Who Is Being Left behind in Water Security towards the Achievement of the 2030 Agenda?

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Posted Date: 11 September 2023

doi: 10.20944/preprints202309.0645.v1

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Article

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Abstract: We investigate if anyone is being left behind in accessing safely managed drinking water (SM) in achieving the 2030 agenda. We use 23 countries grouped globally as critically insecure water (CIWC). The results indicate none of the CIWC had over 50% of the population accessing SM, N. America and Europe had highest percentages while Sub Saharan Africa had the least. People left behind are found in rural areas, in countries vulnerable to climate change because of poor governance, low-income, and women's low education. Institutional quality, equity and equality should be improved in using resources critical to leaving no one behind.

Keywords: water security; sustainable development goals; critically water insecure countries; education; health; nutrition

1. 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 17SDGs, this paper's investigation is on SDG 6 whose task is to ensure availability and sustainable management of water and sanitation for all. We focus 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.

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 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 of human development. However, water is affected by human activities including land use change and pollution that contribute to climate change effects that exacerbate floods and 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

 doi:10.20944/preprints202309.0645.v1

and 1.6 billion will be left behind without access to safely managed drinking water services. To meet the target of LNOB by 2030, asks for 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 UN –Water (2023) report, water use is increasing yearly by about 1% globally since 40years ago, and this same rate is likely to remain through 2050 due to population growth, socio-economic development and changing consumption patterns. During 2000-2019 period, floods caused US$650billion 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% natural disasters (CRED/UNDRR 2020). In 2020, about 44% of domestic wastewater globally did not meet safety treatment requirements before being released into the environment (UN-Habitat/WHO 2021).

The achievement of water security (goal 6) is a determinant factor in meeting the targets of 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 on 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 with unimproved water source, 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 to 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 by the influence of hydration on attentiveness, focusing, and short-term memory (Chard et al. 2019; Hunter et al 2014).

Our aim is to investigate if anyone is being left behind in accessing safely managed drinking water services globally, across regions, nations and within countries in the quest to achieve the 2030 agenda. Given the important role health, nutrition and education plays in human development and their interlinkages with water security, comparisons will be done between the access of safely managed drinking water in schools (education), under-five mortality rates (health), and child nutrition status (zero hunger) across the globe, regions, countries and within countries to gauge who is being left behind.

 doi:10.20944/preprints202309.0645.v1

Several studies including Correa-Porcel et al. (2021); Chen et al. (2019) and Morales-Garcia and Rubio 2023 among others have investigated water - energy- food nexus. To our knowledge, we are among the first to carry out a study on NOLB on water- health-food- education nexus in terms of the 2030 agenda. This paper will highlight on those left behind in accessing safely managed drinking water services 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. We thereby present a well-founded basis to enable policymakers to include it in the design and the implementation of the policies to resolve water security issues common to those furthest at the back.

2. Data and methods

2.1. Data source

The study uses secondary data from numerous sources including Our World in Data, 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 WHO/UNICEF joint program. Moreover, we have directly used data from WHO/UNICEF. We have also used secondary data from World Bank governance indicators, and DHS 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.

2.2. Method

We follow MacAlister et al. (2023) a study that assessed global water security in 2023. 186 countries with sufficient data to access 10 components of water security 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 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 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 2.

WHO/UNICEF definitions across the drinking water ladder are 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 minutes round trip collection time. ‘Limited’ drinking water source is an improved source over 30minutes round trip collection time. ‘Unimproved’ drinking water source connotes water from unprotected dug well or unprotected spring 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 and canal (Ritchie and Roser 2021).

Data on drinking water in schools is for 2021, and is derived from UNICEF/WHO, this data is worldwide, and countries whose schools have more than 99% access to basic water are not included. While some countries are not included because of missing data during the period in question. We use governance indicators to gauge the impact of institutional quality on water security and other variables of interest in the critical water insecure countries. The respective governance indicators are reported in the standard normal units ranging from -2.5 to 2.5, higher values connote better outcomes (Kaufmann et al.2010). Table on descriptive statistics is in Appendix 1, Table 1.

 doi:10.20944/preprints202309.0645.v1

3. Results and discussions

3.1. Who is being left behind

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 in critically water insecure countries (CWIC). In Table 1 out of the 22 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 countries 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 least 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%). CWIC with over 20% unimproved water source 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 in Liberia were 12% respectively. The rest of CWIC had below 10% of their populations using surface water.

In addition, Table 1 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 1 shows all countries had positive percentage changes with the exception of Solomon Islands (-14%), Comoros (-12%), and South Sudan (-1%). The percentage of the Ethiopian population with access to improved water source was 19% in 2000, but has performed so well by increasing the population to 50% in 2020 a 174 percentage increase. Other countries with impressive 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 139percentage change. In terms of the population having access to an improved water source Table 1 suggests that all the CWIC had over 50% of their populations using improved water source in 2020, with the exception of South Sudan (40%), Papua New Guinea (45%), Chad (46%) and Niger (47%).

Table 1. Percentage of people across drinking water ladder in critically insecure water countries.

	SM	Basic	Limited	Unimpr.	Surface	Water	Water	Absolu	Relative
	2020	2020	2020	2020	2020	2000	2020	change	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
Ethiopi	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
Pakista	36	54	4	4	2	87	90	3	3
P.Guine			2	22	30	33	45	12	37
S. Leon	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. Suda			37	14	9	41	40	0	-1
Sri Lank			1	5	2	80	92	12	15
Sudan			27	4	9	43	60	17	39

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Vanua.	1	0	8	82	91	9	11
Yemen	29	8	3	41	61	20	48

Note: Afghan- Afganistan, 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 and Vanua- Vanuatu.

3.2. Where are those left behind in water security found?

There is no disaggregated data of drinking water ladder (safely managed water (SM), basic water, limited water, unimproved water and surface water) showing geographical location of people in CWIC, therefore we use improved water source to locate people left behind in water security. Table 2 presents the percent of people using improved water services in rural areas as a percentage of the rural population and the percent 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 source. Sri Lanka had 100% urban and 91% rural, while Vanuatu 100% urban and 88% rural, the respective countries' percentages of populations had access to improved water source in 2020. All the CWIC countries had above 50% of the urban population with access to improved water source.

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 source. People left behind in accessing at least an improved water source are mostly found in the 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%). These results are similar to Jami and Pizzi (2018) who found that eight out of ten people without access to improved water source live in rural areas, while nine out of ten people drinking surface water live in rural areas. While Adeyeye et al. (2020) reiterate that water supply in rural areas is negligible and inaccessible due its unaffordability, poor service by the formal water infrastructure since local municipalities have limited capacities and resources to maintain or repair when the water systems fail.

Table 2. Immunization, U5MR, access to water, food insecurity and governance indicators.

Year 2020			Water			Food Under		Govt.	Polit.	Regu.	Rule	Voice
	Imm.	U5MR	Total	Rural	Urban	Insec.	nouri.	Corru	Effec.	Stab.	Qual.	Law	Acc.
Afgha	70	58	75	66	100	70	30	-1.5	-1.6	-2.7	-1.4	-1.8	-1.1
Chad	52	111	46	38	74	..	33	-1.5	-1.2	-1.1	-1.3	-1.4	-1.4
Como	87	51	80	77	88	80	..	-1.2	-1.6	-0.3	-1.2	-1.3	-0.8
Djibou	70	56	76	47	84	49	14	-0.7	-0.7	-0.5	-0.8	-1.0	-1.4
Eritrea	95	39	..	..	..	..	..	-1.3	-1.6	-1.0	-2.1	-1.5	-2.1
Ethiop	71	49	50	40	84	56	25	-0.4	-0.6	-1.8	-1.0	-0.4	-1.0
Haiti	51	61	67	43	85	83	47	-1.3	-2.1	-1.0	-1.2	-1.0	-0.8
Liberi	65	78	75	64	86	81	38	-0.9	-1.4	-0.4	-1.0	-1.0	-0.1
Libya	73	11	100	..	..	39	..	-1.6	-1.8	-2.5	-2.2	-1.9	-1.4
Mada	66	66	53	36	80	61	49	-1.0	-1.0	-0.5	-0.8	-0.9	-0.3
Micro	83	26	88	..	..	..	..	0.9	0.2	1.1	-1.0	0.2	1.1
Niger	81	116	47	39	86	56	..	-0.6	-0.6	-1.7	-0.8	-0.6	-0.5
Pakist	77	66	90	89	93	33	17	-0.8	-0.5	-1.8	-0.7	-0.7	-0.9
P. Gui	39	44	45	39	86	..	22	-0.6	-0.8	-0.7	-0.7	-0.7	0.0
S. Le	91	109	64	53	78	87	27	-0.4	-1.0	-0.3	-0.9	-0.8	-0.1
S. Isla	94	19	67	59	91	..	18	0.1	-0.8	0.6	-0.8	0.0	0.6
Somal	42	115	56	37	79	77	53	-1.7	-2.1	-2.6	-1.9	-2.3	-1.8
S. Su	49	99	41	34	70	86	..	-1.9	-2.3	-2.2	-2.0	-1.9	-1.8
Sri La	96	7	92	91	100	10	3	-0.3	0.0	-0.1	-0.2	0.0	-0.1

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St. Kit	99	15	..	..	..	27	..	0.4	0.7	0.9	0.5	0.5	0.8
Suda	90	57	60	53	74	51	13	-1.4	-1.5	-1.7	-1.6	-1.1	-1.4
Vanu	78	24	91	88	100	23	12	-0.1	-0.4	0.9	-0.4	0.3	0.6
Yeme	72	60	61	51	77	..	41	-1.7	-2.3	-2.7	-1.8	-1.8	-1.8

Note: Afghan- Afganistan, Djibou- Djibouti, 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, St. Kit- st Kitts and Nevis, and Vanua- Vanuatu.

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 1 in appendix 1 points to country scores in the adoption and implementation of the DRR strategies in line with the Sendai Framework. Figure 1 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, the countries in question are about 50% of the countries in Figure 1 in appendix 1. Consequently, these countries have low human resilience and capacity building contributing to water insecurity, a study by Gheuens et al. (2019) had similar findings.

Comparisons of drinking water ladder across world regions: Table 3 indicates that North America and Europe are at the top with the highest percentages (90.1%) of the populations accessing safely managed water (SM) in 2000 and in 2020 had zero percent of the population using surface water. While Sub Saharan Africa (SSA) in 2000 had only 17.1% of population, using SM, and 18.7% using surface water, in 2020, the percent of the population using SM rose to 30 and surface water fell to 6.8%. The SSA region had the highest percent (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 percent of the population with limited water access in both 2000 (9%) and in 2020 (12.9%).

In 2020, Table 3 indicates that people being left behind in water security globally are found in SSA, for it had the highest percentages of the population having limited drinking water, population using unimproved water source and surface water.

Comparisons across income levels in Table 3, shows that in 2020 the highest percentages of people being left behind in water security are found in low-income countries. 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 source in 2020, while in the same period 17.1% of the population in low-income countries used unimproved water source. In 2020, the high-income countries had zero percent 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. 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.

Table 3. Comparison of drinking water ladder across world regions and between time-period.

	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020
Entity	**wat_s**		**wat_bas**		**wat_li**		**wat_u**		**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

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W Asia & NAfri	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. Note: wat_s is water safely managed; wat_bas_ is basic water; wat_li is limited water; wat_unimp is unimproved water source; and wat_s is 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 &NAfri – 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.

Figure1 on disaggregated water security across regions and income groups in 2020 vividly confirms the discussions of Table 3.

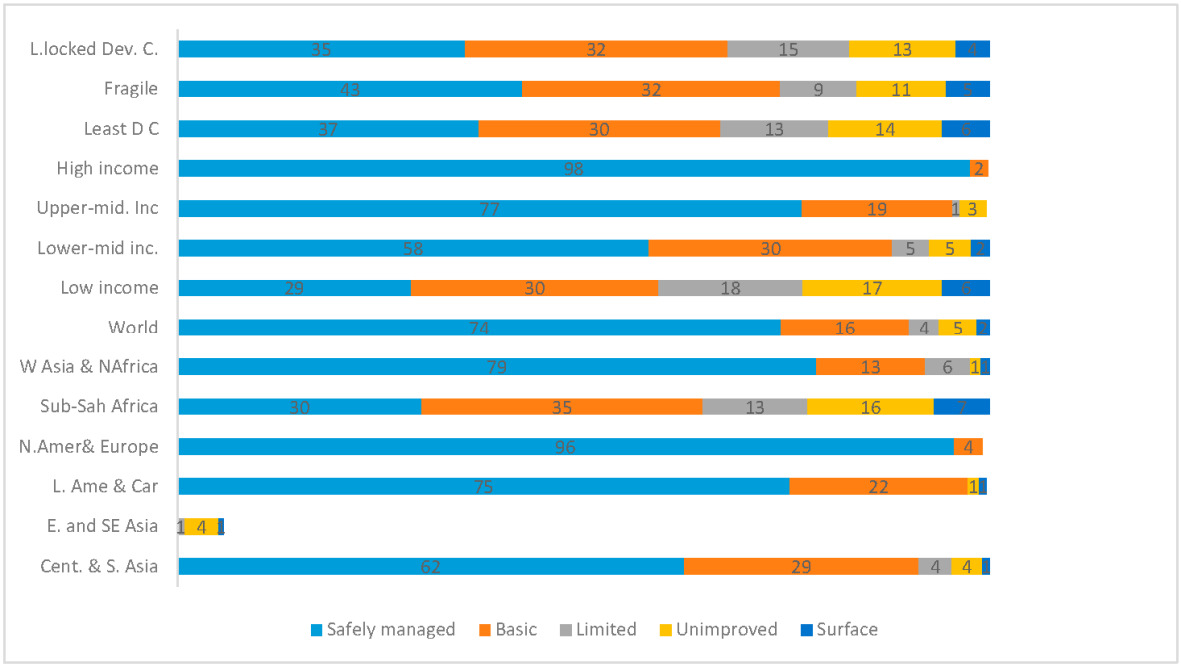

Figure 1. Disaggregated water security across regions and income groups in 2020.

3.3. Why are people left behind in water security?

In Table 2, the columns on 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 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

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accountability. These 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, the institutions are generally ineffective, 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.

Our findings in Table 3 and Figure 1 indicated that in 2020 97.6% of the populations in high-income countries had access to SM while in low income countries was only 28.8%. This has intrigued us to probe wealth quintiles of CWIC, but due to missing data, Figure 2 portrays wealth quartiles in rural and urban areas of 13 countries out of the 23 countries. We find in Figure 2 a wide disparity between the 20% highest wealth quartile in urban and the highest 20% wealth quartile in rural areas. 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%). These disparities partly explain why Table 2 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 majority of rural dwellers belong to the lowest 20% wealth quartile. The lowest 20% in rural Liberia is 39%, Sierra Leone is 34%, Haiti is 33%, and Eritrea is 31%. Swe et al. (2021) concur that reduction of poverty levels substantially increases the percentages of the people accessing basic water services.

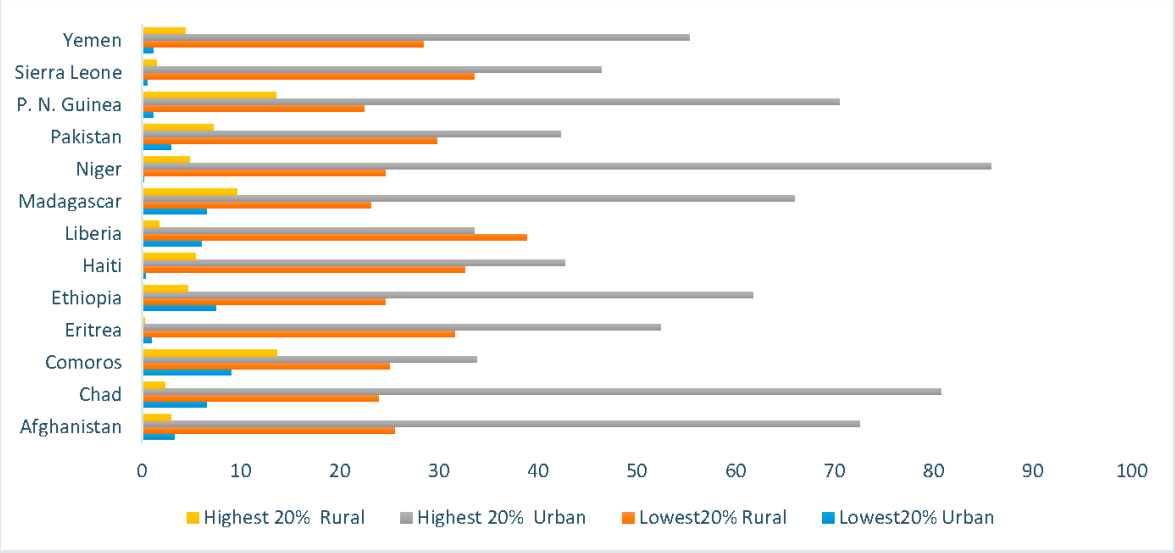

Figure 2. Comparison of wealth quartile of CWIC across rural and urban areas.

Gender roles in developing countries assigns women as domestic water managers for drinking, cooking and 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 family sick members, thus the educated women with awareness of waterborne diseases are most likely to avoid the use of unimproved water sources. Table 4 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 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). Table 4 suggests that lack of education or low levels of education is a contributing factor for leaving people behind in water security. Adil et al (2021) and Thai and Guevara (2019) found that the more educated

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people are, the more likely that they will access improved water source as compared to those with low education or illiterate.

Table 4. Female vs. male education status in the context of urban vs. rural in the critical water insecure countries.

	Wom. no ed.		Men no ed.		Wom. Pri.		Men Pri.		Wom. Sec/hi		Men Sec/hi	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Afgha	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

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 3 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. Thus, a nation's fragility or conflict prone are determinant factors in meeting water security.

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

Table 5 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 6 and 7. 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%). While 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%).

Table 5. Pre-primary schools with unimproved, limited or basic water services in percentages.

No water service or unimproved				Limited 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

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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 6 on primary schools has more data on water as compared to Table 5 on pre-primary schools. Moreover, the number of countries with over 50% of primary schools with basic water services are 47 as compare to 12 countries, which had over 50% of pre-primary schools with basic water services. 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 6. 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.

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Table 7 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%). While countries with over 50% of their secondary or high schools using unimproved water sources include Madagascar (74%), Haiti (63%), Vanuatu (58%), Central African Republic (58%) and Chad (50%).

Table 7. 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	India	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.

3.5. Where are those 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 levels and geographical location in 2021. Figure 3 indicates that in high-income countries a 100% 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 for primary schools is 63%. Urban areas' schools with access to basic services are 71%, while rural areas\ schools are 65%. As concerns low-income countries, 39% pre-primary, 45% of the primary schools and 47% of secondary schools have basic water services. 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 in 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, female's low education levels in rural areas.

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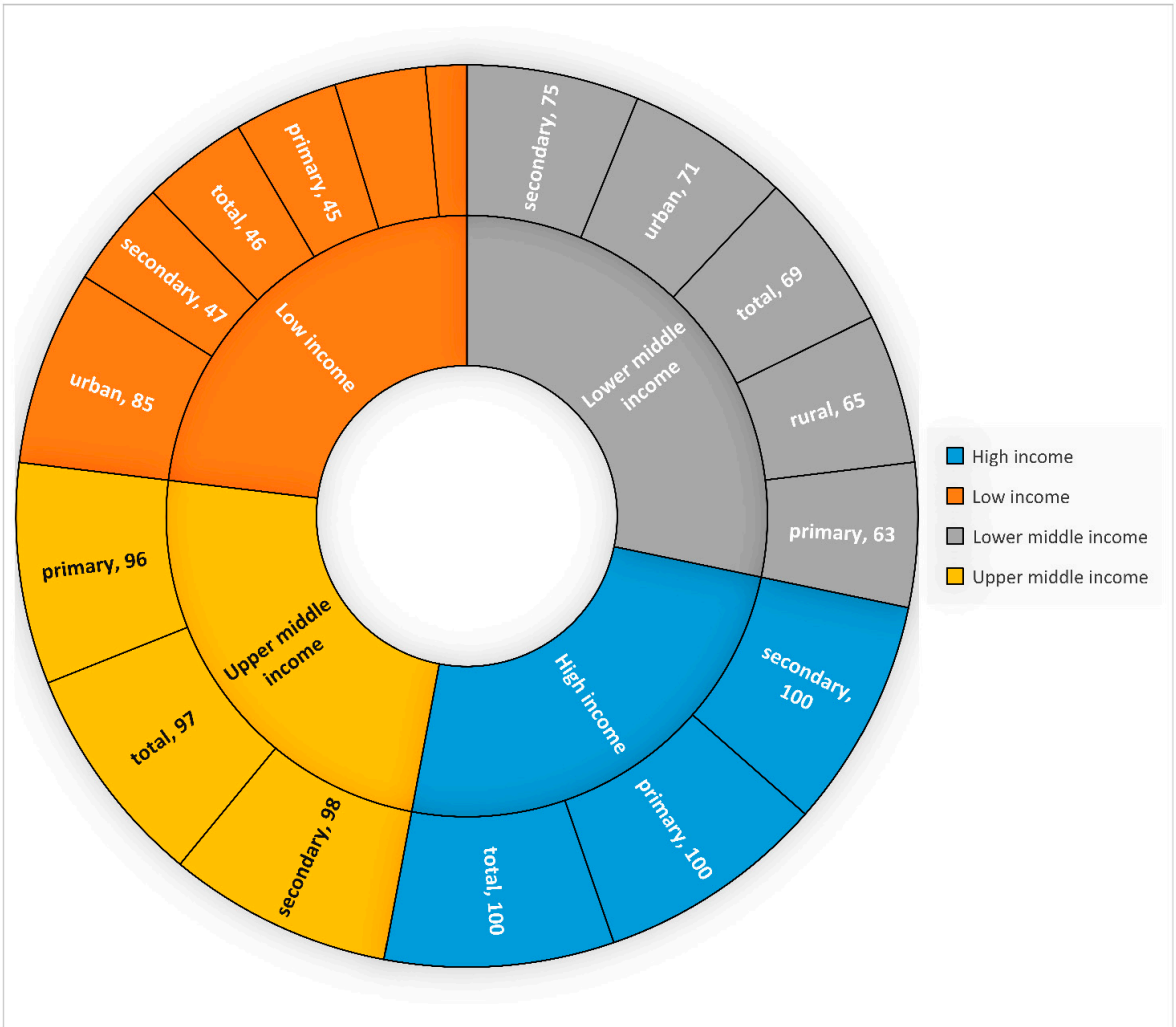

Figure 3. Disaggregated access to drinking water by income to schools and geographic location in 2021.

3.6. Lack of improved water source affects 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 an improved water sources have the highest numbers of under-five child mortality rates. As the improved water line graph rises, the U5MR line graph falls, the lines intersect at Liberia and then water line graph keeps rising reaching its maximum (100%) at Libya with U5MR of 11 for every 1,000 live births. Gaffan et al. (2013) found that 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 basic water services.

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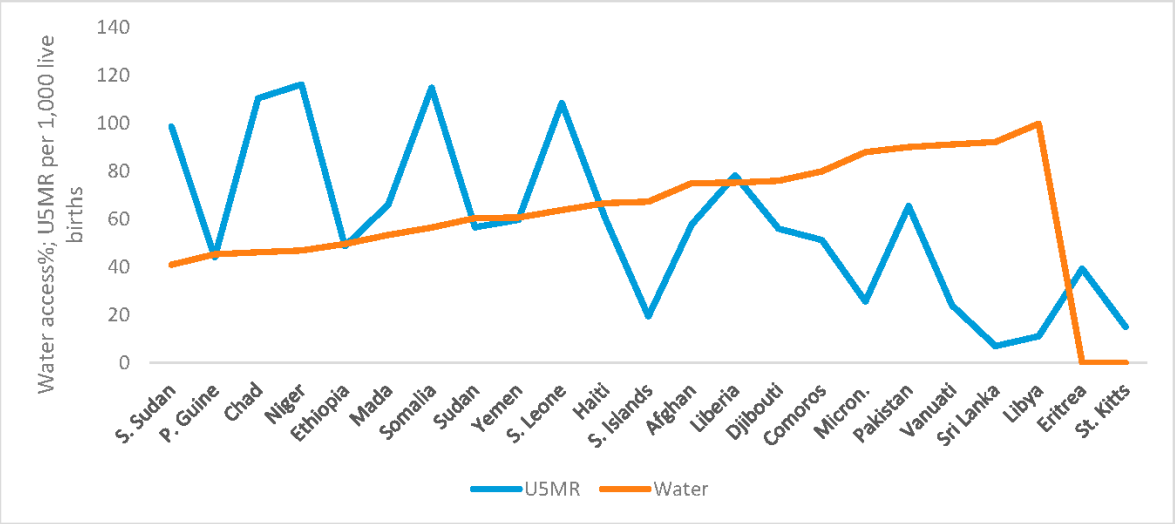

Figure 4. Water security affects health (U5MR).

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. 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 with food security.

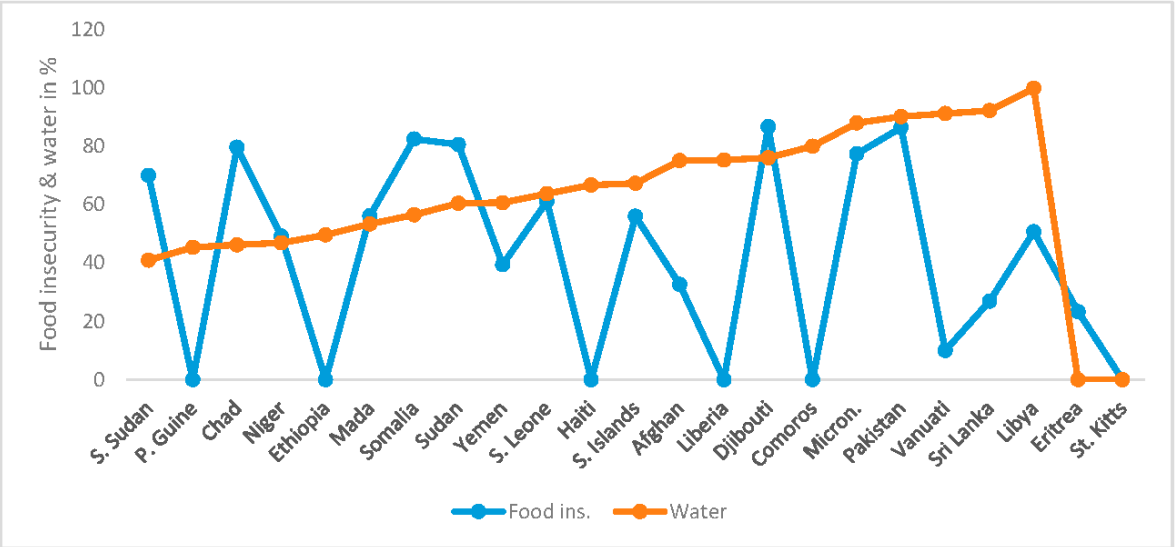

Figure 5. Water security affects food insecurity.

Other factors that complement water security in health and nutritional status are wealth quartiles and geographical location. Table 8 depicts the comparisons of child health and nutrition status across income quartiles, and urban versus rural areas. Apparently, the 13 CWIC with data on the variables of interest do not show much difference between diarrhea in rural and urban areas. Whereas there 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, the urban percentages are 34 compared to the rural that are 51. Rural areas are characterized by low percentages of the population accessing improved water sources, high levels of poverty, low

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levels of female education. A combination of these factors exacerbate poor child health and nutritional status in rural areas.

Table 8. Comparison of child health and nutrition status across wealth quartiles, and urban vs. rural areas.

	L20%		H20%		Diarrhea		Stunted		Wasted	
Country	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Afghan	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
Mada	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. Guine	1	22	71	14	22	13				
S. Leone	1	34	46	2	7	7	25	32	6	5
Yemen	1	28	55	4	28	32	34	51	14	17

4. 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. We focused on target 6.1.1 "Proportion of population using safely managed drinking water services". We aimed at examining if anyone is being left behind in accessing safely managed drinking water services globally, across regions, nations and within countries in the quest to achieve the 2030 agenda. We followed MacAlister et al. (2023) who assessed global water security with the help of 10 components of water security including drinking water, sanitation, good health, water quality, water availability, water value, water governance, human safety, economic safety and water source stability. Country scores were compared globally, countries were grouped based on their aggregate score from the water security component. This study uses the 23 countries grouped as critically insecure water countries (CIWC) to determine who is being left behind in achieving the 2030 agenda of water security for all.

Results of the drinking water ladder in terms of percentages of the population accessing safely managed water (SM), indicate that none of the countries with data had over 50% of the population accessing SM. Thus, CWIC are the ones being left behind in water security, however these countries are doing better in improved water source but not in SM, for in 2020 all the CWIC had over 50% of their populations using improved water source with the exception of South Sudan, Papua New Guinea, Chad and Niger. It is notable that in 2020 countries like Papua New Guinea's, Madagascar, Sierra Leone, and Liberia had over 10% of the population using surface water. North America and Europe are at the top with the highest percentages of the populations accessing SM in 2020 and had zero percent of the population using surface water. While Sub Saharan Africa in the same period had the least percentages of the population using SM, and the highest percentages of the population using surface water.

People left behind in accessing at least an improved water source are mostly found in the rural areas of South Sudan, Somalia, Madagascar, Chad, Niger, Papua New Guinea, Ethiopia, Haiti, and Djibouti. 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, particularly in those countries with low scores in the adoption and implementation of the DRR strategies in line with the Sendai Framework.

People are left behind in water security because of poor governance, for none of the CWIC had positive significant governance indicators. The governments of CIWC are mostly unable to formulate

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and implement effective policies and regulations, and are not credible in their commitment to the policies they make. Income levels are a determinant factor in accessing SM, for we find that in 2020 nearly all the populations in high-income countries had access to SM while in low-income countries a minimal percentage of the population had access to SM. Furthermore, the wide disparity between the 20% highest wealth quartile in urban and the highest 20% wealth quartile in rural areas contribute to high percentages of urban populations and very low percentages of rural populations using SM. SSA being largely rural implies a large percentage of the African population lacks access to improved water services given that majority of rural dwellers belong to the lowest 20% wealth quartile. Women's low education levels is another factor contributing to why CIWC are being left behind in water security, since women are managers of water in most families in developing countries. Educated women are more aware of the benefits of accessing improved water sources and the consequences of drinking unimproved water. High percentages of uneducated women are found in rural areas of Afghanistan, Chad, Eritrea and Niger. Fragile and conflict countries had low percentages of their populations using SM thus, a nation's fragility or conflict are determinant factors in meeting water security.

Pre-primary schools were found to lag behind primary and secondary or high schools in accessing basic water services. Countries with less than 50% of pre-primary schools with access to basic water sources include Tanzania, Burundi , Papua New Guinea, and Solomon Islands. Countries with over 50% primary schools using unimproved water sources include Niger, Central African Republic, Ethiopia, Equatorial Guinea, Chad, Madagascar, Guinea, Democratic Republic of Congo, Cote d'Ivoire, Vanuatu and Burundi. Countries with less than 50% of their secondary or high schools without access to basic water services are Syria, Nigeria, Niger, Philippines, Burkina Faso, Panama, and Ethiopia. While countries with over 50% of their secondary or high schools using unimproved water sources include Madagascar, Haiti, Vanuatu, Central African Republic and Chad. Low-income levels and geographical location (urban/rural) are among the key factors explaining why some schools lack access to basic water services.

CWIC with low percentages of their populations with access to an improved water sources have the highest numbers of under-five child 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 exacerbate poor child health and nutritional status in rural areas.

Appendix 1

Table A1. Descriptive statistics.

			Average	Stdev.err
Lowest20 %	Urban		3.54	3.14
	Rural		28.00	4.99
Highest 20%	Urban		57.20	17.22
	Rural		5.52	4.34
Women	No education	Urban	25.25	17.06
		Rural	51.69	23.01
Men	No education	Urban	12.22	9.16
		Rural	28.74	15.46
Women	Primary	Urban	6.49	3.04
		Rural	6.11	3.47
Men	Primary	Urban	6.39	3.46
		Rural	8.67	3.53

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Women	Secondary/high school	Urban	51.53	16.14
		Rural	20.21	13.39
Men	Secondary/high school	Urban	67.82	10.39
		Rural	38.54	9.16
		Diarrhea	18.00	7.47
		Immunization, DPT (% of children ages 12-23 months)	73.52	17.70
		Mortality rate, under-5 (per 1,000 live births)	58.04	33.82
		People using improved water services (% of pop.)	67.89	17.79
		People using improved water services, rural (% of rural pop.)	54.95	19.17
		People using improved water services, urban (% of urban pop.)	84.98	8.79
		Prevalence of food insecurity in the population (%)	56.98	24.15
		Prevalence of stunting (% of children under 5)	33.40	7.99
		Prevalence of undernourishment (% of population)	27.59	14.84

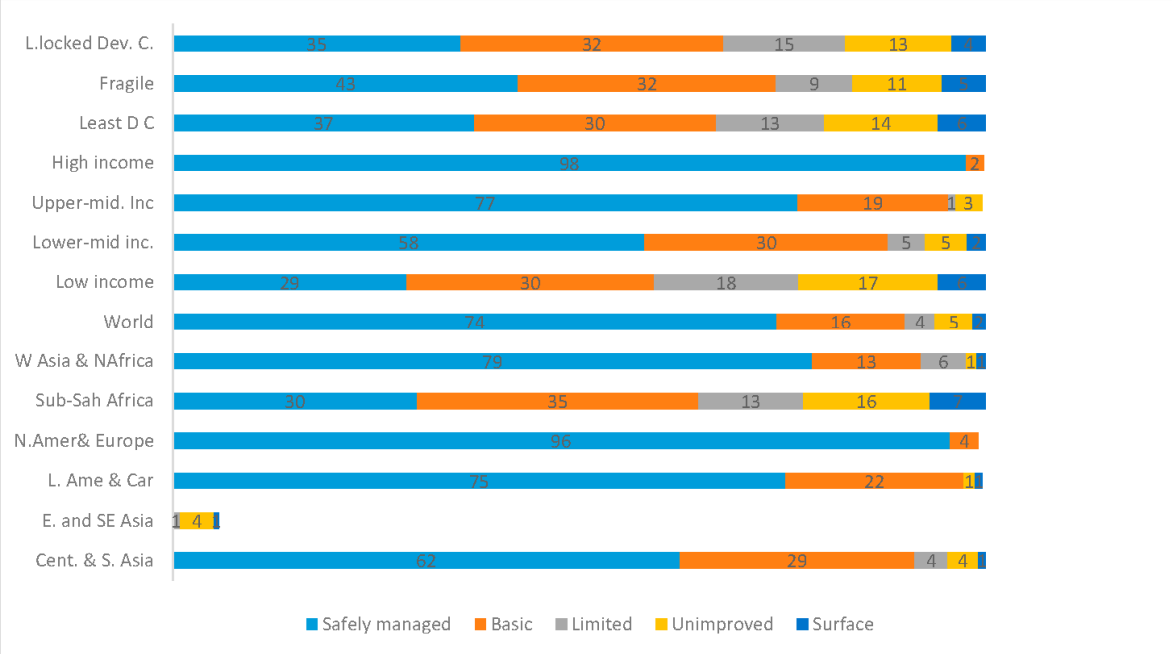

Figure A1. Disaggregated water security across regions and income groups in 2020.

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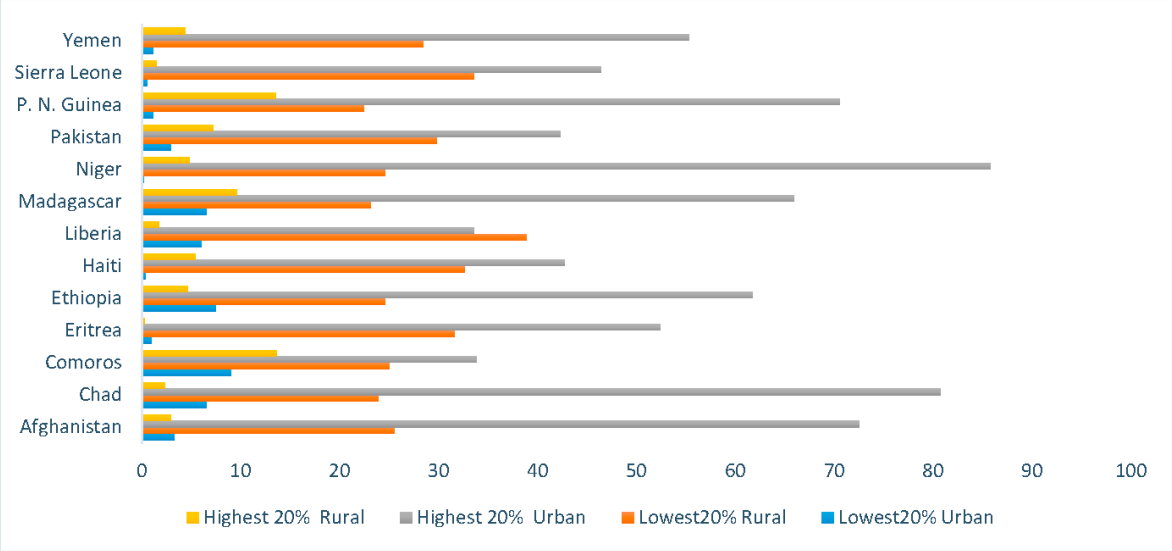

Figure A2. Comparison of wealth quartile of CWIC across rural and urban areas.

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