A pragmatic approach of assessing access to an improved drinking-water source: empirical evidence from a Tanzanian household survey

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Abstract

The United Nations Declaration of 2000 adopted eight Millennium Development Goals (MDGs) designed to forge a new global partnership to reduce extreme poverty and setting out a series of time-bound targets. Among the targets of the MDGs is to halve by 2015 (from 1990 levels) the proportion of the population without sustainable access to safe drinking water and basic sanitation (MDG 7c). However, one indicator used to assess whether the goals of MDG 7c have been met was not defined succinctly. The current indicator defines access to safe water as 'the availability of at least 20 litres per person per day from a source within one kilometre of the user's dwelling.' Using cross-sectional household-level data from Tanzania, this study presents a range of critiques in using the indicator and suggests alternatives for consideration. In addition, this study presents an analysis of socio-economic and demographic determinants on accessing improved drinking-water sources.

Introduction

The United Nations (UN) Declaration of 2000 adopted eight Millennium Development Goals (MDGs) designed to forge a new global partnership to reduce extreme poverty and setting out a series of time-bound targets. Among the targets of the MDGs is to halve by 2015 (from 1990 levels) the proportion of the population without sustainable access to safe drinking water and basic sanitation (MDG 7c). To monitor progress towards achieving the targets relating to MDG 7, Target 7c, the UN through its two member agencies; United Nations Children Fund (UNICEF) and World Health Organization (WHO) established the Joint Monitoring Programme (JMP). The JMP publishes a periodic report on the status and progress towards the MDG target on sanitation and drinking-water.

According to the latest JMP report, advances continue to be made towards greater access to safe drinking-water (World Health Organization (WHO)/UNICEF, 2010). The report indicates that only 13% of the global population by the year 2008 lack access to improved drinking water sources, in comparison to MDG 7c target of 12% by 2015. The report projects that at the current rate of progress; only 9% of the global population is expected to lack access to improved drinking water sources by 2015. Explicitly, the report suggests that the world is expected to exceed the MDG target of halving the proportion of the population without sustainable access to safe drinking-water. However, as indicated elsewhere (Guardiola et al, 2010; Zawahri et al, 2011), this article demonstrates that the current JMP measures of assessing access to safe drinking water are inadequate and overstate the progress. This article uses data collected from the United Republic of Tanzania (Tanzania) as a case study.

This article is structured as follows. The next section highlights some of the problems of the JMP's current assessment techniques for measuring access to improved drinking water sources. The following section provides a brief overview of the study setting - Tanzania. Thereafter, the article briefly provides overview of the methods and data used. Then the article reports the descriptive statistics and the key empirical results. Lastly, the article provides concluding remarks and offers some policy implications of the analysis.

JMP Measures

The assessment questionnaire used by JMP to assess whether the goals of MDG 7c have been met defines access to improved drinking water sources in terms of the types of technology and levels of service afforded. According to JMP the following technologies were included in the assessment as representing access to improved drinking water sources: household connection, public standpipe, borehole, protected dug well, protected spring, and rainwater collection. The following are considered not improved: unprotected well, unprotected spring, vendor-provided water, bottled water, and tanker truck-provided water. Furthermore, JMP defines access to safe water as 'the availability of at least 20 litres per person per day from a source within one kilometre of the user's dwelling' (World Health Organization (WHO)/UNICEF, 2000).

These definitions are problematic. First, by defining access to improved drinking water sources solely based on the types of technology such as household connection, JMP assumes that an "improved" source is more likely to provide safe water. This problem is documented in the UN handbook which provides guidance on the definitions, rationale, concepts and sources of data of all the MDGs indicators that are being used to monitor the goals and targets (United Nations, 2003). The handbook refers access to safe water to the percentage of the population with reasonable access to an adequate supply of safe water in their dwelling or within a convenient distance of their dwelling. However, the handbook indicates that "access and volume of drinking water are difficult to measure, so sources of drinking water that are thought to provide safe water are used as proxy" (United Nations, 2003, p. 64-65). It is clearly that this approach does not guarantee that this water is safe for human consumption as there are no clear standards for its quality other than the nature of its sources. For example, Jimenez and Perez-Foguet (2009) found out that 56% of all rural population served by functional improved water points would be drinking unsafe water in three central regions of Tanzania. Ironically, standard guidelines on the quality of water have been published by WHO, yet for the purpose of assessing the achievement of MDG 7c, the standards have not been adopted.

Second, JMP assumes that if a household is within one kilometre of what is considered an improved drinking water source, then the household has access to an improved drinking water source. In their article, Dar and Khan (2011) suggest that an indicator that takes into account time taken to collect water and return to the dwelling may be a better indicator than relying solely on the distance. It appears that some of the surveys used by JMP have started to address this problem by specifically asking respondents to provide information on time taken to water source rather than distance. However, in the current definition, time taken to collect water as an indicator towards the achievement of MDG 7c, is not officially adopted (Dar and Khan, 2011). Dar and Khan highlight some of the challenges of relying on the distance indicator alone and ignoring time dimension. For example members of a household who access water from a distance of one kilometre take more time to collect water if they have to travel through hilly and mountainous terrain or very sandy terrain than otherwise. In addition, walking speeds are further reduced on a trip back home because of the heavy load (10 - 20 kg) of water.

In addition, JMP assessment does not take into account other important factors. Many people especially in developing countries run out of water for longer periods of time even though they have pipe connections in their households which by JMP criteria are still considered to have access to improved drinking water sources (Zawahri et al, 2011). For example in their study, Guardiola et al, (2010) found out that nearly half of the household interviewed indicated that cuts in water supply were relatively frequent. In his study, Taylor (2009) found out that nearly 46% of the public improved water sources in rural areas of Tanzania are not working.

Tanzania as a case study

General description of the study setting

Tanzania is located in Eastern Africa between longitude 29^{o} and 41^{o} East, Latitude 1^{o} and 12^{o} South. Tanzania derives its name out of the union of two sovereign states namely Tanganyika and Zanzibar. Tanganyika became a sovereign state on 9th December, 1961 and became a Republic the following year. Zanzibar became independent on 10th December, 1963 and the People's Republic of Zanzibar was established after the revolution of 12th January, 1964. The two sovereign republics formed the United Republic of Tanzania on 26th April, 1964. However, the Government of the United Republic of Tanzania is a unitary republic consisting of the Union Government and the Zanzibar Revolutionary Government. It is estimated that more than 80% of the population in Tanzania live in rural areas and the remainder live in the urban areas.

Access to drinking water in Tanzania

Most of the people who live in the rural areas of Tanzania are poor and have limited access to clean water. A third of the country receives less than 800 mm of rainfall and is thus arid or semi arid. Another third of the country has precipitation of above 1,000 mm. The period June to October is normally a long dry season of a year, which has an effect on low river flows and drying of water reservoirs. About 7% of the Tanzania land is covered by lakes which borders the country apart from other inland lakes. These include lake Victoria (second largest fresh water lake in the world), Lake Tanganyika (second deepest lake in the world), and Lake Nyasa. Inland lakes include Lakes Rukwa, Eyasi and Manyara. There are also big rivers flowing to the lakes. Ground water is also another source of water for both urban and rural settlement areas.

In many rural parts of Tanzania, progress increasing access to improved drinking water sources has been slow and uneven. According to official data, access to improved drinking water sources in urban areas of Tanzania mainland (formerly Tanganyika as it was known before the union with Zanzibar) improved from 68% in 1990 to 83% in 2008, while in rural areas increased from 51% in 1990 to about 57% in 2008 (United Republic of Tanzania, nd). The official record suggests that access to improved drinking water sources in the urban areas of Tanzania mainland is ahead of expectation. The expectation was for urban areas of Tanzania mainland to have access to improved drinking water sources of about 80% by 2008 in comparison to the MDG 7c goal of 84% by 2015. For Zanzibar, the official data show that access to improved drinking water sources in urban areas is pretty similar to its counterpart of Tanzania mainland. That is access to improved drinking water sources increased from 68% in 1990 to 83% in 2008. This also suggests that access to improved drinking water sources in the urban areas of Zanzibar is ahead of expectation. The expectation was for urban areas of Zanzibar to have access to improved drinking sources of about 80% by 2008 in comparison to the MDG 7c goal of 84% by 2015. For the rural areas of Zanzibar, access to improved drinking water sources increased from 46% in 1990 to 59% in 2008. In general, the report suggests that the prospect of attaining MDG 7c for the rural areas of Tanzania (both mainland and Zanzibar) by 2015 is unlikely.

Methods

This study uses both descriptive statistics as well as multiple regression analyses. Descriptive statistics are used to describe and analyze access to improved drinking water sources in Tanzania using the same criteria used by JMP. In addition, the article uses descriptive statistics to describe and analyze data on households pipe connection into dwelling/yard/plot as classified by the surveyed data. By isolating the analysis of the households' pipe connection, the article acknowledges its unique importance relative to other sources of drinking water for the welfare of human beings. For example, in their study, Isham and Kahkonen (2002) found that access to a piped water system among households in Indonesia increased the probability of improved health. In the section where the descriptive statistics are presented, the discussion will be used to highlights some of the deficiencies of the JMP criteria of access to improved drinking water sources.

Lastly, the article uses probit models in the analysis of socio-economic and demographic determinants on accessing improved drinking-water sources in Tanzania. This task is accomplished by using multiple regression analysis, specifically using probit models because the dependent variables are dichotomous. The multiple regressions are for access to improved drinking water sources using JMP criteria. In addition, the article employs multiple regression analysis to estimate the determinants of households' connection to piped water into dwelling/yard/plot.

All the analyses described above are conducted at the full sample as well as at the urban and rural levels. This is important for highlighting the existence of inequalities between urban and rural areas. All the statistical analyses in this article are employed using STATA software.

Data

To examine access to improved drinking-water sources, this study employs household level data from the 2010 national survey in Tanzania of the Demographic and Health Surveys (DHS+). Funded by the U.S. Agency for International Development (U.S. AID), the DHS coordinates with ORC Macro International and institutions in developing countries to administer a survey to women aged 15 to 49 drawn from a national sample. The data are collected at the individual as well as household levels. This article uses the household level data. The DHS instrument asks respondents to report retrospectively on a wide range of demographic variables. Information concerning water access, education, family planning, family nutrition and health, and other socioeconomic variables are also collected. Although the quality of the DHS data is potentially limited by problems of recall (due to lapse of memory) and possible underreporting of certain types of behavior due to social norms, researchers view the data as highly reliable for use in demographic analysis (Ali, Cleland, and Shah, 2003). In addition, to assess MDG 7c, JMP relies heavily on the data from the Multiple Indicator Cluster Surveys as well as DHS. Therefore, the use of DHS for this study is very appropriate (Dar and Khan, 2011).

Variables

Table 1 below presents the variable notations and descriptions used in the descriptive statistics and multiple regression models.

Table 1. Description of variables

Name	Variable description
accwat	Dummy = 1 if the household has access to improved source of water, 0 otherwise
hhmem	Number of de jure household members
reside	Dummy = 1 if the household is in urban, 0 otherwise
time	Time to get to water source measured in minutes per round trip
hhsex	Dummy = 1 if the head of the household is male, 0 otherwise
hhage	Age of the head of the household (in years)
treat	Dummy = 1 if the household does anything to treat water, 0 otherwise
windex	Proxy for household income: 1 = poorest 2 = poorer 3 = middle 4 = richer 5 = richest
noed	Dummy = 1 if the head of the household has no education, 0 otherwise
pred	Dummy = 1 if the head of the household has primary education (complete or incomplete), 0 otherwise
seed	Dummy = 1 if the head of the household has secondary education (complete or incomplete), 0 otherwise
hied	Dummy = 1 if the head of the household has higher education, 0 otherwise
piped	Dummy = 1 if the household has access to piped (into dwelling/yard/plot) water, 0 otherwise

Results and discussion of the descriptive statistics

Full sample

The descriptive statistics for the full sample of the Tanzania DHS data set are shown in Table 2 below. The data are nationally representative of all households that participated in the most recent DHS survey. As the data show only about 59% of the surveyed households have access to improved drinking water sources using JMP criteria. An average household has 5 members, with some having as many members as 36. Only 23% of the households are in urban areas. This is typical for a developing country like Tanzania where majority of people live in rural areas.

The average time taken to get to the source of drinking water – round trip (regardless of whether the source is improved or not) was about 29 minutes. However, for some households it can take up to 300 minutes (5 hours) to collect water. About 76% of the households are headed by male, which is not atypical for a patriarch society as Tanzania. The average age of the head of a household is about 46. About 35% of the households treat their drinking water before using it.

The wealth index shows a mean of 3, this implies that majority of the households are classified as middle income as assessed from various types of assets that a household possesses. Majority (59.5%) of the households are headed by people who indicated that they have primary education followed by no education (26.5%) and secondary education (13.1%). Only 0.9% of the head of households have higher education beyond that of secondary school. Only 11.2% of the households have piped connections into dwelling/yard/plot.

Table 2. Summary statistics - full sample

Name	# of Obs	Mean	Std. dev.	Minimum	Maximum
accwat	9,622	0.589	0.492	0	1
hhmem	9,623	5.080	2.894	0	36
reside	9,623	0.230	0.421	0	1
time	9,607	29.217	38.504	0	300
hhsex	9,623	0.759	0.428	0	1
hhage	9,620	46.189	15.634	15	95
treat	9,609	0.348	0.476	0	1
windex	9,623	3.013	1.404	1	5
noed	9,597	0.265	0.441	0	1
pred	9,597	0.595	0.491	0	1
seed	9,597	0.131	0.338	0	1
hied	9,597	0.009	0.095	0	1
piped	9,622	0.112	0.315	0	1

Urban sample

The descriptive statistics for the urban sample of the Tanzania DHS data set are shown in Table 3 below. As the data show 80.1% of the surveyed urban households have access to improved drinking water sources using JMP criteria. An average household has about 5 members, with some having as many members as 18.

For urban households, the average time taken to get to the source of drinking water (regardless of whether the source is improved or not) was about 17 minutes. However, even in the urban areas it can take some households up to 300 minutes (5 hours) to collect water. As it is for the full sample about 76% of the urban households are headed by male. The average age for the urban head of a household is about 43. Almost 50% of the urban households treat their drinking water before using it.

The wealth index shows a mean of about 4.4, this implies that majority of the urban households are relatively wealthier than an average household when the full sample is considered. Majority (57.7%) of the urban households are headed by people who indicated that they have primary education followed by secondary education (27.5%) and no education (11.7%). Only 3.1% of the urban head of households have higher education. About 26.8% of the urban households have piped connections into dwelling/yard/plot. This is more than twice in comparison to the full sample.

Table 3. Summary statistics - urban sample

Name	# of Obs	Mean	Std. dev.	Minimum	Maximum
accwat	2,209	0.801	0.399	0	1
hhmem	2,209	4.634	2.675	0	18
time	2,202	17.093	26.868	0	300
hhsex	2,209	0.761	0.426	0	1
hhage	2,209	42.919	14.190	16	95
treat	2,205	0.499	0.500	0	1
windex	2,209	4.424	0.945	1	5
noed	2,205	0.117	0.322	0	1
pred	2,205	0.577	0 .494	0	1
seed	2,205	0.275	0.447	0	1
hied	2,205	0.031	0.173	0	1
piped	2,209	0.268	0.443	0	1

Rural sample

The descriptive statistics for the rural sample of the Tanzania DHS data set are shown in Table 4 below. Slightly more than half (52.5%) of the surveyed rural households have access to improved drinking water sources using JMP criteria. An average household has about 5 members, with some having as many members as 36 (in comparison to 18 for urban areas).

For rural households, the average time taken to get to the source of drinking water (regardless of whether the source is improved or not) was about 33 minutes. This means that an average rural household spends almost twice as much time as their urban counterparts to fetch water for household uses. Similar to their urban counterparts, it can take up to 300 minutes (5 hours) for some rural households to collect water. As it is for the full and urban samples, about 76% of the urban households are headed by male. This is not surprising that the patriarch nature of the society is widespread in Tanzania. The average age for the rural head of a household is about 47; this means that an average head of the household in the rural areas is older than his/her counterpart in the urban areas. About 30% of the rural households treat their drinking water before using it. This figure is very small compared to the urban areas. Without much information, it can be interpreted that people in the rural areas perceive their water is safer than their urban counterparts. It can also be interpreted that people in the rural areas do not have technology or same understanding of sanitation as their urban counterparts.

The wealth index shows a mean of about 2.6, this implies that majority of the rural households are poor in comparison to their urban counterparts. Majority (60%) of the rural households are headed by people who indicated that they have primary education followed by no education (30.9%) and secondary education (8.8%). Only 0.3% of the rural head of households have higher education. This is also not surprising that people in the rural areas less educated in comparison to their urban counterparts. Only 6.5% of the rural households have piped connections into dwelling/yard/plot. This is very disturbing given the fact that an average household in urban area is about 4 times more likely to have piped connection into dwelling/yard/plot than a rural household.

Table 4. Summary statistics - rural sample

Name	# of Obs	Mean	Std. dev.	Minimum	Maximum
accwat	7413	0.525	0.499	0	1
hhmem	7414	5.213	2.943	0	36
time	7405	32.822	40.647	0	300
hhsex	7414	0.758	0.428	0	1
hhage	7411	47.163	15.910	15	95
treat	7404	0.303	0.460	0	1
windex	7414	2.592	1.234	1	5
noed	7392	0.309	0.462	0	1
pred	7392	0.600	0.490	0	1
seed	7392	0.088	0.284	0	1
hied	7392	0.003	0.052	0	1
piped	7413	0.065	0.247	0	1

Results and discussion of the descriptive statistics – with and without piped water into dwelling/yard/plot

Household with access to piped water into dwelling/yard/plot

The descriptive statistics of the Tanzania DHS data set for the households that have piped water into dwelling/yard/plot are shown in Table 5 below. An average household that has piped water connection into dwelling/yard/plot has about 5 members, with some having as many members as 17. More than half (55%) of households are in urban areas. Since the pipe connection is into dwelling/yard/plot, it takes an average of less than a minute to get water. Surprisingly, even with piped connection, as shown in Table 5, it takes some households up to 90 minutes (an hour and half) to fetch water. This is one of the critiques of JMP measures. This finding implies that the dimension – time taken to fetch water is important in tracking progress of MDG 7c as opposed to relying only on the distance and type of water sources.

Almost 80% of the household that have pipe connections are headed by male. The average age of the head of a household with pipe connection is about 46. Almost half (about 49%) of the households with pipe connection treat their drinking water before using it. This is an indication that even people with pipe connection do not perceive their water is safe for human consumption before treatment. This is one of the deficiencies of JMP criteria that assume that if a household has access to sources such as pipe connection, then it has access to improved drinking water.

As expected the majority of the households with pipe connection are wealthier as shown by the wealth index with a mean of about 4.6. Majority 46.7% of households with pipe connection are headed by people who indicated that they have primary education followed by secondary education (36.3%) and no education (13.4%). Only 0.36% of the head of households that have pipe connection have higher education.

Table 5. Summary statistics for sample with access to piped water

Name	# of Obs	Mean	Std. dev.	Minimum	Maximum
accwat	1,078	1	0	1	1
hhmem	1,078	5.277	2.711	1	17
reside	1,078	0.550	0.498	0	1
time	1,076	0.969	4.906	0	90
hhsex	1,078	0.797	0.403	0	1
hhage	1,078	45.573	14.170	16	95
treat	1,074	0.487	0.500	0	1
windex	1,078	4.622	0.650	1	5
noed	1,076	0.134	0.341	0	1
pred	1,076	0.467	0.499	0	1
seed	1,076	0.363	0.481	0	1
hied	1,076	0.036	0.187	0	1

Results and discussion of the determinants of access to improved drinking water source

The remainders of the tables in this article report the results of probit models, reporting coefficients, robust standards errors, and marginal effects. Reporting marginal effect is an effective way for interpreting binary models such as Probit (Long, 1997). The usage of marginal effects is becoming very common with some recent studies reporting only marginal effects (Rhine & Greene, 2006) and others reporting both coefficients and marginal effects (Fisher, 2005). Note that in the tables of results in this study no marginal effects are reported for constant terms because the concept of marginal effects is based on partial derivative. From the rules of calculus, the derivative of a constant is equal to 0. (for more discussion on marginal effects, see Long, 1997).

Full sample

Table 6 below presents the results of the determinants of access to improved drinking water source for the full DHS sample. The coefficient for number of de jure household members is negative and statistically significant at the 1% level indicating that an increase in number of household members leads to decrease in access to improved drinking water source. As expected, the coefficient for type of residency is positive and statistically significant at the 1% level indicating that urban households are more likely to have access to improved drinking water sources relative to their rural counterparts. Also as expected the coefficient for time to get the source of drinking water is negative and statistically significant at the 1% level indicating that the longer the time it takes for a household to access water, the more likely that the household does not have access to improved drinking water source.

The coefficient of the sex of the head of the household is negative and statistically significant at the 5% level indicating that a household that is headed by male is less likely to have access to improved drinking water source. More than 77% of the households in the DHS full sample are in rural areas where in daily basis women spend significant time to fetch water for domestic uses. Therefore, intuitively, it makes sense for the coefficient of the head of the household to be both negative and statistically significant suggesting that fetching water is a woman's job in Tanzania as it is throughout the developing world. The coefficient to indicate whether a household does anything to treat water prior to consumption is negative and statistically significant at the 1% level. This indicates that a household where its members treat water before consuming is less likely to have access to improved drinking water source. Lastly, as expected, the coefficient for wealth index is both positive and statistically significant at the 1% level. This confirms that wealthier households are more likely to have access to improved drinking water sources. The other coefficient of the age of the head of the household is not statistically significant. In addition, all the coefficients for the education levels of the head of the households are not statistically significant. This indicates neither the age nor the education level of the head of household is important in accessing improved drinking water source.

Table 6. Household access to improved source of water probit model - full sample

Name	Coefficient	Marginal Effects	Robust Standard Error
hhmem	-0.0182***	-0.0070	0.0048
reside	0.2226***	0.0842	0.0407
time	-0.0043***	-0.0017	0.0004
hhsex	-0.0665**	-0.0255	0.0338
hhage	0.0006	0.0002	0.0009
treat	-0.1678***	-0.0651	0.0299
windex	0.3002***	0.1158	0.0129
pred	-0.0379	-0.0146	0.0351
seed	0.0365	0.0140	0.0563
hied	-0.2650	-0.1045	0.1619
Constant	-0.3771***		0.0701

Sample size = 9,563

Wald Chi-Square = 1313.83

Prob > chi2 = 0.0000

Pseudo R2 = 0.1151

*** p<0.01

** p<0.05

Urban sample

Table 7 below presents the results of the determinants of access to improved drinking water source for the urban sample. As it is for the full sample, the coefficient for time to get the source of drinking water is negative and statistically significant at the 1% level. It is an indication that the longer the time it takes for a household to access water, the more likely that the household does not have access to improved drinking water source.

The coefficient for wealth index is both positive and statistically significant at the 1% level. Again, this confirms that wealthier households are more likely to have access to improved drinking water sources. The coefficient for higher education is negative and statistically significant at the 5% level. This is counterintuitive as it was expected that if a household is headed by an educated person, most likely is expected to have access to improved drinking water source. The other coefficients are not statistically significant.

Table 7. Household access to improved source of water probit model - urban sample

Name	Coefficient	Marginal Effects	Robust Standard Error
hhmem	0.0117	0.0031	0.0132
time	-0.0056***	-0.0015	0.0012
hhsex	0.0216	0.0058	0.0764
hhage	0.0021	0.0006	0.0024
treat	0.0205	0.0054	0.0664
windex	0.3311***	0.0881	0.0363
pred	0.0396	0.0106	0.1073
seed	-0.0248	-0.0066	0.1255
hied	-0.4963**	-0.1576	0.2008
Constant	-0.6422***		0.2044

Sample size = 2,194

Wald Chi-Square = 156.50

Prob > chi2 = 0.0000

Pseudo R2 = 0.0798

*** p<0.01

** p<0.05

Rural sample

Table 8 below presents the results of the determinants of access to improved drinking water source for the rural sample. The coefficient for number of de jure household members is negative and statistically significant at the 1% level. Since majority of rural residents have to go far to fetch water, then it makes sense that households with many members are having difficulty in accessing improved drinking sources. These households have many trips to water sources. Hence, the burden of accessing water is significantly increased particularly when there are only few people who are expected to fetch water for many household members.

As it is for the full and urban samples, the coefficient for time to get the source of drinking water is negative and statistically significant at the 1% level. Unlike in urban sample, the coefficient of the sex of the head of the household is negative and statistically significant at the 5% level indicating that a household that is headed by male is less likely to have access to improved drinking water source. This confirms that explanation given above in the discussion of the full sample that fetching water in many rural households in developing world is a woman's job.

The coefficient to indicate whether a household does anything to treat water before using it is negative and statistically significant at the 1% level. The coefficient for wealth index is both positive and statistically significant at the 1% level. It is a confirmation that that wealthier households are more likely to have access to improved drinking water sources regardless of whether they are in urban or rural areas. The other coefficients were not statistically significant.

Table 8. Household access to improved source of water probit model - rural sample

Name	Coefficient	Marginal Effects	Robust Standard Error
hhmem	-0.0229***	-0.0091	0.0052
time	-0.0042***	-0.0017	0.0004
hhsex	-0.0884**	-0.0351	0.0375
hhage	0.0001	0.00003	0.0010
treat	-0.2219***	-0.0883	0.0336
windex	0.2922***	0.1163	0.0139
pred	-0.0484	-0.0192	0.0371
seed	0.0788	0.0313	0.0675
hied	0.3665	0.1408	0.3579
Constant	-0.2775***		0.0763

Sample size = 7,369

Wald Chi-Square = 708.03

Prob > chi2 = 0.0000

Pseudo R2 = 0.0769

*** p<0.01

** p<0.05

Results and discussion of the determinants of household with pipe connection into dwelling/yard/plot

Full sample

Table 9 below presents the results of the determinants of a household with pipe connection for the full DHS sample. The coefficient for type of residency is negative and statistically significant at the 1% level indicating that urban households are less likely to have pipe connection into dwelling/yard/plot relative to their rural counterparts. This is counterintuitive to the expectation. The coefficient for time to get the source of drinking water is negative and statistically significant at the 1% level

The coefficient of the sex of the head of the household is positive and statistically significant at the 1% level indicating that a household that is headed by male is more likely to have pipe connection. This is finding is contrary for the general access to improved drinking water source (above) where the coefficient was negative and statistically significant. The coefficient for wealth index is both positive and statistically significant at the 1% level. The other coefficients are not statistically significant.

Table 9. Household access to piped source of water probit model - full sample

Name	Coefficient	Marginal Effects	Robust Standard Error
hhmem	0.0176	1.22e-08	0.0098
reside	-0.2334***	-1.24e-07	0.0706
time	-0.1569***	-1.09e-07	0.0384
hhsex	0.0525***	3.40e-08	0.0689
hhage	0.0055	3.79e-09	0.0019
treat	-0.0470	-3.15e-08	0.0599
windex	0.6214***	4.31e-07	0.0443
pred	-0.1364	-1.03e-07	0.0948
seed	0.0642	5.05e-08	0.1058
hied	-0.2062	-8.84e-08	0.1862
Constant	-2.6799***		0.2518

Sample size = 9,563

Wald Chi-Square = 409.29

Prob > chi2 = 0.0000

Pseudo R2 = 0.6037

*** p<0.01

Urban sample

Table 10 below presents the results of the determinants of a household with pipe connection for the urban DHS sample. The coefficient for number of de jure household members is positive and statistically significant at the 1% level. The coefficient for time to get the source of drinking water is negative and statistically significant at the 1% level. The coefficient for wealth index is both positive and statistically significant at the 1% level. The other coefficients are not statistically significant.

Table 10. Household access to piped source of water probit model - urban sample

Name	Coefficient	Marginal Effects	Robust Standard Error
hhmem	0.0677***	9.25e-07	0.0161
time	-0.2917***	-3.98e-06	0.0506
hhsex	0.0337	4.42e-07	0.1029
hhage	0.0045	6.19e-08	0.0035
treat	-0.0621	-8.50e-07	0.0872
windex	0.5260***	7.18e-06	0.1070
pred	-0.0153	-2.10e-07	0.1694
seed	0.0976	1.48e-06	0.1902
hied	-0.2493	-2.09e-06	0.2472
Constant	-2.3787***		0.5587

Sample size = 2,194

Wald Chi-Square = 165.77

Prob > chi2 = 0.0000

Pseudo R2 = 0.5957

*** p<0.01

Rural sample

Table 11 below presents the results of the determinants of a household with pipe connection for the rural DHS sample. Only two coefficients are statistically significant. The coefficient for time to get the source of drinking water is negative and statistically significant at the 1% level. The other coefficient is for wealth index which is both positive and statistically significant at the 1% level.

Table 11. Household access to piped source of water probit model - rural sample

Name	Coefficient	Marginal Effects	Robust Standard Error
hhmem	-0.0040	-4.76e-08	0.0114
time	-0.1076***	-1.27e-06	0.0303
hhsex	0.0679	7.42e-07	0.0896
hhage	0.0043	5.11e-08	0.0022
treat	-0.0830	-9.13e-07	0.0782
windex	0.6563***	7.73e-06	0.0426
pred	-0.1769	-2.32e-06	0.0965
seed	0.0366	4.62e-07	0.1158
hied	-0.3796	-2.10e-06	0.3209
Constant	-2.8445***		0.2819

Sample size = 7,369

Wald Chi-Square = 359.74

Prob > chi2 = 0.0000

Pseudo R2 = 0.5636

*** p<0.01

Conclusion

Access to safe water is necessary for all human beings. Through descriptive statistics, this article demonstrates that the current JMP measures of assessing access to safe drinking water are inadequate and overstate the progress. As shown in this article, almost half of the households with pipe connection treat their drinking water prior to consumption. This is a strong indication that even people with pipe connection do not perceive their water is safe for human consumption without treatment. This is one of the deficiencies of JMP criteria that assume that if a household has access to sources such as pipe connection, then it has access to improved drinking water. In addition, failure to officially adopt time taken to fetch water as an indicator of progress towards achieving the MDG 7c target is problematic. As findings in this article show, there are households that spend significant time to fetch water even with piped connection into dwelling/yard/plot. Without more details it can be speculated that water supply in these households may not be reliable.

The article also provides useful information in the analysis of the factors influencing access to improved drinking water sources. For example, throughout the empirical analysis, the variable that is used in this article as a proxy for income has shown to be an important factor in accessing improved drinking water source. The findings of this article also highlight the disturbing existence of inequality between urban and rural areas.

A clear policy implication is that access to safe water should be regarded as a multi-dimensional phenomenon. This article used a case of Tanzania; however, the findings are unlikely to be isolated. This leads to recommendation that action be taken to make sure proper techniques and criteria are appropriately used to monitor progress of the MDG 7c. The findings call for evaluation of the JMP methodologies that are used to track MDG 7c progress.

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