon	29	Mauritania	58	Iraq	9
Jamaica	97	Sierra Leone	66	Philippines	28	C. A. R.	58	Fiji	8
Armenia	97	P. New Guinea	65	Zimbabwe	26	Chad	50	Djibouti	7
Bangladesh	95	Liberia	65	Mongolia	25	E. Guinea	49	Ghana	6
Palau	95	Zimbabwe	63	Tuvalu	24	Ethiopia	47	Ghana	6
Morocco	94	Timor-Leste	62	Papua New Guinea	23	Niger	45	Costa Rica	5
Ecuador	93	Lebanon	61	Solomon Islands	21	Burkina Faso	39	Zambia	5
Algeria	92	Solomon Islands	59	Nigeria	19	Somalia	37	S.T.Principe	5
Fiji	90	Marshall Islands	57	Costa Rica	19	Lebanon	37	Ecuador	4
Uzbekistan	89	Gabon	57	India	19	Sierra Leone	34	Malawi	4
British Virgin Islands	88	Togo	54	Tanzania	19	Nigeria	32	El Salvador	4
Sri Lanka	87	Burundi	52	Burkina Faso	15	Philippines	25	Ukraine	3
Kiribati	86	Syrian	49	Ghana	15	Liberia	24	Senegal	2
Pakistan	85	Nigeria	49	Malawi	14	Solomon Islands	20	Syria	2
Romania	85	Niger	48	El Salvador	12	Eritrea	20	Mongolia	1
El Salvador	84	Philippines	46	Peru	12	Cambodia	17	Algeria	1
Cambodia	82	Burkina Faso	46	Indonesia	11	Benin	16		
Malawi	82	Panama	41	Liberia	11	Pakistan	15		
Myanmar	82	Ethiopia	22	Niger	7	Guinea	14		
Ghana	79			Algeria	7	Gabon	14		
Rwanda	77			Bangladesh	5	Indonesia	14		
Nepal	76			Ecuador	3	Côte d'Ivoire	14		
Tuvalu	76			Jamaica	3	South Sudan	13		
Costa Rica	76			Lebanon	3	Peru	13		
India	75			Fiji	2	Gambia	12		
Afghanistan	75			Grenada	1	Tanzania	12		
Peru	75			Saint Vincent	1	Zimbabwe	12		
Indonesia	75			Malaysia	1	P. New Guinea	12		

Note: First quartile; Second quartile; Third quartile; and Fourth quartile

is low. The child mortality rates decline with rising rates of households with access to improved water services as evidenced by the scatter plot.

Figure 5 portrays the impact of improved water sources on food insecurity; countries with low percentages of population with access to improved water sources mostly have high percentages of food insecure people. While countries with high percentages of the population with access to improved water sources have low percentages of food insecurity, the movements of the two-line graphs point to the important role water plays in nutritional status.

Other factors indicating the interrelations between water security and health, and nutritional status are wealth quartiles and geographical location (wealth and location have been explained in the preceding texts). Table 10 depicts the comparisons of child health and nutrition status across income quartiles, and urban versus rural areas. The 13 CWIC with data on the variables of interest do not show much difference between diarrhea in rural and urban areas. Lack of water contributes to diarrhea through sanitation

and hygiene (WASH), some children who are under 5 die daily from WASH-related diseases. There are notable differences in percentages of stunted children between urban and rural areas, with rural areas having higher percentages, for instance, Yemen has the highest percentage of stunted children, and the urban percentage is 34 compared to the rural which is 51.

Discussions

Who is left behind?

Considering that most countries have no data on safely managed water services, this research identifies people left behind in water security based on the drinking water ladder of basic water, limited water, unimproved water, and surface water. In 2020, people being left behind in water security globally were found in SSA, for it had the highest percentages of the population having limited drinking

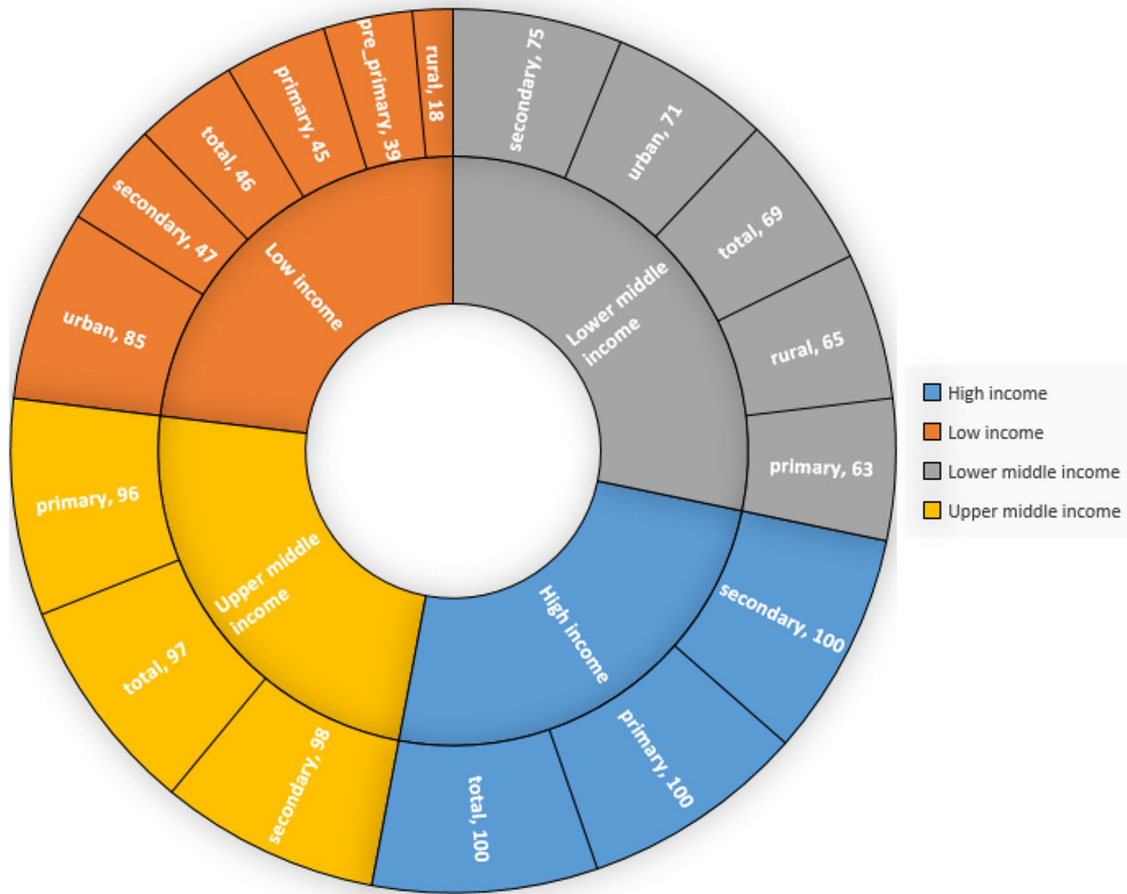


Fig. 3 Disaggregated access to drinking water in schools by income groups and geographic location in 2021 (%). Comparisons of access to drinking water in schools globally based on income groups and geographical locations in 2021

Fig. 4 Water security affects health (U5MR) in CWIC. The scatter plots indicates child mortality rates declines with increasing access of households to improved drinking water

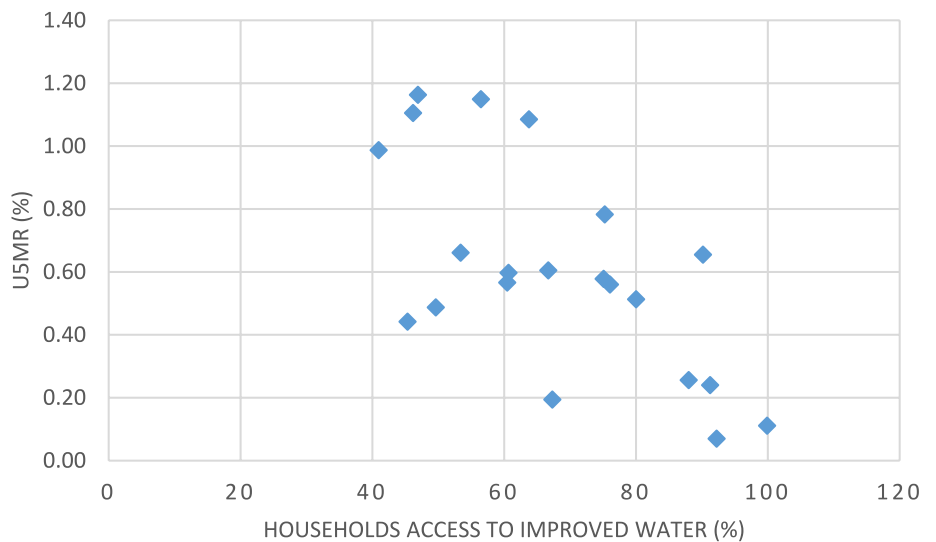


Fig. 5 Water security affects food insecurity in CWIC. The line graphs depict increasing access to water contributes to decreasing food insecurity in CWIC



Table 10 Comparison of wealth quartiles, diarrhea and nutrition status between urban and rural areas in CIWC

Country	L20%		H20%		Diarrhea		Stunted		Wasted	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Afghanistan	3	26	73	3	32	28				
Chad	7	24	81	2	23	22	32	42	13	13
Comoros	9	25	34	14	16	17	25	32	12	11
Eritrea	1	32	52	0	11	15	32	49	10	17
Ethiopia	8	25	62	5			26	40	5	8
Haiti	0	33	43	5	23	21	18	24	5	3
Liberia	6	39	34	2	14	17	25	35	3	3
Madagascar	7	23	66	10	10	9	36	41	8	8
Niger	0	25	86	5						
Pakistan	3	30	42	7	19	19	31	41	7	7
P. Guinea	1	22	71	14	22	13				
Sierr Leone	1	34	46	2	7	7	25	32	6	5
Yemen	1	28	55	4	28	32	34	51	14	17

All variables are expressed in percentages

water, population using unimproved water sources and surface water. Comparisons across income levels revealed that in 2020 the highest percentages of people being left behind in water security were found in low-income countries. Swe et al. (2021) and Hannah et al. (2022) found that globally people lacking access to basic drinking water services are found in low and lower-middle-income countries, particularly in South Asia, Southeast Asia, and SSA.

Whereas in terms of critically water insecure countries (CWIC), based on the findings in 2020, those left behind in water security starting with the percentage of the population using (a) surface water was in Papua New Guinea (33), followed by Sierra Leone, and Liberia (12). (b) Unimproved water sources were Chad and Madagascar (32), Niger (27), Haiti (23), Papua New Guinea (22), and Solomon Islands

(21). (c) Limited access to water were South Sudan (37), Yemen (29), Somalia (28), Ethiopia (27), Sudan (27), and Niger (22).

Where are those left behind in water security found?

Due to the lack of disaggregated data, we used improved water sources to find the geographical location of people left behind in water security in CWIC. Rural areas turn out to have higher percentages of people using unimproved water sources as compared to urban areas. This trend is common to CWIC including South Sudan (34), Somalia (37), Madagascar (36), Chad (38), Niger (39), Papua New Guinea (39), Ethiopia (40), Haiti (43), and Djibouti (47). These results are similar to Jami and Pizzi (2018) who found that eight out

of ten people without access to improved water sources live in rural areas; and nine out of ten people drinking surface water also live in rural areas. Adeyeye et al. (2020) reiterate that the water supply in rural areas is negligible and inaccessible due to its unaffordability, and poor service by the formal water infrastructure since local municipalities have limited capacities and resources to maintain or repair when the water systems fail.

Why are people left behind in water security?

We find in Fig. 2 a wide disparity between the 20% highest wealth quartile in urban and the 20% highest wealth quartile in rural areas. These wealth disparities partly explain why Table 4 depicts that urban areas have higher percentages of the population with access to improved water services than rural areas. Africa is largely rural this connotes a large percentage of the African population lacks access to improved water services given that the majority of rural dwellers belong to the lowest 20% wealth quartile. High percentages of the lowest 20% wealth quartile in rural areas are found in Liberia (39) Sierra Leone (34), Haiti (33), and Eritrea (31). Swe et al. (2021) concur that the reduction of poverty levels substantially increases the percentages of people accessing basic water services.

In Table 5, out of the 12 countries with data on female versus male education status in the context of urban versus rural in the CWIC indicates that in 2020 only three countries had below 30% of women in rural areas without education the rest had mostly over 60%. Table 5 suggests that lack of education or low levels of education is a contributing factor to leaving people behind in water security. Adil et al (2021) and Thai and Guevara (2019) found that the more educated people are, the more likely they will access improved water sources as compared to those with low education or illiterate.

A nation's fragility or conflict-prone is a determinant factor in meeting water security, fragile countries in Table 2 depicted low percentages of populations accessing safely managed and basic water. At the same time, percentages of the people accessing water were spread out across the water ladder including limited water, unimproved water sources, and surface water.

Governance indicators across the 23 CWICs in Table 6 were mostly insignificant and with negative impacts. The results suggest people in CWIC are left behind in water security because of poor governance, the marginalized have no voice to participate in water security issues, and the institutions are generally ineffective, and unaccountable leading to inequitable, inadequate, and unjust laws, policies, and budgets. Bayu et al (2020) and Jami and Pizzi (2018) concluded that faulty policies and institutions contribute to poor basic service

provision including safe drinking water; the poor are affected the most for they cannot afford alternative solutions.

Due to climate change effects, countries with poor governance in the adoption and implementation of the Disaster Risk Reduction (DRR) strategies in line with the Sendai Framework handling are bound to be left behind in water security. We find in Fig. 6 in Appendix that Papua New Guinea has low scores in adopting DRR (poor governance). Countries with low human resilience and capacity building in adopting DRR strategies are most likely to face water insecurity issues, a study by Gheuens et al. (2019) had similar findings. We have identified Papua New Guinea as the country with the highest percentage of the population using surface water and at the same time has over 20% of its population using unimproved water source.

Which countries are being left behind in accessing water in schools?

Data on pre-primary schools is scarce, one of the reasons being that investment in pre-primary education and coverage of early childhood education is still too low in a majority of countries (Holla et al. 2021). Countries like Equatorial Guinea, Vanuatu, Eritrea, and Papua New Guinea have over 50% of their pre-primary schools using unimproved water sources. Table 8 on primary schools has more data on water as compared to Table 7 on pre-primary schools. Moreover, the number of countries with over 50% of primary schools with basic water services is 47 as compared to 12 countries, which had over 50% of pre-primary schools with basic water services. However, it is notable that there are still high percentages ranging from 50–83 of primary schools using unimproved water sources in countries including Niger, Central Africa Republic, Ethiopia, Equatorial Guinea, Chad, Madagascar, Papua New Guinea, Democratic Republic of Congo, Cote d'Ivoire, Vanuatu, and Burundi. Water services in secondary or high schools are far better than in primary and pre-primary schools evidenced by all countries having below 50% of their schools without basic water services. However, a few countries including Madagascar, Haiti, Vanuatu, Central African Republic, and Chad have over 50% of their secondary or high schools using unimproved water sources.

Although the analysis on schools left behind in accessing water is based on all schools at a global level, the majority of countries featuring schools using unimproved water sources are from CWIC, thus these CWIC should be at the top of the agenda of 'leaving no one behind'.

Where are those schools left behind located and why are they left behind?

The disparity between rural and urban schools' access to basic water services in low-income countries is unacceptably high (18%:85%). Figure 3 indicates that schools left behind

in water security are found in rural areas, and low-income countries, the reasons for being left behind are numerous as already discussed in the preceding texts including poverty (wealth quartiles), poor water governance, and female low education levels in rural areas.

The lack of improved water sources affects health and food security.

Child mortality rates decline with rising rates of households with access to improved water services as evidenced by the scatter plot in Fig. 4. Gaffan et al. (2023) found that for children living in households with unimproved water services, their probability of dying before age 5 was higher than that of children living in households using improved water services. At the starting point in Fig. 5, the line graph of access to water security is below the line graph of food insecurity. The two lines intersect at Niger, Madagascar, Yemen, Sierra Leone, Djibouti, Micronesia, and Pakistan. Thereafter, the line graph of access to water security rises above that of food insecurity reaching 100% in Libya and food insecurity falls to 51%. Thus, rising access to water security contributes to declining percentages of food insecurity. Linderthof et al. (2021) reported that water quality affects food security, for example, irrigation with polluted water; and people accessing unimproved water for food preparation compromise food security. Rural areas are characterized by low percentages of the population accessing improved water sources, high levels of poverty, and low levels of female education. A combination of these factors exacerbates poor child health (child mortality) and nutritional status (stunting) in rural areas.

Conclusion

This paper embarked on the investigation of SDG 6 whose task is to ensure availability and sustainable management of water and sanitation for all by 2030. The study focused on target 6.1.1 “Proportion of population using safely managed drinking water services”. The study followed MacAlister et al. (2023) who compared country aggregate scores from the water security components globally, countries were grouped based on their aggregate score from the water security component. This study uses the 23 countries grouped by MacAlister et al. (2023) as critically insecure water countries (CWIC), in addition, the study also utilizes world regions, countries, and income groups to examine if anyone across households and schools is being left behind in water security, where those left behind live and why they are left behind in the quest to achieve the 2030 agenda of water security for all. The study also examined the interaction between water security, health, nutrition, and food insecurity

in CWIC. Descriptive statistics were used to analyse data with the help of the Excel program.

The highest percentages of the population ‘being left behind’ in water security globally are poor people and Sub-Saharan Africans due to Africa’s highest percentages of the population using limited drinking water, unimproved water sources and surface water. In addition, people in CWIC particularly Papua New Guinea, Sierra Leone, Liberia, Chad, Madagascar, Niger, Haiti, Solomon Islands, South Sudan, Yemen, Somalia, Ethiopia and, Sudan. Pre-primary schools were found to lag behind primary and secondary or high schools in accessing basic water services. Those left behind mostly live in low-income countries, rural areas and countries vulnerable to climate change but have low climate resilience. There are numerous reasons for being left behind including the wealth disparities between urban and rural areas given that urban areas have higher percentages of the population with access to improved water services than rural areas. Africa is largely rural with the majority of rural dwellers belonging to the lowest 20% wealth quartile. This connotes a large percentage of the African population lack access to improved water services. Moreover in most of the CWIC over 60% of rural women lack education despite the critical role of women’s education in accessing improved water sources. Fragile and conflict countries, and countries that had low human resilience and capacity building in adopting DRR strategies had low percentages of populations accessing water security. Wealth disparities, low levels of women’s education, conflicts and fragility, and low climate resilience are largely outcomes of poor institutional quality. People are left behind in water security because of poor governance, for none of the CWIC had positive significant governance indicators. Poor people generally lack political representation, and their human rights to water are normally disregarded. Whereas when water services are available in poverty-stricken areas, institutional accountability is low, at the expense of repair and maintenance.

CWIC with low percentages of their populations with access to improved water sources have the highest numbers of under-five mortality rates. Countries with low percentages of population with access to improved water sources mostly have high percentages of food insecure people. Rural areas are characterized by low percentages of the population accessing improved water sources, high levels of poverty, and low levels of female education. A combination of these factors exacerbates poor child health and nutritional status in rural areas.

The findings of the present research are crucial to the scientific community, policymakers, the public and the proponents of SDG6 that seek to ensure safe drinking water for all by monitoring the progress in the proportion of the population using safely managed water services. Literature is abundant on water security issues including innovative technologies, and reduction of inequalities, among others but scarcely is the role of good governance highlighted. Yet

good quality institutions are fundamental in the inclusive formulation and implementation of effective and efficient policies and regulations critical to bringing everyone on the water security board. This study has filled this important gap in the quest to achieve the 2030 Agenda. Our results showed the poor performance of CWIC in governance indicators including voice and accountability, political stability, government effectiveness, regulatory quality, rule of law and control of corruption.

Although water insecurity affects most countries, the most affected are the CWIC which requires priority in water security strategies. The stakeholders of water security issues can use the findings of this study that point out who is ‘being left behind’, where they live and why they are left behind, in accelerating the progress of bringing everyone on the water security board. The majority of the households and schools featured as using unimproved water sources are from CWIC, thus CWIC should be at the top of the agenda of ‘leaving no one behind’ in water security. High percentages of people left behind live in low-income countries and in rural areas, at the same time there is a wide income disparity between the highest 20% wealth quartile in urban areas and the highest 20% wealth quartile in rural areas. This calls for programs that close the wealth disparity gaps, reduce poverty levels, and create an enabling environment in rural areas to increase the percentages of people accessing basic water services. There is a need to make gender-sensitive education policies, particularly in critically water-insecure countries that have alarming percentages of illiterate women in rural areas. Educated women are aware of the importance of accessing improved water services, and in the process reducing child mortality rates resulting from using unimproved or surface water sources. Mechanisms should be put in place to resolve conflicts and to boost climate resilience. All the changes

needed to enable everyone to access water security asks for good institutional quality.

The limitations of this study include missing data, some countries might fall under the category of CWIC or lack access to water security but due to missing data, they have been excluded. WHO/UNICEF’s drinking water sources ladder including basic, limited, unimproved, and surface point to those that need immediate help being the populations that use surface drinking water sources. The CWIC lack disaggregated data based on drinking water sources’ ladder. This has limited the present study’s findings in locating *where those left behind in water security are found; instead, we have used* improved water sources to find the geographical location of people left behind in water security in CWIC.

The World Governance Indicators (WGI) methodology report margins of errors of respective countries’ estimates to enable purposeful relevant cross-country comparisons. It is notable that the practice of standardizing governance into quantifiable measures for comparison purposes is not conclusive but suggestive. This is because WGI methodology does not take into consideration country context-specific social, cultural, and political issues. Given the key role of good institutional quality, future studies could take on the task of carrying out studies on the role of governance indicators that include country context-specific social, cultural, and political issues in accessing water security for countries like Papua New Guinea, Madagascar, South Sudan, Yemen, Chad and Niger that mostly have high percentages of their population suffering from lack of access to water security.

Appendix

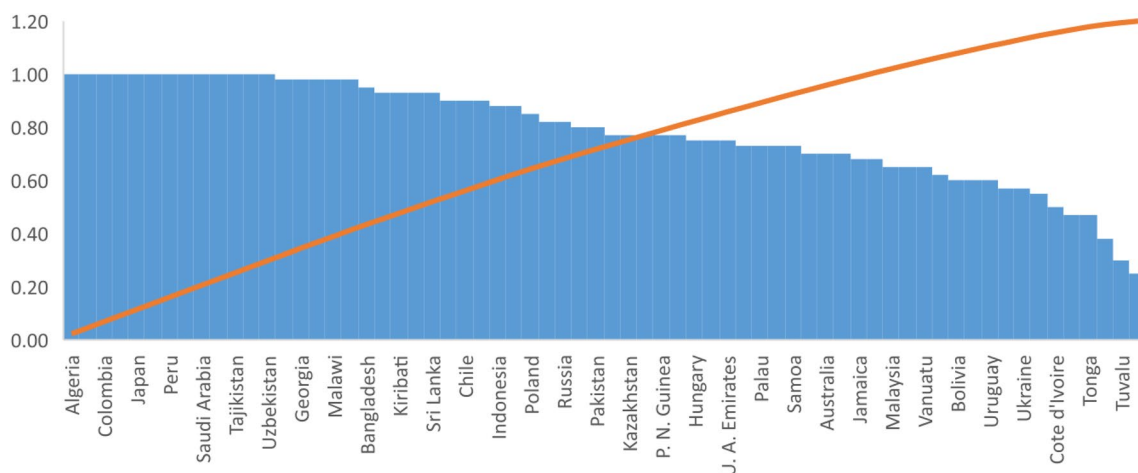


Fig. 6 Score of adoption and implementation of national DRR strategies in line with the Sendai Framework. DRR is disaster risk reduction for resilience against climate change impacts. Country scores in

the adoption of DRR strategies are in descending order, low scores indicate low resilience

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Declarations

Conflict of interest There are no conflicts of interest.

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