Examining the Influencing Factors of Access to Improved Water Sources in Sub-Saharan Africa

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ABSTRACT

This research aims to examine factors that influence access to improved water sources (AIWS) in sub-Saharan Africa (SSA) from 1990-2020. Even though extant literature on AIWS has focused on water quality, just a few have centered on urbanisation and other socio-economic indicators. This research, therefore, employed robust empirical methods to analyse the impact of urbanisation on AIWS in SSA. Economic growth, labor, climate change and human capital development were used as associated variables to explore urbanisation's influence on AIWS. The result of the Johansen cointegration test revealed a statistically significant relationship between AIWS and all the independent variables. Results of the Autoregressive Distributed lag (ARDL) long-run coefficients of urbanisation, economic growth, labor, and human capital development (HCD) showed a positive impact on AIWS. Furthermore, the result of the short-run coefficients revealed that a unit change in urbanisation, economic growth, labor, and HCD will increase AIWS by 14.270, 1.508, 1.225, and 0.647 units whereas CO_2 will decrease AIWS by 0.914 units respectively. The Granger causality result displays a unidirectional causality running from HCD and economic growth to AIWS. A bidirectional causality existed between urbanization and labor to AIWS. Moreover, no causal relationship existed between CO_2 and AIWS in SSA. This study thus, recommends that countries within SSA should formulate and implement feasible urban planning policies that focus on providing sustainable, accessible, and quality water sources for all. In addition, the provision of 21st century employment opportunities should be a propriety of authorities in SSA countries to enable citizens afford improved water, thereby, achieving the SDG 6 by 2030 and beyond.

Keywords: Access to improved water; Autoregressive distributed lag model; sub-Saharan Africa; Sustainable development goals; Urbanisation

INTRODUCTION

A fundamental human right that is vital to everyone's well-being is having access to safe water, but many individuals across the globe lack access to this essential resource (WHO/UNICEF JMP 2021). In the study of (Armah et al. 2018), an estimated 1.1 billion people do not have improved water sources, whereas 3 billion people living in poor countries need better sanitation facilities. The study further explained that globally, approximately 36% of deaths among children between the ages of 0 and 14 can be attributed to unhealthy or insufficient water supplies. According to (Prüss-Ustün et al. 2019), about 10,000 individuals die every day due to water-related ailments, and thousands more endure a variety of crippling conditions. Contagious drinking water illnesses like diarrhea, typhoid, and cholera are the leading triggers of diseases and deaths in undeveloped nations. However, (Mohammed et al. 2013) have reported that good water, sanitation, and hygiene standards have the potential to reduce at least nine percent of water-related infections worldwide and six percent of all deaths.

The International Drinking Water Supply and Sanitation Decade (1981 – 1990) was established in 1976 to offer recommendations for immediate response on programs to improve the quality and availability of potable water for urban and rural areas by 1990 (Mulenga et al. 2017). This sparked a dedication to expanding access to sanitation and water supplies, notably for those who are less privileged and without these facilities. In the year 2000, the Millennium Development Goals (MDGs) were introduced as a follow-up. Goal 7 of the MDGs, which focused on protecting the environment, called for halving the number of people without access to clean water and appropriate sanitary facilities (Sun et al. 2021), and the goal was to meet 75% of the population having access to better water sources. In 2010, the world's drinking water goal was achieved, giving 91% of the population access to better potable water, up from 76% in 1990 (Mulenga et al. 2017). By 2015, the Progress Report on Drinking Water, Sanitation, and Hygiene of the (WHO/UNICEF 2017) indicated that seventy-one percent of the world population used a safely managed drinking water service; that is, one on-site, accessible when needed and free from pollution. Then came the Sustainable Development Goals (SDGs) launched in 2015 of which goal 6 aims to provide everyone with adequate access to potable water by 2030 in order to overcome the discrepancies in access to water resources.

One of the regions with limited access to better water source coverage is SSA (WHO/UNICEF 2015). Although SSA's inhabitants doubled throughout the MDG era (1990–2015), the region only saw a 20% growth in the utilization of potable water sources. More importantly, water problems are still quite concerning as it leads to climate change, food crisis and social instability in the sub-region (Dos Santos et al. 2017). Concerns regarding the distribution and use of water resources, water infrastructure, inadequate management, and a lack of government effort to deal with the increasing water shortages in SSA are rising, which is a barrier to meeting the SGD 6 by 2030 (Cassivi et al. 2020).

From a socio-economic perspective, much scientific research on how urbanisation, economic growth, employment, human capital development, and climate change has not been conducted to stimulate the accessible nature of better water sources in SSA. However, bringing together data on these essential variables would be useful to policymakers at the national and regional levels. To aid in the assessment of the complicated, conflicting, and rapidly evolving social settings associated with evaluating improved water sources, a time series data analysis of SSA is conducted over the period 1990-2020 in this work. This research seeks to make the following significant contributions to the body of literature already in existence: First, this study employs a set of critical elements (urbanisation, economic growth, labor, human capital development, climate change) in exploring access to improved water sources in SSA. Most literature on access to improved water sources hovered around qualitative estimations centering on demographic characteristics of household access to improved water ignoring the real impact of other socioeconomic factors which could also influence residential quality water supply. Secondly, this current report presents estimations of robust methodologies such as the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Johansen cointegration to explore the nexus amid urbanisation, economic growth, labor, human capital development, climate change, and access to improved water sources. Recently developed models such as the ARDL and the granger causality tests are employed to estimate the equilibrium and causal path of the explanatory variables on AIWS and to avoid eminent issues associated with feeble conventional methodologies like the ordinary least square. This in-depth research will provide nations within SSA with policy initiatives on how to achieve access to safe water sources to achieve SDG 6 by 2030 and beyond.

MATERIALS AND METHODS

Data sources and variables

Annual time series data for SSA from 1990 to 2020 was used in the present research. This study used sub-Saharan Africa as the research setting due to its socioeconomic heterogeneity, centered on the exploitation of natural resources, particularly water. sub-Saharan Africa is one of the fastest growing regions with increasing urbanisation leading to high demand for potable water sources. Data used in this study were derived from the World bank Development Indicators (WDI). Following the argument of (Sun et al. 2021), urbanisation is among the forces that influence economic growth, and the evolution of urbanisation in SSA is a particularly fascinating development that has implications for the socioeconomic activities in various distinct regions. From 14.7% in 1960, urbanisation in SSA has increased tremendously to 41.3% in 2020 (WDI 2022) affecting the total demand for safely managed water resources, and this issue has received a great deal of attention in the scientific community, but not much has been done in the context of urbanisation and access to improved water sources in SSA. Considering the study's goal, urbanisation has been researched (Dos Santos et al. 2017; Armah et al. 2018) as a channel to boost economic growth and pieces of evidence derived were with mixed outcomes. Therefore, urbanisation (total urban population) is the major determinant adopted in this current study. Economic growth is adopted due to its ability to influence the development of economies, and it is measured with GDP per capita (constant 2015 US$). Labor, human capital development and climate change are used as control variables in this study. Scholars (Sun et al. 2021; Addae et al. 2022) have extensively discussed the interaction between water availability, human capital development, and climate change with varied approaches and evidence. Human capital development is proxied with the total literacy rate of adults (% of people aged 15 years and above). A total labor force within the age range of 15 to 64 is adopted to represent labor. Last, carbon emission (CO_2 kt) is chosen as a benchmark for climate change depending on the propensity of human activities that increase economic growth within the urban setting which eventually affects access to water resources. Other explanatory variables such as institutional quality and regional infrastructure disparities were not included due to insufficient data availability. Table 1 therefore shows the elements along with their respective units and sources.

Table 1: Definition of the observed variables

Variable	**Description /Unit**	**Source**
Improved water sources	Safely managed water source	WDI
Urbanization	Urban population (total)	WDI
Economic growth	GDP per capita (constant 2015 US$)	WDI
Labor	Total labor force (% of labor ages 15-64)	WDI
Human capital development	Total literacy rate of adults (% of people aged 15 years and above)	WDI
Climate change	CO_2 (kt)	WDI

Please note: WDI means World Development Indicators

Empirical model

The empirical research of (Dos Santos et al. 2017; Sun et al. 2021) served as the basis to explore the influence of urbanisation, economic growth, labor, human capital development, and climate change on access to improved water sources in a multivariate framework. As a result, the suggested function for access to improved water sources, which appears to be consistent with past research is:

$$AIWS_t = f\,(URB_t, GDP_t LABOR_t HCD_t, CO_{2t}) \qquad (1)$$

The covariates used in the research are defined as linear relationships of their corresponding values and subsequently converted into natural logarithms, which helps with econometric analyses and minimizes the problems of probable heteroscedasticity. Noteworthy is the discovery by (Addae and Kyere 2021) that elements in their logarithmic forms offer explicit elasticities that make explanations easier. According to (Sun et al. 2021), a model with a log-linear structure produces results that are coherent and reliable when compared to a model with a simple linear transformation. Thus, the modified multivariate function of having access to better water is defined as follows in a converted log-linear model with a time series classification:

$$lnAIWS_t=\beta_0 + \beta_1 lnURB_t + \beta_2 lnGDP_t + \beta_3 lnLABOR_t + \beta_4 lnHCD_t + \beta_5 lnCO_{2t} + \varepsilon_t \qquad (2)$$

where AIWS denotes access to improved water sources, URB, GDP, LABOR, HCD, and CO_2 signify urbanisation, economic growth, labor, human capital development, and carbon dioxide respectively; β_0

designates the constant term, $\beta_{1,\ldots,}\beta_5$ estimate the elasticities of URB with respect to GDP, LABOR, HCD, and CO_2; whiles t is the period of study (1990-2020), and ε is the error term.

Empirical econometric tests

The time series data is summoned to go through various phases before achieving the targeted study objective as indicated in Equation 2. Therefore, the applied statistical procedures are as follows:

(a) unit root tests by Augmented Dickey-Fuller (ADF, 1979) and Phillips-Perron (PP, 1990) which are robust to time-dependent series of serial correlation and heteroskedasticity were employed to confirm stationarity among the study variables since the fairly large time series data theoretically presupposes that the variables under study might possess a unit root (Sun et al. 2021). Notably, a regression analysis is performed to examine the properties of the series if the unit root tests reveal that the data series lacks a unit root. Nonetheless, the differenced test is used to establish that the series is stationary if it has a unit root. Consequently, a cointegration test can be performed when the elements are shown to be integrated in the same order.

(b) After running the unit root tests, the Johansen cointegration test is used to assess whether there is a long-term link between the relevant variables and to check the number of cointegration matrices (Ullah et al., 2018). The Johansen cointegration test is based on the Trace ($Trace^J$) and Max-Eigenvalue (Max^J). The tests $Trace^J$ and Max^J are mathematically computed as follows:

$Trace^J(c) = -N\sum_{i=c+1}^{k}\ln(1-\delta_i)$ (3)

$Max^J(c+1) = -Nln(1-\delta_{c+1})$ (4)

where N stands for the sample size; c stands for the cointegrating vector numbers in the proposition; δ represents the estimated value for the ith order, and a product of the matrix Π is the Eigenvalue. To compare the claims H_0: level $\Pi \leq c$ and H_1: level $\Pi > c$, the $Trace^J$ (c) test is used. Here, Max^J (c+1) is used to contrast the statements H_0: level $\Pi \leq c$ and H_1: level $\Pi > c+1$ (Ullah et al. 2018).

(c) To confirm the long-run interaction between urbanisation, economic growth, labor, human capital development, CO_2, and access to improved water sources, the study performed the Pesaran et al. (2001) ARDL bounds test. The preceding justifies the adoption of the ARDL model: (1) this model can estimate the short- and long-term connection, and it can be used for small data. (2) this method does not require the variables to be (0) or I (1).

(d) We used four residual diagnostic tests to assess the ARDL model's dependability and stability. To detect autocorrelation in the residuals, the autoregressive conditional heteroskedasticity (ARCH) and Breusch-Godfrey Serial Correlation Lagrange Multiplier tests are used. The Jarque-Bera test was performed to check the normal distribution of the series whereas the RESET test was conducted to check specification errors of the model.

(e) The ARDL series shows that the variables are in both short-run and long-run equilibrium, but does not specify the direction of causality. Consequently, the pairwise causal link is investigated using the Granger causality.

EMPIRICAL RESULTS AND DISCUSSION

This section of the research offers the findings and discusses the results in line with current studies and techniques discussed in the earlier sections. The presentation of the descriptive statistics, unit root tests, and ARDL findings will be based on a comparison with earlier research and the actual scenario of having access to safely managed water supplies.

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Descriptive statistics and correlation results

The descriptive statistics displayed in Table 2 include the characteristics of the data used in this investigation. According to the findings, economic growth (GDP) had the highest mean value (16.187) indicating its strength in the growth of SSA and its impact on access to improved water sources. This was followed by CO_2 (13.293); labor (12.588); urbanisation (12.45); human capital development (4.068); and access to improved water sources (2.960). The results of the correlation test showed a positive and significant connection between AIWS and the independent variables. This result seems to support erstwhile studies that urbanisation, economic growth, labor, human capital development and climate change stimulate access to improved water resources in SSA. Interestingly, all study variables recorded statistically significant and positive correlations with one another.

Table 2: Descriptive statistics and correlation results

Descriptive						
	AIWS	URB	GDP	LABOR	HCD	CO_2
Mean	2.960	12.453	16.187	12.588	4.068	13.293
Median	2.983	12.448	16.175	12.598	4.059	13.342
Maximum	3.407	13.058	16.725	12.973	4.188	13.642
Minimum	2.342	11.845	15.698	12.176	3.948	12.897
Std. Dev.	0.314	0.466	1.372	0.242	0.170	0.254
Skewness	-0.320	0.416	0.264	-0.077	0.616	-0.149
Kurtosis	2.035	1.801	1.477	1.348	2.046	1.557
Jarque-Bera	1.734	1.857	3.017	3.552	1.245	2.802
Observations	31	31	31	31	31	31
Correlation						
	AIWS	URB	GDP	LABOR	HCD	CO_2
AIWS	1					
URB	0.901	1				
GDP	0.972	0.873	1			
LABOR	0.924	0.930	0.987	1		
LIT	0.966	0.971	0.945	0.960	1	
CO_2	0.715	0.956	0.978	0.889	0.947	1

Unit root test

This research employed the ADF and PP unit root tests in the investigation. The results of the ADF and PP tests, shown in Table 3, mean that the variables used were non-stationary at the initial stage but thereafter became stationary (at first difference). All of the covariates' *p*-values at the level were higher than 0.05% ($p>0.05$), however, after the 1st difference, all the *p*-values of the unit root tests were less than 0.05%, indicating that the sampled parameters are espoused in first order I (1). These findings indicate that the Johansen cointegration approach is suitable for this research.

Table 3: Results of the unit root test

Variable	Level		First difference		Integration order
	ADF	PP	ADF	PP	
AIWS	-1.072 (0.71)	-4.925 (0.99)	-6.159 (0.00) *	-8.175 (0.00) *	I (1)
URB	1.043 (0.10)	-0.477 (0.88)	-4.113 (0.00) *	-2.909 (0.05) ***	I (1)
GDP	-1.367 (0.86)	0.052 (0.96)	-1.328 (0.00) *	0.052 (0.00) *	I (1)
LABOR	-4.542 (0.58)	-1.911 (0.52)	-4.926 (0.00) *	-2.397 (0.02) **	I (1)
HCD	-0.572 (0.86)	-2.397 (0.88)	-6.436 (0.00) *	-6.411 (0.00) **	I (1)
CO_2	-1.366 (0.58)	0.052 (0.96)	-5.024 (0.00) *	-5.024 (0.00) **	I (1)

*, **, and *** denote 1%, and 5%, and 10% significant levels

Results of the cointegration test

Based on the integration order of I (1), the hypothesis of cointegration is examined using the Johansen cointegration to ascertain if the variables for this study are cointegrated or not. The estimated results of Johansen's cointegration (Trace and Max-Eigen) tests are presented in Table 4. The trace statistics values are greater than the critical values at a 5% significant value for six (6) cointegrating vectors. Therefore, in the case of the trace statistics, the null hypothesis of H_0: $n = 0$, H_0: $n \leq 1$, H_0: $n \leq 2$, H_0: $n \leq 3$, H_0: $n \leq 4$, H_0: $n \leq 5$ are rejected in favor of the alternative hypothesis H_1: $n = 1$, H_1: $n = 2$, H_1: $n = 3$, H_1: $n = 4$, H_1: $n = 5$, H_1: $n = 6$. Consequently, the alternative hypothesis in the case of the Max-Eigen statistics (H_1: $n = 1$, H_1: $n = 2$, H_1: $n = 3$, H_1: $n = 4$, H_1: $n = 5$) is accepted over the null hypothesis of H_0: $n = 0$, H_0: $n \leq 1$, H_0: $n \leq 2$, H_0: $n \leq 3$, H_0: $n \leq 4$, H_0: $n \leq 5$ because the Max-Eigen statistics values are greater than the critical values at 5% significant value for five (5) cointegrating vectors. This result indicates the presence of cointegration relationships among the study variables which means that the employed variables together have long-run relationships.

Table 4: Johansen cointegration test

Johansen cointegration test using trace statistics						
Hypothesized no. of CE (s)	Null hypothesis	Alternative hypothesis	Eigenvalue	Trace statistic	.05% critical value	*p*-value
None*	H_0: $n = 0$	H_1: $n = 1$	0.711	118.389	95.754	0.001*
At most 1*	H_0: $n \leq 1$	H_1: $n = 2$	0.565	82.388	69.819	0.004*
At most 2*	H_0: $n \leq 2$	H_1: $n = 3$	0.525	58.237	47.856	0.003*
At most 3*	H_0: $n \leq 3$	H_1: $n = 4$	0.497	36.669	29.797	0.007 *
At most 4*	H_0: $n \leq 4$	H_1: $n = 5$	0.332	16.726	15.495	0.033**

At most 5*	H_0: $n \leq 5$	H_1: $n = 6$	0.159	5.046	3.842	0.025**
Johansen cointegration test using Max-Eigen statistics						
Hypothesized no. of CE (s)	Null hypothesis	Alternative hypothesis	Eigenvalue	Max-Eigen statistic	.05% critical value	*p*-value
None*	H_0: $n = 0$	H_1: $n = 1$	0.711	36.001	40.078	0.013**
At most 1*	H_0: $n \leq 1$	H_1: $n = 2$	0.565	24.151	33.877	0.045**
At most 2*	H_0: $n \leq 2$	H_1: $n = 3$	0.525	21.567	27.584	0.002*
At most 3*	H_0: $n \leq 3$	H_1: $n = 4$	0.497	19.944	21.131	0.073 ***
At most 4*	H_0: $n \leq 4$	H_1: $n = 5$	0.332	11.679	14.265	0.012**
At most 5	H_0: $n \leq 5$	H_1: $n = 6$	0.159	5.046	3.841	0.325

*, **, and *** denote 1%, and 5%, and 10% significant levels

Results of the ARDL estimation

The ARDL model was employed in this investigation since the prerequisite is that none of the variables is integrated with I (2). Therefore, the bounds test is used to further evaluate the cointegration between the dependent and independent variables (F-statistics) as shown in Table 5. The findings of this investigation demonstrate that k=5 was a suitable order for cointegration at the lag length, and the predicted value of F was above the upper critical bound of 1%. Therefore, the alternative hypothesis that a long-run integration is evident among the sampled parameters replaces the null hypothesis of the bound test of no cointegration.

The estimations of the ARDL model's short-run and long-run coefficients are reported in Table 6. Based on the model's significance and the theory of sustainable development, the deterministic term in the model was specified. In the short-run, URB, GDP, and HCD coefficients had a significant positive impact on AIWS, meaning that a unit change in URB, GDP, and HCD in SSA will increase AIWS by 0.857, 0.091, and 0.39 respectively. Thus, the noticeable impact of urbanisation on AIWS in the short-run implies that urban authorities in SSA countries are contributing to ensuring potable water for their populace; specifically, through urban planning with the provision of quality and adequate water. This outcome is supported by the assertion of (Agócsová and Chodasová 2021) that increased urbanisation results in the availability of cutting-edge technologies and knowledge to improve water resources for a variety of consumption reasons support this conclusion. Additionally, (Banerjee et al. 2022) described how the introduction of integrated water resources management in the urban cities of Singapore and Bengaluru, India, was aided by smart water metering and early flood warning technologies. On the contrary, In Fort Collins, Northern Colorado, (Heidari et al. 2021) performed an investigation into the effects of urban development on public water supply, and the results showed that urban areas with an informal settlement pattern are more susceptible to water problems with high severity, and time frame than urban areas with proper layouts.

In line with (Sun et al. 2021), the favorable correlation amid GDP and AIWS suggests that when income within the economies of SSA increase, there will be enough capital to finance projects and infrastructure for potable water supply. According to (Armah et al. 2018), the increase in access to improved water over their period of study in fifteen SSA nations was mainly accounted for by a rise in economic progress. Comparatively, the (OECD 2016) reported that economic expansion creates chances for development strategies, strengthens organizations for water governance, and provides funding for infrastructure investments, systems engineering, and technology related to water. (Zheng et al. 2018) found that economic growth contributes to appreciable levels of improved water supplies and use efficiency in China. Also, the result of this study revealed a substantial affiliation between HCD and AIWS. This evidence is in tandem with (Addae et al. 2022) who reported HCD's impact on water use efficiency in West Africa. This is an indication that as more people in the sub-region are being educated, they will learn diverse ways of abstracting and processing water in a more efficient ways.

Climate change negatively influenced AIWS (-0.055). This is an indication that as the emission of carbon dioxide increases resulting in the ozone layer depletion, distorting of rainfall is maximized. In addition, pollution of stormwater which drains into water bodies is enhanced when CO_2 increases leading to poor quality of water sources. This result supports the studies of (Cassivi et al. 2020) that climate change increases vulnerability to water stress, especially for the susceptible population who had limited coping strategies in Malawi.

The long-run estimates revealed a significant link between urbanisation and AIWS; that is, a unit change in urbanisation contributes to a 1.857 unit increase in AIWS in SSA. This outcome supports (WDI 2022) that about 41.4% of the urban population in SSA has access to safely managed water sources. Thus, in recent years, most countries in SSA such as Nigeria, Ghana, Rwanda, and Gabon, are staking their ascent on policies and interventions, as well as developing an economic engine that is highly attracting both local and multinational companies that are promoting investments in diverse portfolios of which residential development and industrialization are prime (Addae et al. 2022). In order to meet State of the Art urban planning, these investors are keen on ensuring the supply of quality and easy-to-access water for their customers while the target for SDG 6 is implemented. This finding supports (Mohammed et al. 2013) that about 42.5% of their sampled population in Ethiopia had access to piped water in their homes. For a sustainable supply of potable water, (Yu et al. 2018; Stoler et al. 2021) advocate for sustainable urban development that correlates with water resources management. Corresponding to the outcome of the short-run estimates, GDP and HCD had a substantial impact on AIWS in the long-run equilibrium. Interestingly, LABOR had a statistically significant and positive influence on AIWS. Thus, a unit change in LABOR increased AIWS in SSA by 1.225 units. The implication of the above result is that in the long-run, the surge in urbanisation, economic growth, development of human capital, and the creation of employment avenues will promote safely managed water resources across SSA. Harmoniously, the rate of adjustment in the error correction model (ECM) of the variables gives the impression that the covariates react to changes in the long-run equilibrium very quickly.

Table 5: Results of the short-run and long-run estimate of the ARDL model (dependent variable: AIWS)

Variable	Coefficient	t-statistic	*p*-value
Constant	-9.886	-0.392	0.000*
Short run estimate			
ΔURB	1.857	5.241	0.000*
ΔGDP	0.091	0.618	0.043**
ΔLABOR	0.074	0.095	0.937
ΔHCD	0.39	0.150	0.025**
ΔCO_2	-0.055	-0.376	0.011**
ECM	-0.195	5.038	0.000*
Long run estimate			
URB	14.270	0.220	0.028**
GDP	1.508	0.278	0.004*

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LABOR	1.225	0.085	0.002*
HCD	0.647	0.150	0.033**
CO_2	-0.914	-0.236	0.016**
R^2	0.997		
Adjusted R^2	0.996		
F-statistic	1029.595*		
Wald test		17.01 df (2, 22)	<0.00
Bound test		Low bound I (0)	High bound I (1)
F=4.7887*, K = 5	@10%	2.08	3
	@5%	2.39	3.38
	@1%	3.06	4.15

*, and ** denote 1%, and 5% significant levels

Diagnostic tests

Residual diagnostic tests were performed to check the adequacy and stability of the model using the Autoregressive conditional heteroskedasticity, Breusch-Godfrey serial correlation LM test, the Jarque-Bera normality test, and the Ramsey RESET test. As presented in Table 6, the diagnostic test results proved that the models in our study overcame serial correlation with 1.10 and a *p*-value of 0.37. The results of the Jarque-Bera test (18.06, *p*-value 0.11), the Heteroskedasticity tests (1.88, p-value 0.12), and the Ramsey RESET test (2.72, p-value 0.12) show that the parameters used are distributed evenly.

Table 6: Residual diagnostics test results

Diagnostic test	Statistic test	*p*-value
Breusch-Pagan-Godfrey Heteroskedasticity test	1.88 (F-stat)	0.12
Jarque Bera Normality test	18.06 (J-B stat)	0.11
Ramsey RESET test	2.72 (F-stat)	0.12
Residual Serial Correlation LM Tests	1.10 (F-stat)	0.37

Granger causality test

To test the direction of causality amid the study variables, the pairwise granger causality test was employed. The result of the causality test as presented in table 7 shows that the null hypothesis of no causality is rejected at 5% and 10% significant levels which assume that urbanization, economic growth, labor, and human capital development, cause access to enhanced water sources in SSA except climate change. That is, evidence of unidirectional causality from GDP→AIWS, and HCD→AIWS was witnessed. There is also evidence of bidirectional causality between URB↔AIWS, and LABOR↔AIWS. However, no causality was found between CO_2≠AIWS.

Table 7: Result of the Pairwise Granger causality test

Null hypothesis	*F*-statistic	*p*-value	Conclusion
URB does not Granger cause AIWS	2.45842	0.018**	URB↔AIWS
AIWS does not Granger cause URB	2.77745	0.083***	
GDP does not Granger cause AIWS	3.59456	0.044**	GDP→AIWS
AIWS does not Granger cause GDP	1.71438	0.202	
LABOR does not Granger cause AIWS	2.13581	0.014**	LABOR↔AIWS
AIWS does not Granger cause LABOR	1.05440	0.036**	
HCD does not Granger cause AIWS	2.93162	0.073***	HCD→AIWS
AIWS does not Granger cause HCD	1.02951	0.373	
CO_2 does not Granger cause AIWS	3.07688	0.465	CO_2≠AIWS
AIWS does not Granger cause CO_2	1.54505	0.235	

, and * denote 5%, and 10% significance levels

The result of the unidirectional causality running from economic growth to access to improve water sources suggests that the surge in economic development harnesses access to potable water supply in the case of SSA which supports (Armah et al. 2018) that economic growth has a robust association with access to improved water in their sampled SSA countries. They further recommended that a substantial increase in access to a potable water supply is very possible through infrastructure investment in the water supply sectors. The result of this study also shows that HCD positively links to access to improved water sources. A study by (Dhital et al. 2022) revealed a statistically significant relationship between education and access to a quality water supply. This is an indication that with the development of human capital, people can comprehend awareness of water resources management programs. This outcome also aligns with (Antunes and Martins 2020) who reported that HCD had a significant relationship with access to improved water in their sampled 111 countries globally. The evidence of bidirectional causality from urbanisation to access to improved water sources strengthens the report of (Sun et al. 2021) where a bi-direction was found between urbanisation and water resources availability. They buttressed their result that, more people migrate into the urban centers to enjoy better standards of living such as access to adequate and quality water supply. This phenomenon (access to adequate and quality water supply) in turn, leads to public health improvement, increases labor productivity, and reduces mortality resulting from water-related diseases in SSA. In addition, the bidirectional causality between labor and access to improved water sources as presented in Figure 1 is in agreement with (Jacques De et al. 2019) who assessed the impact of water access and sanitation on local economic development in the Sedibeng district of South Africa. This implies that, any changes in access to enhanced water supply in SSA could lead to positive or negative outcomes in labor. For instance, (Lawson et al. 2019) stated in their policy brief that people who are employed can afford adequate and quality water. On the other hand, people who have access to improved water sources, especially within their premises or neighborhood do not need to trek several hours before they could access a few liters of water (Zoungrana 2021). In the report of (Staneva et al. 2021), more people, especially women and children walk for about 30 minutes to search for water for the household during their study on child development impact of water scarcity in Ethiopia. Some of these women have to stay home to take care of their dependents who are suffering from water-related diseases, thus, reducing their productivity and leaving them poor as they cannot work.

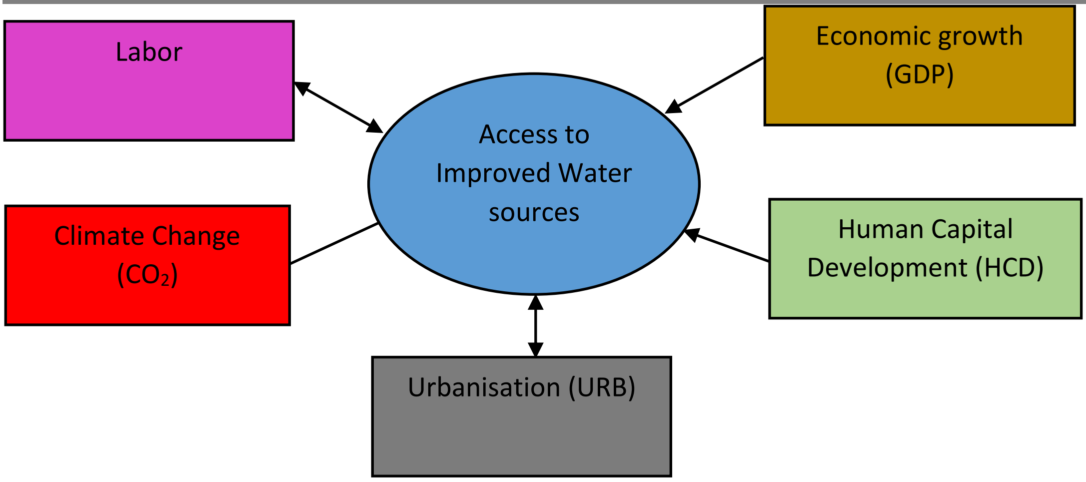

Fig. 1: Graphical representation of the causal relationship between the study variables

CONCLUSION, RECOMMENDATIONS, AND LIMITATIONS

Africa is ranked the second most populated continent in the world with a population of about 1.37 billion (17.4% of the total world population). By 2030, it is expected that there will be 1.68 billion people living in Africa. This growth in population will accelerate urbanisation and other socioeconomic activities, which will raise the need for adequate and high-quality water supplies for a variety of human needs. The purpose of this study was to look into the impact of urbanisation, economic growth, labor, human capital development, and climate change on access to improved water sources in SSA using annual data from 1990 to 2020. The study investigated the long-run cointegration, strength, and direction of the regressors on access to improved water sources in SSA using the ADF and PP unit root, Johansen cointegration, the ARDL model, and granger causality estimates.

The outcomes of the Johansen cointegration test demonstrated that the covariates had a long-term, statistically meaningful cointegration relationship. Findings of the long-run coefficients of labor, urbanisation, economic growth, and human capital development have a positive impact on access to improved water sources. The Granger causality shows unidirectional causality running economic growth and human capital development to access improved water sources. There was bidirectional causality from urbanization and labor to access to improved water sources. Moreover, no causal relationship existed between climate change and access to improved water sources in SSA. These facts show that the present socioeconomic activities will have a long-term substantial impact on access to better water sources in SSA.

Several significant policy implications are discussed in light of the findings of this study. Notably, the findings demonstrate a strong causal link between socioeconomic factors and access to improved water sources in SSA. To increase this accessibility and achieve SDG goal 6 by 2030, it is very essential to promote innovative ways of abstracting, and refining water for adequate supply in subsequent urban planning policies. Various activities that lead to economic growth such as strengthened trading and investment partnerships in SSA should be expanded to finance the water supply sectors. Since labor had a significant positive impact on access to better water sources in SSA, this study suggests that more employment opportunities should be made available in the SSA countries so that the citizens could earn substantial amounts of money to afford potable water. Every country within the SSA region should promote human capital development by making basic formal education free for all citizens. This would harness the citizen's knowledge of measures to provide potable water, and the need to manage the available water resources for efficient and sustainable use. Furthermore, to strengthen the efforts of countries within SSA to achieve SDG goal 6 by 2030, pre-emptive measures through a comprehensive set of policies must be taken to curtail water scarcity.

Although the present research has significant implications for policymaking, it also has some limitations which can be explored in future studies. The current study only explored the influence of urbanization, economic growth, labor, human capital development, and climate change on access to improved water sources in SSA. However, future studies may include institutional and governance factors provided data is available. In addition, future studies may perform a comparative study that will include other regions such as Asia and Europe. The research design for this study could not incorporate other important economic indicators such as water price and technological innovation which can influence access to improved water sources from a broader contextual perspective due to unavailability of data for SSA. In future, a relational variable such as foreign aid in the water sector could also be included to analyse its synergies and trade-offs on access to improved water sources in SSA and the rest of the world.

Conflict of Interest: this study declares no conflict of interest

Data Availability: Data for the study will be made available upon request.

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