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Determinants of access to potable water in South Africa: A household level analysis of wellbeing

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ABSTRACT
The United Nations Sustainable Development Goals (SDGs) targeted for 2030 are in jeopardy, with goal one of ending poverty and its associated poverty-related goals (SDGs 2–6) far from being realised. SDG 6, access to water, is an important measure of well-being for households, especially those below the poverty line. In South Africa, the discussion on service delivery has become an important issue as many households have limited access to essential services such as water, electricity, and education. The need to have a clear understanding of how far the country is from achieving this goal is therefore paramount, as it can help drive policy that can turn things around. The purpose of this study is to investigate the determinants of access to potable water at the household level. A multinomial logistic regression was estimated on the main water sources, with water inside the house used as the reference category. The results show that age, gender, marital status, population group, and income of the head of household are significant determinants of access to potable water. Household size and poverty status were also significant household characteristics determining whether the household would have access to potable water or not. The findings point to the need for a holistic approach in dealing with water access for households. Older female heads of households are more at risk, and deliberate policies that target these vulnerable groups will go a long way in achieving Sustainable Development Goal six. The study recommends targeted interventions that address both demographic and socioeconomic vulnerabilities. This paper contributes to scholarship by providing empirical household-level evidence on the factors shaping access to potable water in South Africa and deepening understanding of the links between service delivery, poverty, and wellbeing.

Keywords: Water access, Sustainable Development Goals, Household, poverty status, Multinomial regression

INTRODUCTION
The Sustainable Development Goals of the United Nations (SDGs) have availability and sustainable management of water and sanitation for all people by 2030 as the sixth goal (SDG6).[1] The possibility of achieving this goal, as well as the other SDGs, appears to be more and more unattainable. It is alleged

[1] United Nations, "The Sustainable Development Goals Report 2024," *United Nations*, 2024.

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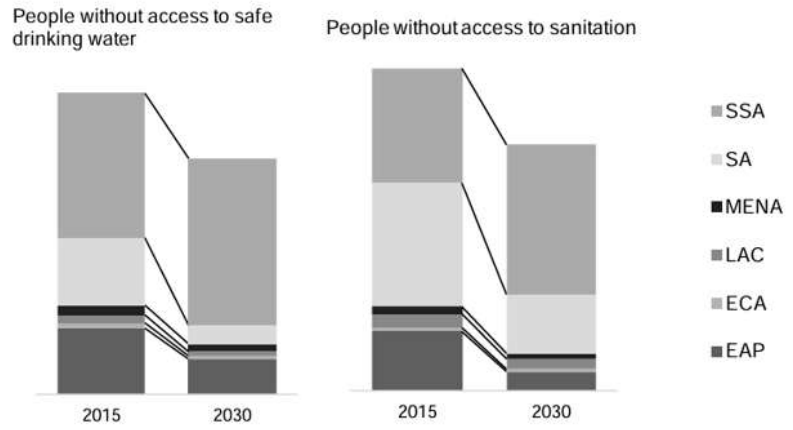
that billions of people still do not have access to safe drinking water.[2] The literature shows that the global effort to achieve the 17 goals by 2030 is not on track. The world is facing cascading and interlinked crises that are putting the 2030 global agenda in jeopardy.[3] The COVID -19 pandemic, the Ukraine war and the conflict in Gaza have all contributed to the existing conglomeration of problems that the global economy is grappling with. Other related consequences are not yet felt, for example, the impact of COVID-19 on 147 million school-going children who missed half of their in-person instruction between 2020 and 2021. These and other resultant effects and losses are not even considered, many of which could have been prevented through equitable and adequate access to water and sanitation. It is universally agreed that access to potable water is a fundamental human right. The fact that there still exist disparities based on socioeconomic circumstances is unacceptable. Households that are already grappling with a lack of necessities are also the most likely to have limited access to portable water. The global south has been considered the most severely hit region in terms of poverty and, hence, the related deprivations. The scourge is more pronounced among females, especially in rural areas.[4]

The former United Nations secretary general, Ban Ki-moon, stated that safe drinking water and adequate sanitation are crucial for poverty reduction, crucial for sustainable development and crucial for the achievement of the then Millennium Development Goals. It can be argued that this remains true for the Sustainable Development Goals as well. Water access and adequate sanitation are crucial for the achievement of the Sustainable Development Goals. This paper, therefore, assesses the determinants of access to clean water in South Africa using the general household survey data collected by Statistics South Africa in 2023.

LITERATURE REVIEW

Access to water has many aspects to it; it includes availability and ability of individuals and communities to obtain safe, reliable and sufficient water for drinking, sanitation and other daily home use. Thus, factors such as availability, affordability, quality, reliability and access are crucial for water security. Governments worldwide, particularly those in developing countries, are grappling with ensuring that their inhabitants have equal access to safe drinking water, an important service delivery agenda item.
Countries in the geographical tropics, many of which are least developed and poor, are struggling to contain the effects of diseases such as typhoid, cholera, skin infections and a host of other waterborne illnesses brought about by the lack of access to clean water and adequate sanitation.[5] As shown in the figure below, sub-Saharan African countries have the lowest access to safe drinking water compared to the East Asian Pacific and the situation is expected to worsen by the year 2030.

[2] UN-Water, "Water and Gender," United Nations, 2024, https://www.unwater.org/water-facts/water-and-gender#:~:text=Women and girls are disproportionately,we risk the 2030 Agenda.
[3] United Nations, "The Sustainable Development Goals Report 2022," *New York*, 2022.
[4] World Bank, "Gender-Dimensions-of-the-COVID-19-Pandemic," 2021.
[5] J. D. Sachs, "Tropical Underdevelopment," *CID Working Papers 57A,* (Center for International Development at Harvard University, 2001).



Note: EAP—East Asia and Pacific; ECA—Europe and Central Asia; LAC—Latin America and Caribbean; MENA—Middle East and North Africa; SA—South Asia; SSA—sub-Saharan Africa.

Source: Yusuf et al., "WIDER Working Paper 2023 / 123 Will Economic Growth Be Sufficient to End Global Poverty?[6]

South Africa, like many developing countries, is faced with challenges associated with inadequate water security.[7] The South African government has made considerable strides since the democratic dispensation in its goal of ensuring increased access to piped water and sanitation for millions of citizens in the country, mainly through its Reconstruction and Development Programme (RDP) housing scheme, amongst other measures, which also helped restore the dignity of many previously disadvantaged South Africans.[8] In recent years, the South African government has since amended its former policies to align with the SDGs and introduced the South African National Development Plan 2030 (NDP 2030), a national policy framework designed in alignment with the SDGs, which includes detailed policy objectives, one of which is to ensure that all South Africans have access to potable running water in their homes by the year 2030.[9]

Despite the considerable progress made in the 30 years of democracy, many inhabitants are still left behind, particularly those living in rural areas or slums in urban and peri-urban areas. Urbanisation has put immense pressure on the South African government, particularly provincial and local governments, who are faced with the mammoth task of restructuring towns to accommodate the ever-increasing migration of inhabitants seeking economic opportunities.[10]

The adverse effects of climate change have reversed many gains related to ensuring water security for numerous countries, including South Africa.[11]As one of the 30 driest countries in the world due to its arid climate, South Africa faces significant challenges in realising the water security objectives outlined in the National Development Plan. The El Niño climate pattern has profoundly impacted agricultural output, threatening food security and the livelihoods of households that depend on farming activities for their survival.[12] Furthermore, Meza et.al. assert that South Africa is grappling with deep

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[6] Arief A Yusuf et al., "WIDER Working Paper 2023 / 123 Will Economic Growth Be Sufficient to End Global Poverty ? New Projections of the UN Sustainable Development Goals," *WIDER Working Paper 2023/123*, no. October (2023).

[7] Amos Apraku et al., "Water Security in Rural Eastern Cape, SA: Interrogating the Impacts of Politics and Climate Change," *Scientific African* 19 (March 2023): e01493, https://doi.org/10.1016/j.sciaf.2022.e01493.

[8] David Hemson, "Water, Sanitation and Health: South Africa's Remaining and Existing Issues," *South African Health Review* 2016, no. 1 (2016): 25–34.

[9] National Planning Commission, "National Development Plan (2030)," *Department: The Presidency Republic of South Africa*, 2010.

[10] S. Dos Santos et al., "Urban Growth and Water Access in Sub-Saharan Africa: Progress, Challenges, and Emerging Research Directions," *Science of The Total Environment* 607–608 (December 2017): 497–508, https://doi.org/10.1016/j.scitotenv.2017.06.157.

[11] Dos Santos et al.,"Urban Growth and Water Access in Sub-Saharan Africa: Progress, Challenges, and Emerging Research Directions," al.

[12] Isabel Meza et al., "Drought Risk for Agricultural Systems in South Africa: Drivers, Spatial Patterns, and Implications for Drought Risk Management," *Science of The Total Environment* 799 (December 2021): 149505, https://doi.org/10.1016/j.scitotenv.2021.149505.

structural unemployment, which exacerbates already high levels of poverty.[13] In this context, agricultural activities have been a critical means of alleviating poverty, particularly for households in rural areas. To address the issue of drought and create rural employment, farming communities have benefited from irrigation schemes provided by the state.

The broader effects of water insecurity extend beyond agriculture, threatening not only food security but also the sustainability of a country's economy.[14] Limited access to safe drinking water has an effect on human productivity, which is likely to have an impact on a country's economic growth prospects.[15] The World Bank further alluded to economic growth being a 'thirsty business.' Shortages in water supply translate to reduced production and diminished growth.[16] The optimisation of water management and proper planning can contribute to improved welfare and sustainable economic growth. Impactful policy interventions required to address the vast challenges pertaining to access to potable water rely on a thorough understanding of the problem itself. As such, it is crucial to investigate, through existing literature, the possible determinants of potable water access to gain sufficient understanding and propose potential solutions. Despite the considerable research done on access to potable water, very few studies, if any, have investigated the determinants at the household level for poor and non-poor households.

A study conducted by Gurung et al., which looked at the determinants of access to improved drinking water and sanitation in India, found that household heads with lower levels of education, larger household sizes, living in urban areas and with limited rooms had better access to potable water.[17] Sikod, who conducted a study on the determinants of household choice of drinking water sources in Cameroon, found that the distance from the water source, coupled with factors such as household size and household expenditure, was significant in determining the choice of a potable water source.[18] Adil et al. investigated the determinants of access to safe drinking water and improved sanitation in Punjab, Pakistan, and found that a household's wealth status, access to media, the head of household's level of education and ethnicity were significantly associated with a household's access to safe drinking water.[19] Simelane et al. analysed the determinants of household access to safe drinking water in Eswatini using the Multiple Indicators Clusters Surveys for the years 2010 and 2014 and found that access to improved sources of drinking water was significantly dependent on the head of household's gender, age, wealth status and location.[20] Tshililo et al. examined the determinants of household water access and payment among poor urban households in a South African Township and found that household type and size had a significant effect on household water access and payment for water.[21] Other factors such as income, employment status, education, gender, potable water and satisfaction levels were not significant factors of water access. These studies inform the methodology section in deciding which variables to consider in the analysis.

[13] Meza et al., "Drought Risk for Agricultural Systems in South Africa: Drivers, Spatial Patterns, and Implications for Drought Risk Management,"

[14] Flannery Dolan et al., "Evaluating the Economic Impact of Water Scarcity in a Changing World," *Nature Communications* 12, no. 1 (March 26, 2021): 1915, https://doi.org/10.1038/s41467-021-22194-0.

[15] John Luke Gallup et al., "Geography and Economic Development" (Boston, 1999).

[16] World Bank, "Taking on Inequality, Poverty and Shared Prosperity," 2016.

[17] Rajiv Gurung et al., "Determinants of Access to Improved Drinking Water and Sanitation in India: Evidence from India Human Development Survey-II (IHDS)," *Water Policy* 25, no. 10 (October 1, 2023): 980–95, https://doi.org/10.2166/wp.2023.083.

[18] F Sikod, "Determinants of the Households' Choice of Drinking Water Source in Cameroon," *Journal of Sustainable Development in Africa* 14, no. 3 (2012): 86–97.

[19] Shahid Adil, Muhammad Nadeem, and Irfan Malik, "Exploring the Important Determinants of Access to Safe Drinking Water and Improved Sanitation in Punjab, Pakistan," *Water Policy* 23, no. 4 (August 1, 2021): 970–84, https://doi.org/10.2166/wp.2021.001.

[20] Maswati S. Simelane et al., "Determinants of Households' Access to Improved Drinking Water Sources: A Secondary Analysis of Eswatini 2010 and 2014 Multiple Indicator Cluster Surveys," *Advances in Public Health* 2020 (March 24, 2020): 1–9, https://doi.org/10.1155/2020/6758513.

[21] Fhulufhelo Phillis Tshililo et al., "Analysis of the Determinants of Household's Water Access and Payments among the Urban Poor. A Case Study of Diepsloot Township," *Physics and Chemistry of the Earth, Parts A/B/C* 127 (2022): 103183.

METHODOLOGY

The paper used data collected by Statistics South Africa in a General Household Survey (GHS) of 2023. These are annual data surveys that collect data from all nine provinces of South Africa, and the sampling is a representation of the population of each province. Table 1 shows the sample by province.

Table 1: Frequency of province representation

Province	Freq.	Percent	Cum.
Western Cape	1776	8.64	8.64
Eastern Cape	2732	13.30	21.94
Northern Cape	845	4.11	26.06
Free State	1293	6.29	32.35
KwaZulu-Natal	3307	16.10	48.44
North-West	1346	6.55	55.00
Gauteng	5253	25.57	80.56
Mpumalanga	1632	7.94	88.51
Limpopo	2361	11.49	100.00
Total	**20 545**	**100.00**	

Source: Authors' own compilation from GHS 2023

Table 1 shows the frequency for each province and hence represents the contribution of each province in the sample. This is basically a reflection of the population distribution in the country, with Gauteng having the biggest number of people and hence a higher representation of 25.57%. Table 2 also gives an image of the data representation by population group. According to the most recent census in South Africa, the majority of the country is African and hence the same is reflected in the sample.[22] Table 3 shows the interaction of gender and marital status.

Table 2: Frequency of population group/Race

Population group of household head	Freq.	Percent	Cum.
African/Black	17403	84.71	84.71
Coloured	1576	7.67	92.38
Indian/Asian	347	1.69	94.07
White	1219	5.93	100.00
Total	**20545**	**100.00**	
Source: Authors' own compilation			

The majority of the households are headed by males at 56.06%. This, however, shows that almost half of the sample is headed by females. Mostly, when a female is indicated as a head, it usually signals that a single parent is present. That can be confirmed by Table 3, which shows the marital status of the head of households as well. It shows that only 14.3% of the legally married are headed by females; thus, most of the legally married, 85.7%, indicate a male as the head of household.

Table 3: Marital status by gender

Marital Status	Sex of Household Head		
	Male	Female	Total
Legally married	5334 (85. 7%)	887 (14.3%)	6221
Living together like husband and wife/partners	1765 (81.5%)	400 (18.5%)	2165
Divorced	231 (32.6%)	477 (67.4%)	708
Separated, but still legally married	120 (38.5%)	192 (61.5%)	312

[22] STATSSA, "Census 2022 Statistical Release," 2022, https://census.statssa.gov.za/assets/documents/2022/P03014_Census_2022_Statistical_Release.pdf.

Widowed	577 (17.2%)	2785 (82.8%)	3362
Single, but have lived together with someone as husband/wife	271 (44.2%)	342 (55.8%)	613
Single and have never been married	3219 (44.9%)	3945 (55.1%)	7164
Total	**11517 (56%)**	**9028 (43%)**	**20545**

Table 3 also shows that the majority of the divorced, separated and widowed are the ones who indicated female as head of household. This shows an increase in single-parent female-headed households.[23] These findings reflect cultural and societal dynamics in South Africa, where traditional gender roles often place men as heads of households. However, the high percentage of divorced and widowed women suggests evolving social structures, where women may increasingly experience independence or face challenges related to widowhood.[24]

Poverty rates were calculated using the 2022 poverty lines, and the upper-bound poverty rates for the sample are reported in Table 4. Based on the upper-bound poverty line, it shows that 45% of the sampled households were below the poverty line. Many studies have looked at the determinants of poverty in South Africa, but not many have looked at what poverty is influencing.[25] Thus, this variable will be one of the determinants of water access.

Table 4: Poverty rates based on the upper-bound poverty line

	Freq.	**Percent**	**Cum.**
Non poor	11155	54.30	54.30
Poor	9390	45.70	100.00
Total	**20545**	**100.00**	

Model Specification

The objective of the paper is to assess the determinants of water access for households. The paper utilises the 2023 GHS data on the main sources of water for the households in different categories. The information has been recategorized into 5 main categories as reported in Table 6. Based on these 5 categories and the main water sources being the dependent variable, a Multinomial Logistic Regression (MLR) is specified to model the 5 main water sources and investigate the determinants that explain the odds of a household getting water from any of these sources.

Table 6: Main water sources

Main sources of water categorized	**Freq.**	**Percent**	**Cum.**
Pipe and tap in-house	8407	40.92	40.92
pipe and tap on site	6334	30.83	71.75
Borehole and tank	1295	6.30	78.05
Public clean sources	3672	17.87	95.93
Unclean sources	837	4.07	100.00
Total	**20545**	**100.00**	

An MLR is suited to model a categorical dependent variable with more than two categories. Where only two categories are involved, a binary Logistic regression is appropriate. An MLR can use

[23] Daniela Casale and Dorrit Posel, "Gender Inequality and the COVID-19 Crisis: Evidence from a Large National Survey during South Africa's Lockdown," *Research in Social Stratification and Mobility* 71 (February 2021): 100569, https://doi.org/10.1016/j.rssm.2020.100569.

[24] Victor Sulla and Precious Zikhali, "Overcoming Poverty and Inequality in South Africa: An Assessment of Drivers, Constraints and Opportunities" (The World Bank, 2018).

[25] Tshediso Joseph Sekhampu, "Determinants of Poverty in a South African Township," *Journal of Social Sciences* 34, no. 2 (February 9, 2013): 145–53, https://doi.org/10.1080/09718923.2013.11893126.

both factors and covariates as independent variables, just like in a logistic regression. It assumes that the odds ratios of any two categories are independent of all other response categories. As a form of linear regression, an MLR uses a linear function $f(k,i)$ to predict the probability that observation i has outcomes k of the following form,

$$f(k,i) = \beta_{0,k} + \beta_{1,k}x_{1,i} + \beta_2 x_{2,i} + \cdots + \beta_{M,k}x_{M,i,} \quad \ldots \quad 1$$

Where, $\beta_{m,k}$ is a regression coefficient associated with the mth independent variable and kth outcome. Just as in Logistic Regression, the coefficient and explanatory or independent variable are grouped in size of M+1 so that the function can easily be expressed as

$$f(k,i) = \beta_k * x_i \qquad \ldots 2$$

Where β_k is a set of regression coefficients associated with outcome k and x_i being a row vector is a set of explanatory variables associated with observation i. Thus, for a possible K outcome, running K independent binary regressions in which one is a reference and then another K-1 regression against the reference regression. So if K outcome is chosen as the reference, then the K-1 regression equations are:

$$\boldsymbol{ln}\frac{Pr(Y_i = k)}{Pr(Y_i = K)} = \beta_k * x_i\,, k < K \ \ldots . \qquad 3$$

Equation 3 is called an additive log ratio transform. If both sides of equation 3 are exponentiated to solve for probabilities, we get

$$Pr(Y_i = k) = Pr(Y_i = K)^{e^{\beta_k * x_i}}, \quad k < K \quad \ldots 4$$

And using the fact that all K of the probabilities must sum up to 1 then we end up with

$$Pr(Y_i = k) = 1 - \sum_{j=1}^{K-1} \Pr(Y_i = j) = 1 - \sum_{j=1}^{K-1} \Pr(Y_i = K)\ e^{\beta_j * x_i} \rightarrow \Pr(Y_i = K)$$
$$= \frac{1}{1 - \sum_{J-1}^{K-1} e^{\beta_j * x_i}} \quad \ldots . 5$$

Thus, we use equation 5 to find other probabilities

$$\Pr(Y_i = k) = \frac{e^{\beta_k * x_i}}{1 - \sum_{J-1}^{K-1} e^{\beta_j * x_i}} \ , k < K \quad \ldots . . \ 6$$

PRESENTATION OF RESULTS AND DISCUSSION

Table 7 depicts the multinomial logistic regression where the results for the four dependent variables, namely pipe and tap onsite, borehole and tank, public clean sources and unclean sources, are discussed with the pipe and tap in-house as the base model.

Age and access to water

The first variable was age. The results of the coefficient indicate that as the age of the head of household increases, they are less likely to have access to water onsite (-.006) and through communal sources (-.002) relative to having access to water inside the house, which is the reference model. Additionally, the older the head of household, the more likely they will rely on borehole and tank water (.014) as well as unclean water sources such as water from streams, dams or rivers (.01). The odds ratios indicate that with each additional year of age, the odds of having access to water on-site and through communal sources decrease by 0.55% and 0.3% respectively. On the contrary, the odds increase for using borehole/tank and unclean sources, suggesting that older household heads are more likely to rely on these alternative sources compared to having water inside the house. The findings are in line with the expectation that older household heads may be residing in rural areas where infrastructure may be lacking and may have no other choice but to use borehole/tank water sources, as well as unclean water

sources from streams and rivers.[26] The p-values show that there's a strong statistically significant relationship between the age of the head of household and access to various water sources, where the coefficients for the four models have p-values of less than 0.01. These results demonstrate that age significantly impacts the type of water source used, and this may also indicate the vulnerability of older people as regards access to services.[27]

Income and access to portable water sources

The second variable was the income of the heads of household. The results revealed households with higher incomes are more likely to access piped tap water inside the house as depicted by the negative coefficients for pipe and tap onsite (-.581), borehole and tank (-.628), communal sources (-.748) and unclean sources (-.898). These results therefore suggest that as the income of the head of household increases, they are more likely to have access to tap water inside the house as opposed to the other sources. Water in the house is the most desirable source, and hence it is expected that the better off people become, the more likely they will opt for pipe and tap water inside. Having water in the house is an indication of better living conditions.[28] The results of the p-value also show that there is a statistically significant relationship between the head of household income and access to the various water sources under observation: pipe and tap water onsite (0.00), borehole/tank (0.00), communal sources (0.00) and unclean sources (0.00). The fact that income is statistically significant is not surprising, as income is linked to many aspects of well-being. Numerous studies have found income to be a significant determinant of access to portable water, health and poverty.[29]

Household size and access to portable water

For household size, the results indicate that as the household size increases, households are less likely to access piped tap water inside the house. This is reflected in the positive coefficients for pipe and tap onsite (.069), borehole and tank (.061), communal sources (.082) and unclean sources (.176) for models 1 to 4, respectively, as shown in Table 7. The odds ratio for household size is 1.0624 for the water onsite model, 1.085 for the borehole and tank model, 1.085 for the communal sources model, and for the unclean sources model, the odds are 1.192. These results, therefore, imply that as the household size increases, the likelihood of relying on these alternative sources also increases for their water needs.

Thus, moving away from the most preferred position of having water in the house. This is an indication that the bigger the household, the higher the cost for all the competing needs of the household and hence the higher the likelihood for the household to be faced with the difficult decision to trade off water needs for other pressing needs. The odds ratios confirm that for each additional household member, the odds of using water on-site compared to water in-house increase; the odds for all the other models are all higher as the household size increases. This is in agreement with studies that have found household size as an important determinant of household wellbeing.[30] The results of the p-value also show that there is a statistically significant relationship between household size and access to the various water sources. Table 7 provides the following p-values, pipe and tap water onsite (p-value <0.00),

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[26] Ademola Jegede and Pumzile Shikwambane, "Water 'Apartheid' and the Significance of Human Rights Principles of Affirmative Action in South Africa," *Water* 13, no. 8 (April 16, 2021): 1104, https://doi.org/10.3390/w13081104.

[27] UNDESA, "Income Poverty in Old Age: An Emerging Development Priority," 2017, http://www.un.org/esa/socdev/ageing/documents/PovertyIssuePaperAgeing.pdf.

[28] Prosper Bazaanah and Raesibe A. Mothapo, "Sustainability of Drinking Water and Sanitation Delivery Systems in Rural Communities of the Lepelle Nkumpi Local Municipality, South Africa," *Environment, Development and Sustainability* 26, no. 6 (April 11, 2023): 14223–55, https://doi.org/10.1007/s10668-023-03190-4; OPHI, *Global Multidimensional Poverty Index 2018 : The Most Detailed Picture To Date of the World's Poorest People*, 2nd ed. (Oxford, UK: Oxford Poverty and Human Development Initiative (OPHI), 2018).

[29] J. Marchand and T. Smeeding, "Poverty and Aging," in *Handbook of the Economics of Population Aging.*, vol. 1 (Elsevier B.V., 2016), 905–50, https://doi.org/10.1016/bs.hespa.2016.09.004; Chase Sackett, Sara Goldrick-Rab, and Katharine Broton, "Addressing Housing Insecurity and Living Costs in Higher Education," *US Department of Housing and Urban Development, Office of Public Development and Research*, 2016; Ada Jansen et al., "Measurements and Determinants of Multifaceted Poverty in South Africa," *Development Southern Africa* 32, no. 2 (March 4, 2015): 151–69, https://doi.org/10.1080/0376835X.2014.984377.

[30] Luc Armand Totouom Fotue and Fondo Sikod, "Determinants of the Households' Choice of Drinking Water Source in Cameroon," *Journal of Sustainable Development in Africa* 14, no. 3 (2012): 86–97; Gurung et al., "Determinants of Access to Improved Drinking Water and Sanitation in India: Evidence from India Human Development Survey-II (IHDS)."

borehole/tank (p-value<0.001), communal sources (p-value<0.00) and unclean sources (0.00). These findings suggest that household size has a significant effect on water access, with larger households more likely to rely on non-piped water source alternatives.

Table 7: Multinomial logistic regression results

Base Model: Tap and pipe in-house	**Model 1: Pipe and tap on site**				**Model 2: Borehole and tank**				**Model 3: Public clean Sources**				**Model 4: Unclean Sources**			
Variable	Beta	Odds ratio	t-value	P-value	Beta	Odds ratio	t-value	P-value	Beta	Odds ratio	t-value	P-value	Beta	Odds ratio	t-value	P-value
Age head of household	-.006	0.9945	-3.75	.00***	.014	1.014	5.99	.00***	-.002	0.997	-1.23	.221	.01	1.010	3.34	.001***
log income	-.581	0.5596	-21.2	.00***	-.628	0.533	-13.4	.00***	-.748	0.4733	-22.9	.00***	-.898	0.407	-15.0	.00***
Household size	.069	1.0709	6.37	.00***	.061	1.0624	3.43	.001***	.082	1.085	6.46	.00***	.176	1.192	9.37	.00***
Gender	0		.	.	0		.	.	0		.	.	0		.	.
Female	-.139	0.8702	-3.15	.002***	-.088	0.915	-1.15	.248	-.137	0.872	-2.64	.008***	.091	1.094	0.95	.342
Marital status	0		.	.00***	0		.	.	0		.	.	0		.	.
Living together as husband and wife	.712	2.038	10.46	.00***	-.691	0.5011	-4.49	.00***	.494	1.639	6.15	.00***	.204	1.226	1.36	.173
Divorced	-.279	0.756	-2.42	.016**	-.805	0.447	-3.93	.00***	-.41	0.663	-2.98	.003***	-1.302	0.272	-3.84	.00***
Separated, but still married	-.053	0.948	-0.35	.728	-.286	0.751	-1.19	.234	-.121	0885	-0.69	.493	-.823	0.439	-2.15	.032**
Widowed	.184	1.202	2.67	.008***	.004	1.003	0.04	.972	.17	1.185	2.14	.032**	.244	1.275	1.90	.058*
Single, but have lived with someone	.399	1.491	3.61	.00***	-1.144	0.318	-4.21	.00***	.246	1.278	1.91	.056*	-.884	0.413	-2.80	.005***
Single and have never married	.149	1.160	2.71	.007***	-.417	0.659	-4.53	.00***	-.051	0.949	-0.79	.427	-.361	0.697	-3.06	.002***
Population group	0		.	.	0		.	.	0		.	.	0		.	.
Coloured	-1.76	0.171	-22.0	.00***	-3.79	0.022	-9.22	.00***	-2.275	0.102	-18.19	.00***	-4.417	0.012	-6.22	.00***
Indian/Asian	-2.68	0.068	-9.66	.00***	-3.93	0.019	-3.92	.00***	-2.935	0.053	-7.02	.00***	-2.43	0.088	-3.38	.001***
White	-3.33	0.035	-13.4	.00***	-1.13	0.320	-6.62	.00***	-1.356	0.2577	-9.56	.00***	-1.56	0.210	-4.26	.00***
base Nonpoor	0		.	.	0		.	.	0		.	.	0		.	.
Poor	-.123	0.8840	-2.13	.033**	.007	1.007	0.07	.941	.013	1.013	0.20	.844	.473	1.604	3.81	.00***
Constant	5.02	151.64	19.78	.00***	3.186	24.18	7.51	.00***	5.683	293.86	19.12	.00***	4.184	64.62	8.02	.00***
Mean dependent var 2.130 SD dependent var 1.238, Pseudo r-squared 0.110, Number of observations: 20270, Chi-square 5997.576, Prob > chi2 0.000, Akaike crit. (AIC) 48447.842, Bayesian crit. (BIC)48922.856 *** *p<.01, ** p<.05, * p<.1*																

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Gender of head of household and access to portable water

The results for the gender variable, where the male categorical variable was the reference category, reveal that females are significantly less likely than males to have access to water using the various water sources under investigation as indicated by the negative coefficients; tap on site of -.0139, -.088 for borehole or tank and -.137 for communal sources, compared to having a tap inside the house. On the contrary, female household heads were found to be more likely to use water from streams and rivers, as indicated by a positive coefficient for access to unclean water sources (.910). These results indicate their vulnerability to water insecurity. Additionally, females have about 0.870 lower odds of having access to tap water on-site, 0.915 lower odds of having access to water through boreholes or tanks and for communal sources, the odds were 0.915 lower. Conversely, females are 9.4% more likely to use unclean water sources than males. Lastly, the findings on the p-values reveal that the gender difference is statistically significant for tap on-site ($p = 0.002$) and communal sources ($p = 0.008$), but not significant for borehole/tank ($p = 0.248$) and unclean sources ($p = 0.342$). These result indicates that gender remains an important predictor of access to portable water. It also shows that females are more likely to rely on unclean sources than male headed households.

Marital status and access to water

The results for the marital status have the legally married category is specified as the reference group for the marital status variable. The results indicate that those who are living together as husband and wife are significantly more likely than those who are married to have access to water from a tap on site, through communal sources and unclean sources, compared to having a tap inside the house, as shown by the positive coefficients of 0.712, 0.494 and 0.204, respectively. The opposite is the case for access through a borehole and tank (-0.691), implying that those who are living together are less likely to use a borehole and tank. Furthermore, individuals living together as husband and wife have higher odds of accessing water via a tap on site (odds ratio = 1.639), communal sources (odds ratio = 1.226), and unclean sources, relative to the reference group. Conversely, they are less likely to access a borehole or a tank. The results of the p-values confirm that all the coefficients are statistically significant. Only the unclean sources coefficient is not statistically significant with a p-value of 0.173.

The results for those who are divorced show that this group has a low likelihood of accessing water through a tap onsite, through a borehole or tank, through communal sources and unclean sources, as shown by the negative coefficients of -0.279, -0.805, -0.41 and -1.302, respectively. This implies that the well-being of the divorced is slightly better as they have a better chance of having water in the house. The odds ratios inidcate that divorced individuals have a lower likelihood of accessing water through a tap onsite (0.756 odds ratio), a borehole or tank, and communal sources (0.663 odds ratio). They are also 72.8% less likely to access water through unclean sources, relative to the reference group. The p-values indicate that these results are statistically significant. for borehole or tank ($p < 0.00$), communal sources ($p <0.003$) and unclean sources ($p<0.00$), but for taps on site, the coefficient was not statistically significant with a p-value of 0.16. These results are in line with studies that have found the divorced to be well off compared to other marital statuses, only falling behind the legally married.[31]

Individuals who are separated but still married, just as those who are divorced, were found to be

[31] Steven Henry Dunga, "A Gender and Marital Status Analysis of Household Income in a Low-Income Township," *Studia Universitatis Babeș-Bolyai Oeconomica* 62, no. 1 (2017): 20–30, https://doi.org/10.1515/subboec-2017-0002; Jabulile Lindiwe Makhalima, "An Analysis of Poverty in Households Headed by Millennials in South Africa," *International Journal of Economics and Financial Issues* 12, no. 6 (November 23, 2022): 38–44, https://doi.org/10.32479/ijefi.13504; Sarah Dickin and Sara Gabrielsson, "Inequalities in Water, Sanitation and Hygiene: Challenges and Opportunities for Measurement and Monitoring," *Water Security* 20 (December 2023): 100143, https://doi.org/10.1016/j.wasec.2023.100143.;Christelle Liversage, Marié P Wissing, and Lusilda Schutte, "Promotion of Well-Being in Work and Interpersonal Relationships: A Scoping Review of Goals and Meaning Interventions," *International Journal of Wellbeing* 13, no. 3 (2023).

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significantly less likely to access water through the various water sources (tap on site, borehole, communal, or unclean sources) compared to having access inside the house. The odds ratios indicate that these households have 5.2% lower odds of accessing water onsite, a 24.9% lower likelihood of accessing water through a borehole or tank, 11.5% lower likelihood through communal sources and a 56.1% lower likelihood of accessing water from unclean sources. The p-values are not significant except for unclean sources. These results suggest that individuals who are separated but legally married may still benefit from the economic and social advantages associated with marital status, thereby improving their well-being and their ability to access potable water.[32]

Water access in the case of the widowed sample shows that they are generally more likely to access water through the various sources as opposed to having water inside the house, as indicated by the positive coefficients of 0.184 for tap water onsite, 0.004 for borehole or tank, 0.17 for communal sources and 0.244 for unclean sources. The results of the odds ratios further suggest that the widowed are 20% more likely to access a tap onsite, almost equally likely to use a borehole or tank, 18.5% likely to access water through communal sources onsite and 27.5% more likely to use unclean sources. The p-values show that these results are statistically significant for taps on site (p=0.008) and communal sources (p= 0.032), while the results for unclean sources (p =0.058) are marginally significant, and those for borehole or tank (p = 0.972) are not significant. The results for those who are single but have lived with someone show that this group has a higher probability of accessing water onsite (coefficient=0.399) and from communal sources (coefficient=0.246), with the odds ratios showing that these respondents are 49.1% more likely to access water through a tap onsite and 27.8% more likely to access water through communal sources. Contrarily, this group is less likely to access water through a borehole or tank (coefficient= -1.144) and unclean sources (coefficient= -0.884), with the odds ratios showing a 68.2% lower likelihood for borehole or tank, and a 58.7% lower likelihood for unclean sources. The results of the p-values show a statistical significance for tap water onsite and borehole or tank with p-values of 0.00 for both water sources (p= 0.005) for unclean sources, while the results for communal sources were found to be marginally significant with a p-value of 0.056. The results for those who are single and never married reveal that this group is less likely to access water using, as shown by a negative coefficient for boreholes or tanks at -0.417; -0.051 for communal sources, and -0.361 for unclean sources. Contrarily, respondents in this group had a higher probability of accessing water onsite as opposed to water inside the house. The results of the odds ratio are confirmatory of these trends, with single individuals being 16% more likely to access water onsite, 34.1 less likely to access water through boreholes or tanks, 5.1% less likely to use communal sources, and 30.3% less likely to use unclean sources. The p-values indicate that the differences in water access are statistically significant for tap onsite (p=0.007), borehole (p=0.00), and unclean (p=0.002), while communal sources are not significant (p=0.427).

Population Group

Population group was the next variable under observation, with the African categorical variable taking the place of the constant. The results of the coefficients show that the Coloured racial group were found to be less likely to have access to water onsite (-1.764), through boreholes or tanks (-3.791), using communal sources (-2.275) and unclean sources (-4.417). The results of the odds ratio further assert these findings, showing that Coloureds are 83% less likely to use water from a tap onsite, 97.8% less likely to use a borehole or tank for their water needs, 89.8% less likely to use water from communal sources, and 98.8% less likely to use water from unclean sources. The p-values for all sources (tap onsite, boreholes or tank, communal sources, and unclean sources) are highly significant, with a p-value of 0.00 across all these water sources. The results for the Indian racial group are similar to those for the Coloured group, indicating a lower likelihood of accessing water from the various water sources compared to the base variable. The logit coefficients for the Indian group are negative across all categories, confirming a negative association relative to the reference category. The results of the odds ratio provide a clearer interpretation of these effects. Indian household heads are 93.2% less likely to use water from a tap onsite, 98.1% less likely to use a borehole or tank, 94.7% less likely to use water from communal

[32] Dunga, "A Gender And Marital Status Analysis Of Household Income In A Low-Income Township."

sources, and 91.2% less likely to use water from unclean sources. These differences are statistically significant (p=0.00 for tap onsite, boreholes or tank, communal sources, and p=0.001 for unclean sources). The last racial group was the white racial group, also exhibiting similar findings to those of Coloured and Indian respondents. The coefficient results show that the white racial group have a low likelihood of using water from a tap onsite (-3.335), borehole or tank (-1.137), through communal sources (-1.356) and unclean sources (-1.56). The results of the odds ratios reveal that the white racial group 96.5% is less likely to access tap water onsite, 68% less likely to access water through a borehole, 74.2% less likely to access water through communal sources and 79% less likely to access water from unclean sources The p-values are highly significant across all the water sources under investigation. Taken together, these patterns suggest structural differences in service provision rather than behavioural choice. These findings reflect the enduring legacy of spatial apartheid in infrastructure provision, which continues to shape water access across previously disadvantaged communities in South Africa.

Poverty Status

The final independent variable regarding water access on-site is poverty status. The non-poor categorical variable took the place of the constant. The results reveal that poor households are less likely to have access to water from a tap onsite (coefficient=-0.123) compared to their non-poor counterparts. This is consistent with the multidimensional nature of poverty, where limited income restricts access to basic services such as safe water. On the other hand, poor households have a higher likelihood of accessing water through a borehole or tank (coefficient=0.007), from communal sources (coefficient=0.013), or unclean sources (coefficient=0.473). This is further asserted by the odds ratio, where the odds of having access to water onsite are 11% lower for poor households. Furthermore, poor households are 0.7% more likely to use a borehole or tank, which is not too far off from that of non-poor households, 1.3% more likely to use communal sources and 60.4% more likely to use unclean sources. The results of the p-values show that the difference in access by poor households for tap water onsite (p=0.033) and unclean sources (p=0.00) is statistically significant, while the p-values for borehole or tank (p=0.00) and communal sources (p=0.844) are insignificant. These findings emphasise the close link between poverty and inadequate access to safe water.

RECOMMENDATIONS

From the findings and discussion, it is recommended that employment and wage policies relating to housing benefits need to be revised for increased access to piped housing. Gender disparities also emerge, with female-headed households being more likely to use unclean water sources. Various studies have highlighted the plight of females regarding water access. The government needs to be intentional in its efforts to improve access to water, as inadequate access increases vulnerability to gender-based violence and femicide, with the burden of household water collection often falling on women. Furthermore, marital status influences water access, with married individuals generally having better access to water through piped systems, whereas divorced and separated individuals are less likely to use these sources. The findings also highlight racial and poverty-related disparities, with non-white and poorer households being more likely to rely on less reliable water sources, underscoring the intersection of socio-economic factors in water access.

CONCLUSION

Access to water is an important indicator of the extent to which the SDGs will be achieved or missed by 2030. Using the different water sources as captured in the GHS of 2022, it is clear that a significant percentage of households are still left behind. The results from the multinomial logistic regression analysis provide valuable insights into the factors influencing household access to different types of water sources. The study concludes that household-level characteristics such as age, income, household size, gender, marital status, population group, and poverty status collectively play significant roles in determining how households access water. Older household heads are more likely to rely on alternative water sources such as boreholes and unclean sources, while younger individuals tend to have better access to in-house piped water. These findings are reflective of the disparities endured by the elderly

who may be residing in rural areas, mostly characterised by inadequate infrastructure. Though policies on housing are aimed at providing adequate housing, particularly for the elderly, housing reforms need to reconsider the timeframe for implementation. The study also deduced that households with higher incomes are more likely to have water inside the house, reflecting better living conditions, while larger households face greater challenges in accessing in-house piped water and may rely more on onsite or alternative sources. Such findings are indicative of the burden faced by the household heads who may be the sole breadwinners and whose earnings may only be enough for subsistence. These results suggest that efforts to improve water access need to address these intersecting social and economic factors to ensure more equitable access to clean and safe water for all households.

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