Access to improved water, human capital and economic activity in Africa

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Abstract

This paper examines the correlation between access to improved water, human capital and economic activity in Africa. It shows that countries with higher access to improved water tend to have lower mortality rate than those with lower access to improved water even they have the same per capita GDP, population characteristics and other time-invariant characteristics. One percentage point increase in the proportion of population accessing improved water is associated with a decrease of 0.45 and 0.89 in the mortality rate (calculated as per mil). Although there is a very small correlation between the access to improved water and GDP per capita, there is a strong correlation between the access to improved water and poverty. Countries with higher proportion of population with access to improved water are more likely to have lower poverty.

Keywords: urbanization; piped water; household welfare; income; household survey

JEL Classification: O18, O10, R11.

1. Introduction

Water is essential to human life. The Union Nation Water Conference, Mar Del Plata 1977, noted that : ‘‘All people (. . .) have the right to have access to drinking water in quantities and of a quality equal to their basic needs’’. In addition to its importance for life, water is also a vital element in any society and any ecosystem. Indeed, water plays an important role in the productive process and almost all sectors that serve as the foundation for the economic activity depend on water. Thus, unavailability on water in a sufficient quantity and good quality is a major constraint for social development and economic growth especially in developing countries and in particular in Africa.

Nowadays, economic development and increasing urbanization have caused an accelerated increase of water consumption. As a consequence, sustained growth and health of countries are increasingly threatened by unequal access to water and environmental deterioration which makes water resources a trade-off between different human activities.

Water resources and infrastructure development can contribute in many ways toward reaching the Millennium Development Goals and post 2015 agenda. The benefits of such development can include job creation, economic and social integration, trade and foreign direct investment, local company competitiveness and the improvement of basic social services. But to make these socioeconomic outcomes from water resources development sustainable, it is also necessary to develop human capital. Only human capital development can bring innovation to Africa’s water sector, allow countries to maintain their newly constructed systems, and enable strategic policy reforms.

Accordingly, this paper provides general guidelines on the integration of human capital development into water infrastructure programs and projects—for competitiveness, for productivity, for job creation and for improved access to basic services. This paper is structured as follows. Section 2 provides a discussion about access to improved water in Africa. Section 3 introduces a conceptual framework to better understand the relationship between water access, human capital and economic development. Section 4 presents some empirical evidence on the impact of improved water access on human capital and economic activity in Africa. Section 5 discusses the main policy implications from our findings. Finally, section 6 concludes the paper.

2. Access to improved water in Africa: the landscape

African countries are characterized by very heterogeneous conditions of water access. Difficult water access situations contribute to the lack of water supply in many countries, especially in rural areas. Africa's water and sanitation infrastructure deficit remains a serious challenge to growth and socioeconomic development, partly accounting for the continent's low competiveness. Weak human capacity, inefficient service delivery and poor transparency and accountability—all are contributing factors. The heavy costs include overburdened public health systems and stifled productive capacity.[1]

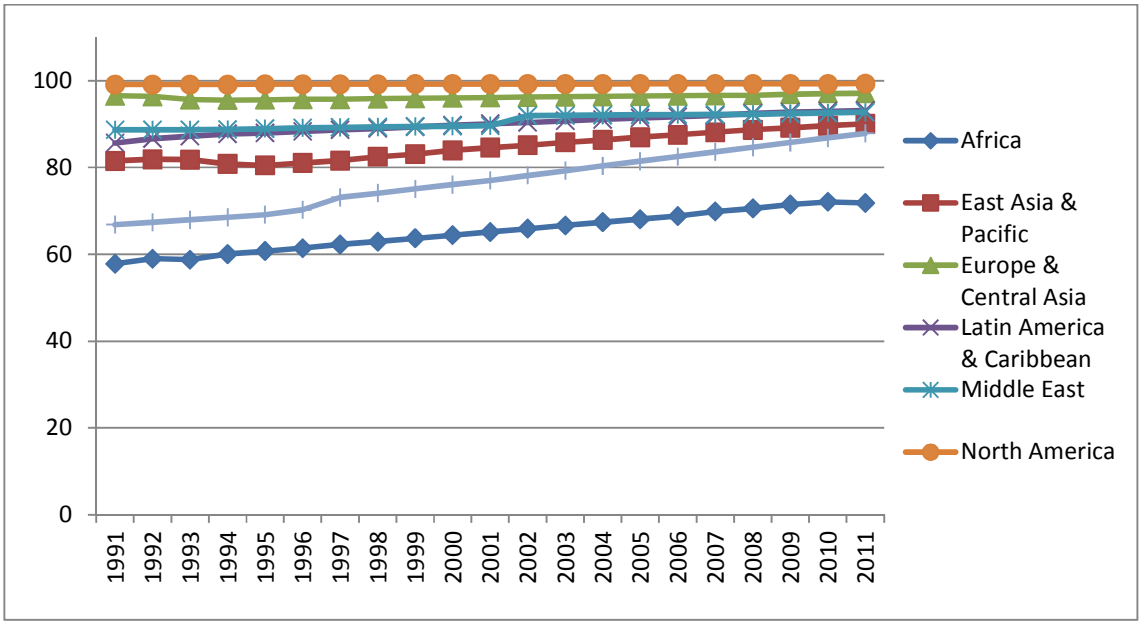
2.1. Low proportion of households with access to improved water in Africa

In this paper, we will rely on the World Development Indicators Database (WDI, 2013) prepared by the World Bank for analysis.[1] This very rich data set contains yearly data on a large number of indicators of countries throughout the world since 1960. However, for a large number of indicators such as water, education and health, the data are available only in recent years. According to the Wold Development Indicators Database from the World Bank (2013), the proportion of population in Africa had access to improved water was 71.8% in 2011.[2] This proportion is much lower than the proportion in other regions in the world (Figure 3). Although the share of population accessing improved water increased overtime in Africa, this share did not increased recently during the period 2009-2011.

[1] Data are available at http://data.worldbank.org/.

[2] According to the World Bank (2013), access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 liters a person a day from a source within one kilometer of the dwelling.

Figure 3: The percentage of households with access to improved water in the world

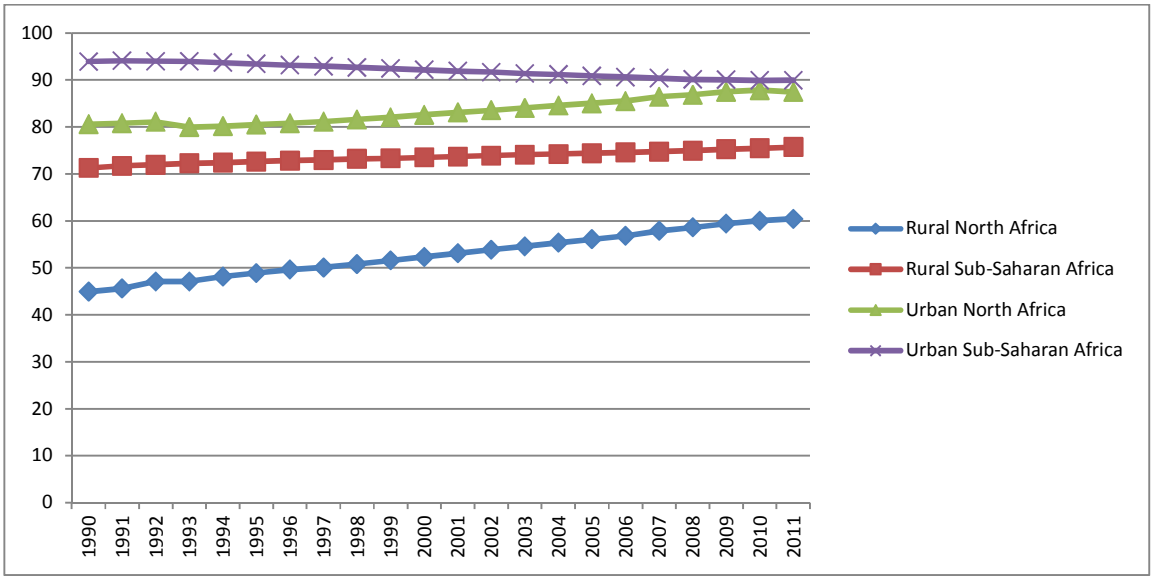


Sources: Authors' preparation from the World Development Indicators Database

2.2. Inequalities between and within African countries

There is inequality in accessing the improved water within Africa. Figure 4 and Table 1 show the evolution of the share of population with access to improved water in Africa. Although, the share of population with access to improved water has significantly increased overtime in North-Africa as well as in Sub-Saharan Africa, there is a significant difference between urban and rural areas as well as between North and Sub-Saharan Africa.

Figure 4: The percentage of households with access to improved water in Africa.



Sources: Authors' preparation from the World Development Indicators Database

Table 1: Percentage of population with improved water

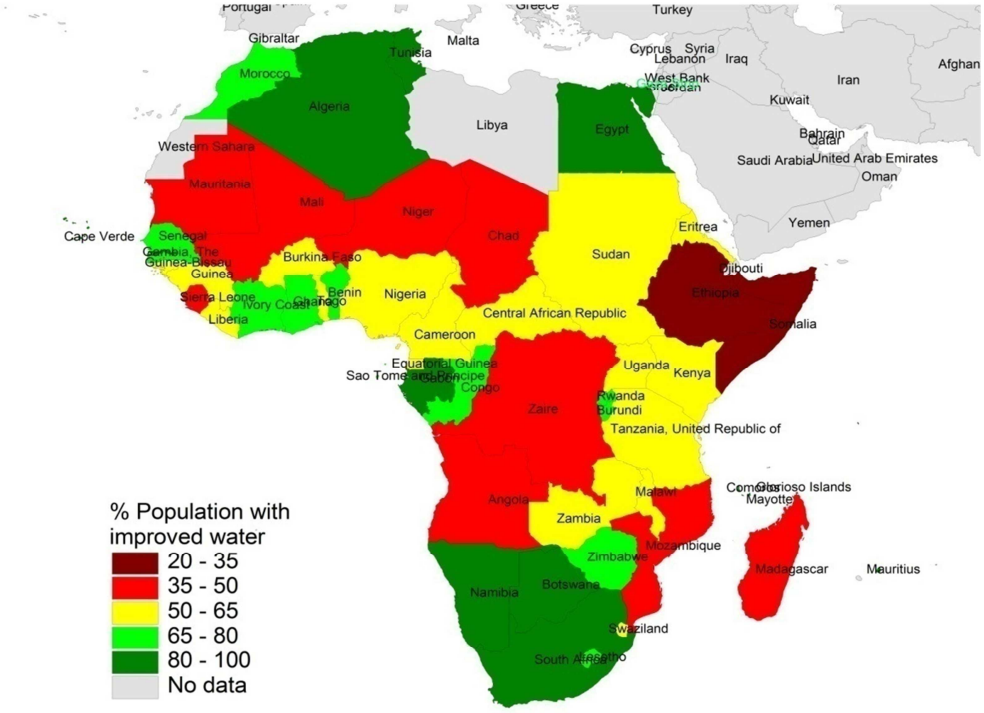
Year	North Africa			Sub-Saharan Africa		
	Rural	Urban	All	Rural	Urban	All
2000	52.3	82.6	62.4	73.5	92.2	83.0
2001	53.1	83.1	63.2	73.7	91.9	83.0
2002	53.8	83.6	64.0	73.9	91.7	83.0
2003	54.6	84.1	64.9	74.1	91.4	83.0
2004	55.4	84.6	65.7	74.2	91.2	83.0
2005	56.1	85.0	66.5	74.4	90.9	83.0
2006	56.8	85.5	67.2	74.6	90.6	83.0
2007	57.9	86.4	68.4	74.8	90.4	83.0
2008	58.6	86.8	69.2	75.0	90.1	83.0
2009	59.4	87.5	70.1	75.3	90.0	83.1
2010	60.0	87.8	70.8	75.5	89.9	83.2
2011	60.4	87.5	70.5	75.7	89.9	83.4

Sources: Authors' preparation from the World Development Indicators Database

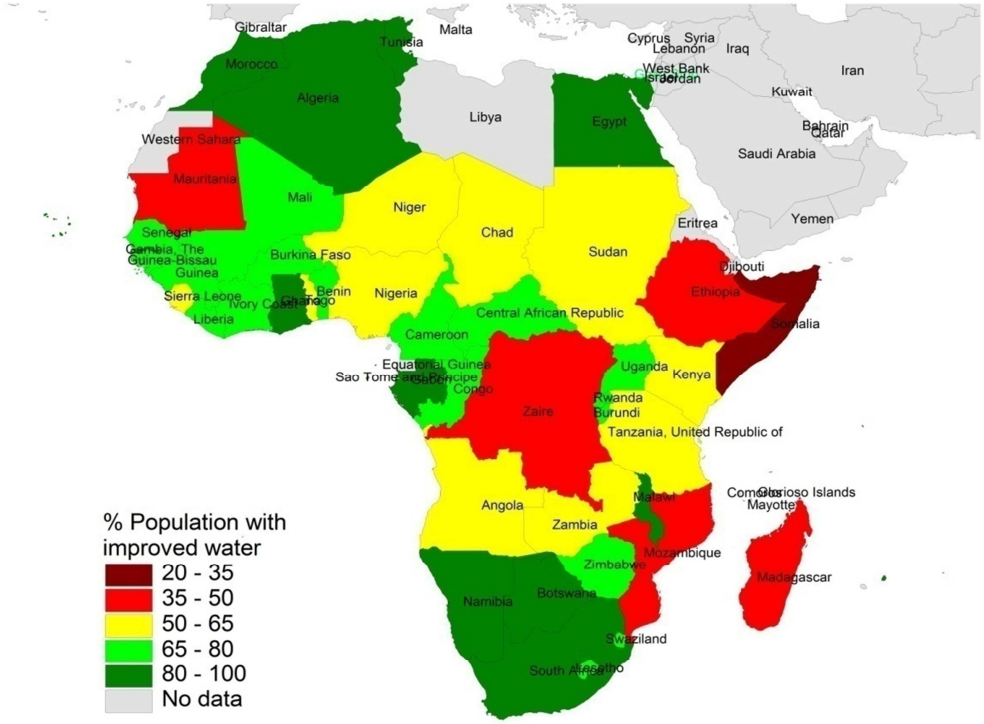
Figure 5 shows that the access to improved water of African countries over the period 2000-2011. There is a large gap in access to improved water among the countries. Some countries such as Ethiopia and Somalia have very low access to improved water and the progress on the water improvement is very low during the 2000-2011.

Figure 5: Percentage of population having access to improved water

The year 2000



The year 2011



Sources: Authors' preparation from the World Development Indicators Database

Given the harm being wrought in the water sector by climate change (extreme rainfall, floods and droughts), the sector should look to human capital development as one way to attract climate financing resources. In particular, local governments undergoing fiscal decentralization need greater skills and capacity in management—and in information and communications technology (ICT)—to improve the organization and financial management of water supply systems.

2.3. Low institutional and Technical capacities

Low institutional, managerial and technical capacity generally reduces competitiveness and impedes growth in African countries. There is no doubt that human resources in Africa's water sector are insufficiently developed. Moreover, programs to train and inform water users—and other economic actors in the sector—are unsatisfactory. Making investments in the water sector sustainable will require highly qualified personnel with adequate managerial, technical and scientific skills to construct and maintain new infrastructure. Research centers and universities can evaluate impacts and build stakeholder capacity: through policy and strategy research, they can aim to improve development outcomes in the water sector.

Africa's water and sanitation infrastructure deficit remains a serious challenge to growth and socioeconomic development, partly accounting for the continent's low competiveness. Integrating human capital and water sector development has many other benefits. It can make water and sanitation service delivery more efficient and accountable through increased participation by users, who have the power of numbers: giving citizens a voice in the development of basic services can improve the services. In addition, local and small enterprises can gain business and create jobs through the construction of water and sanitation infrastructure and its routine and periodic maintenance. Such opportunities can also benefit individual entrepreneurs. Finally, the development of regional water sector infrastructures can contribute to regional integration—developing regional labor markets, and possibly improving the living conditions of regional populations.

To make these socioeconomic outcomes from water resources development sustainable, it is also necessary to develop human capital. Only human capital development can bring innovation to Africa's water sector and to the overall economic development, allow countries to maintain their newly constructed systems, and enable strategic policy reforms. The following sections discussed the channels through which improved water access improves human capital formation and discuss these links in the African context.

Box 2.2. Challenges for Africa's water supply

Building professional, scientific, technical, managerial and financial skills in the water sector could help develop the water supply subsector—especially by addressing three challenges:

- *Low participation by the poor in water operations.* The poor often are unable to put forth their concerns and assert their interests.
- *Others' misperceptions of the poor.* Contrary to common assumptions, the poor have been found both willing and able to pay for better service: the challenge is to increase access.
- *External political constraints.* The greatest challenges to water supply development are political corruption, nepotism and cronyism—all causing inefficiency.
- *Ineffective utility management.* Such ineffectiveness commonly results from low capacity and corruption.
- *Disruptive effects of fiscal decentralization.* Local governments are often too weak, disorganized and lacking in capacity to manage their own resources.

Source: MACS, February 2008.

3. Access to improved water and human capital: a conceptual framework

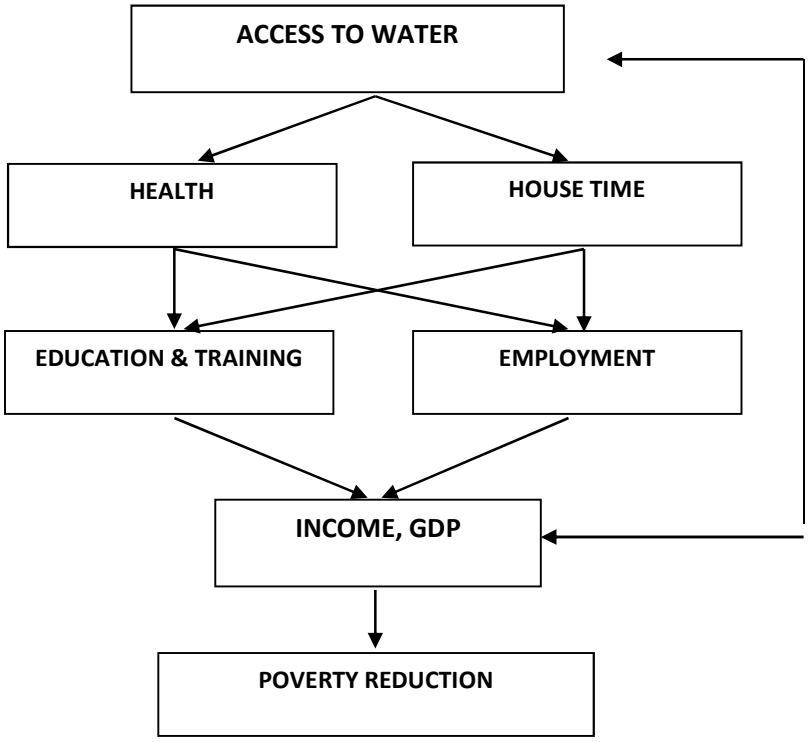
The conceptual framework we develop in this paper is described in the Figure 2 below. In order to capture the interactions between improved water access, human development and the economic activity in Africa, we distinguish two main channels of interactions: a direct channel and indirect one. In fact, water is a natural resource and a commodity that costs money to extract, treat, process, and distribute. It affects the economic activity directly because it is used as an input for several industries but also indirectly because water is considered as a facilitator of economic activity mainly through its impact on human capital. Numerous studies have showed that good access to improved water improves human capital and contribute to GDP growth, and that lack of dependable water supply affects negatively human development and contributes to economic stagnation and decline.

3.1. Improved Water access and human capital: direct channels

Therefore, the first and most direct channel via which water affects economic activity is human capital, especially health. Individuals engaged in the economy to produce goods and services must have access to improved water for their health, survival, and lifestyle if they are to be productive. Water is essential to human life, its total value is without measure. However, access to potable water is not evenly distributed and numerous individuals are forced to purchase supplementary water

or to drink non-potable water. This threatens the health of the population resulting in sick leave and loss of working potential. Poor access to clean water and treatment for water-related diseases cost a lot to the economy and the individuals.

Figure 2: Conceptual Framework



Source: Authors' preparation

There are numerous empirical studies on the effect of water on health in both developed and developing countries. For example, Collin et al. (1981) found that epidemics is positive associated with poor quality water in France. Dasgupta (2004) concluded that increased availability of water reduces the incidence of water-related diseases in India. Several studies such as Galiani et al. (2005), Macinko et al. (2005), and Gamper-Rabindran et al. (2010) found that access to clean water was negatively associated with infant mortality. Other studies can be found in Fewtrell and Kaufmann (2005), Günther and Fink (2010), Waddington et al. (2009), and Fewtrell et al. (2009), Nguyen and Vu (2013).

The second direct effect of clean water is on house time. Individuals engaged in the economic activity need convenient access to improved water so that they can spend their time working or being educated or caring for children rather than spending time to procure water like in numerous African and Asian countries. Devoto et al. (2012) showed that water connection could improve the

households' leisure and social activities in urban Morocco due to saving time for procuring water.

3.1. Improved Water access and human capital: indirect channels

In addition, access to water affects also directly the economic activity. Nearly every sector of the economy is influenced in some way by water. Indeed, water is used in the direct production of goods such as foods and beverages and it is used to produce energy (electricity and gasoline) and to extract mineral resources from the earth. Figure 2 shows that through health and time saving, access to clean water can have indirect effects on education and employment, and then household income and GDP of the countries. Finally, increased income can help household escape from poverty. It should be noted that there is an interlink between household income (as well as GDP) and access to water of households. Households with high income are more likely to have access to better improved water than households with low income.

If Africa fails to develop its human capital, its overall development will suffer. In particular, failing to integrate human capital development into water sector development will mean fewer socioeconomic benefits from the expansion of infrastructure—in job creation, in entrepreneurship development and in sustainable access to basic services. Integrating human capital and water sector development requires a more holistic approach in the design and implementation of water sector operations. Water sector experts should be trained and sensitized on human capital development concepts. Similarly, human development sector experts should participate more in the design and implementation of water sector operations.

4. Access to improved water, human capital and economic growth in Africa: the empirical evidence

In this section, we investigate empirically how improved water can be associated with human capital and economic activities using data from World Development Indicators Database (World Bank, 2013).[3]

4.1. Descriptive analysis and causality test

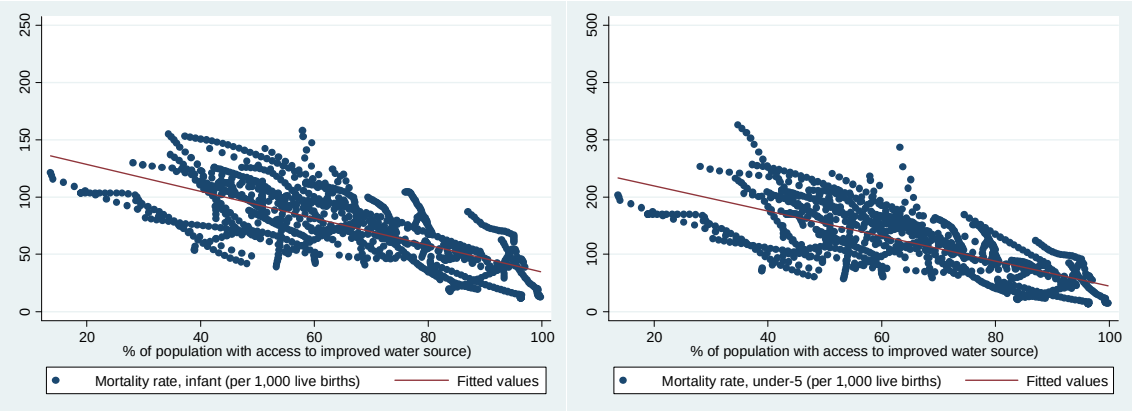
As known, clean water is essential for health and living. Access to improved water can lead to good health for people, especially children. This relation also holds in African countries. Figure 5 shows a negative relation between the access to improved water and the mortality rates.

[3] Data are available at http://data.worldbank.org/.

Figure 5: Improved water and mortality rate

The share of population accessing to improved water and Mortality rate, infant (per 1,000 live births)

The share of population accessing to improved water and Mortality rate, under-5 (per 1,000 live births)



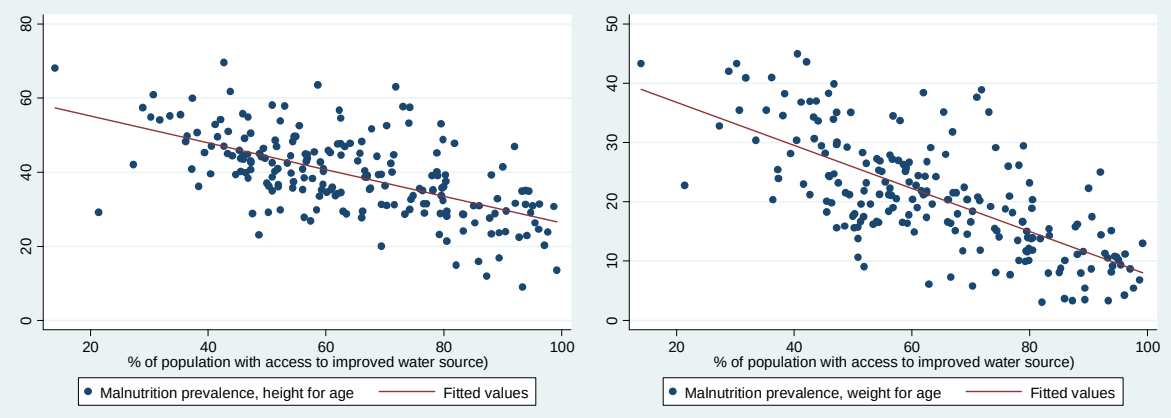
Sources: Authors' preparation from the World Development Indicators Database

Figure 5 shows that as the share of population with access to improved water increases, malnutrition problems decrease.

Figure 6: Improved water and malnutrition

The share of population accessing to improved water and malnutrition prevalence height for age

The share of population accessing to improved water and malnutrition prevalence weight for age

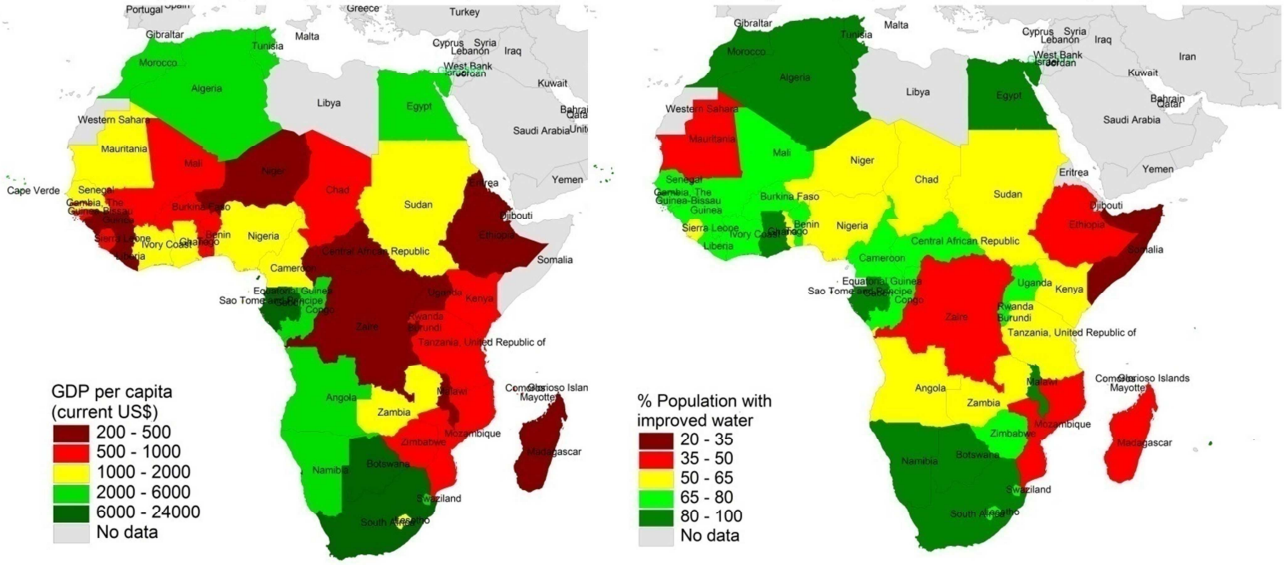


Sources: Authors' preparation from the World Development Indicators Database

Figure 4 suggest that there a positive correlation between improved water access and economic growth in Africa. Countries with high per capita GDP tend to have higher proportion of households with improved water than countries with low per capita GDP.

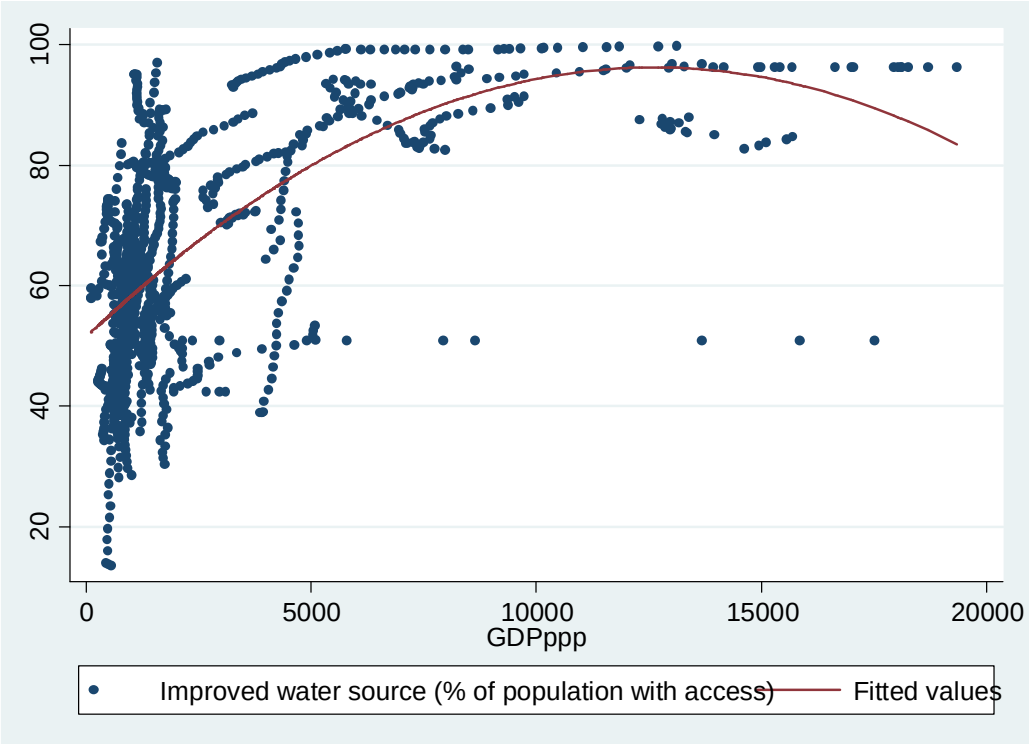
Figure 7: Maps of improved water and GDP (PPP constant price 2005)

GDP per capita (current US$) Percentage of population with improve water



Sources: Authors' preparation from the World Development Indicators Database

Figure 7: Improved water and GDP (PPP constant price 2005)



Sources: Authors' preparation from the World Development Indicators Database

4.2. Granger causality analysis

In order to further examine the impact of improved water access on human capital and economic activity in Africa, we proceed to Granger causality tests on data aggregated for all Africa, North Africa and Sub-Saharan Africa. We consider the following variables: Child mortality, Employment, GDP per capita, Human development Index (this index measures development by combining indicators of life expectancy, educational attainment and income into a composite index, HDI), Life expectancy, Reported malaria deaths, School enrolment-Secondary and Tertiary, and the Share of population with access to improved water. Except for variables that represent a percentage, we take the logarithm of variables.

We proceed in three steps. First, to determine the order of integration of our series we apply three standard unit root tests: Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski *et al.*(KPSS) tests. The ADF and PP tests are based on the null hypothesis of a unit root, while the KPSS test considers the null of no unit root. Results suggest that the series appear to be integrated of order one, which is a standard result in the literature for such series. Second, we apply three tests of the null hypothesis of no cointegration between the share of urban population and the considered series: ADF, PP and Johansen tests.[4] In most cases, the considered variables appear to be cointegrated with the share of population with access to improved water, which suggests that access to improved water moves together over the long-run with human capital and economic activity in Africa. Third, we implement Granger Causality tests. Indeed, it is well established that the existence of a cointegration relationship between two series means that at least one of the two series Granger causes the other.

Results are summarized in Table 2. Given the aim of the paper and to save space, we report only p-value for the causality running the share of population with access to improved water to the other studied variables.

Table 2: Results of causality tests

Access to improved water does not Granger Cause:

Variable	Panel A: All Africa P-value	Panel B: North Africa P-value	Panel C: Sub-Saharan Africa P-value
Child mortality	0.0000	0.08219	0.0000
Employment	0.04060	0.00493	0.07665
GDP per capita	0.00018	0.00126	0.00011
Human capital development	NA	0.62444	0.01424
Life expectancy	0.0000	0.00897	0.0000
Reported malaria deaths	0.00344	---	0.00290
School enrolment-Secondary	----	0.33417	0.05037
School enrolment-Tertiary	NA	NA	0.04645

[4]Stationary and cointegration tests are not reported to save space but available upon request.

Variable	Panel A: All Africa P-value	Panel B: North Africa P-value	Panel C: Sub-Saharan Africa P-value
Notes: NA denotes that the series is not available or that the number of observations available is too short to get robust results. --- denotes that the considered variable is not cointegrated with the share of urban population. Figures in bold indicate significance at the 10% level.			

Sources: Authors' preparation from the World Development Indicators Database

Panel A shows that when data aggregated over all Africa are considered, the share of population with access to improved water Granger-causes child mortality, reported malaria deaths and life expectancy. Thus, access to improved water significantly improves health and life of individuals in Africa. Moreover, our findings suggest that improved water access increases the rate of employment and as a consequence augments GDP per capita. However, it seems that the share of population with access to improved water is not linked to education as the variables access to water and education are not cointegrated and thus do not necessary move together over the long-run.

When one considers North Africa, Panel B shows that the share of population with access to improved water Granger causes employment and life expectancy, and weekly Granger causes child mortality, but at the same time it does not affect education such that the global effect on human capital is weak. As far as Sub-Saharan Africa is concerned, our findings reported in Panel C show very interesting facts. Access to improved water does significantly Granger cause all the studied variables. Thus, as the share of population with access to improved water increases, employment, life expectancy and education improve. As a consequence, access to imported water improves both GDP per capita and human capital development.

4.3. Regression analysis

Estimating the effect of the access to improved water is very challenging since access to improved water is not random. Unobserved variables can be correlated with the access to improved water and cause the impact estimates biased. In this study, we use country fixed-effects regressions to examine the effect of access to improved water and health, education and poverty. The main advantage of fixed-effects regression is that it uses panel data to eliminate time-invariant unobserved variables such as geography and culture, thereby lessening the selection bias (see for example Wooldridge 2010 for detailed presentation of the method).

Table 3 presents the regressions of life expectancy and mortality on the access to improved water. We use simple models with more exogenous variables including population density, the proportion of children and elderly. Per capita GDP is very

important variable to determine water access, but it can be endogenous variable. Thus we present both models with and without controlling for per capita GDP. For all regressions, we include the dummy variables of years. The list of variables is presented in Table A.1. in Appendix.

Table 3 shows that countries with higher access to improved water tend to have lower mortality rate than those with lower access to improved water even they have the same per capita GDP, population characteristics and other time-invariant characteristics. One percentage point increase in the proportion of population accessing improved water is associated with a decrease of 0.45 and 0.89 in the mortality rate (calculated as per mil). If we consider the mean of the proportion of improved water and mortality rate, we can compute the elasticity of the mortality rate with respect to the improved water proportion (see Table A.1 in Appendix for the variable mean). The elasticity is estimated at around 0.3 and 0.4: A one percent increase in the proportion of improved water is associated with a 0.3 percent and a 0.4 percent decrease in the mortality rate of infants and children under five, respectively. The access to improved water is also significantly negatively correlated with the malnutrition rate (Table 4). Even for countries with the same economic level (measured by per capita GDP), countries with higher access to improve water tend to have lower rate of malnutrition. The per capita health expenditure is also lower in countries with higher access to improved water. Possibly, improved water help people improve health and reduce the health care cost.

In Table 5, we examine the effect of improved water on school enrollment of children. There is a positive correlation between improved water and primary school enrolment. However, the correlation between improved water and higher school levels is not statistically significant. Possibly, health status is more important for primary schooling than secondary schooling.

Finally, we investigate the role of improved water in economic activities. Although, there is a very small correlation between the access to improved water and GDP per capita, there is a strong correlation between the access to improved water and poverty. Countries with higher proportion of population with access to improved water are more likely to have lower poverty.

Table 3: Country fixed-effects regression of life expectancy and mortality

Explanatory variables	Life expectancy at birth, total (years)	Mortality rate, infant (per 1,000 live births)	Mortality rate, under-5 (per 1,000 live births)	Life expectancy at birth, total (years)	Mortality rate, infant (per 1,000 live births)	Mortality rate, under-5 (per 1,000 live births)
% of population with access to improved water source	0.0358*	-0.5228***	-1.0367***	0.0219	-0.4484***	-0.8945***
	(0.0212)	(0.0662)	(0.1262)	(0.0210)	(0.0639)	(0.1234)
Log of per capita GDP (2005 constant PPP$)				1.7602***	-13.6759***	-20.8546***
				(0.4994)	(1.5230)	(2.9386)
Population ages 0-14 (% of total)	0.6022***	-2.2161***	-5.2969***	0.5810***	-2.5884***	-6.0178***
	(0.0657)	(0.2016)	(0.3844)	(0.0674)	(0.2012)	(0.3883)
Population ages 65 and above (% of total)	0.4679	-2.7287**	-3.2959	0.3475	-2.9112***	-4.0548*
	(0.3695)	(1.1394)	(2.1725)	(0.3744)	(1.1227)	(2.1663)
Population density (people per sq. km of land area)	0.0881***	-0.1216***	-0.2786***	0.0878***	-0.1057***	-0.2445***
	(0.0059)	(0.0183)	(0.0350)	(0.0058)	(0.0177)	(0.0341)
Dummies of year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	21.3295***	204.8308***	411.4524***	10.2644*	316.9768***	587.0044***
	(3.9072)	(11.9579)	(22.8000)	(5.3921)	(16.2449)	(31.3449)
Observations	1075	1085	1085	1025	1035	1035
Number of countries	51	51	51	49	49	49
R-squared	0.4412	0.6841	0.6943	0.4578	0.7259	0.7287

Standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.
Sources: Authors' preparation from the World Development Indicators Database.

Table 4: Country fixed-effects regression of malnutrition and health spending

Explanatory variables	Malnutrition prevalence, height for age (% of children under 5)	Malnutrition prevalence, weight for age (% of children under 5)	Health expenditure per capita, PPP (constant 2005 $ international)	Malnutrition prevalence, height for age (% of children under 5)	Malnutrition prevalence, weight for age (% of children under 5)	Health expenditure per capita, PPP (constant 2005 $ international)
% of population with access to improved water source	-0.2823**	-0.1464*	-1.3167**	-0.2549**	-0.1348*	-0.5950
	(0.1166)	(0.0764)	(0.5440)	(0.1150)	(0.0737)	(0.5046)
Log of per capita GDP (2005 constant PPP$)				-10.556***	-7.3253***	122.28***
				(3.490)	(2.2541)	(10.57)
Population ages 0-14 (% of total)	0.3193	-0.2366	-2.0954	0.1421	-0.3363	-2.8904**
	(0.3947)	(0.2598)	(1.5167)	(0.3940)	(0.2534)	(1.4250)
Population ages 65 and above (% of total)	-4.6501*	-3.4809**	121.9098***	-4.7248*	-3.4411**	116.6436***
	(2.5428)	(1.6670)	(8.5137)	(2.5271)	(1.6189)	(7.9116)
Population density (people per sq. km of land area)	-0.0042	-0.0291	-0.0534	0.0049	-0.0237	0.0242
	(0.0324)	(0.0213)	(0.1362)	(0.0320)	(0.0205)	(0.1247)
Dummies of year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	59.271**	56.847***	-148.03	140.95***	107.15***	-1,029.76***
	(23.135)	(15.186)	(90.20)	(33.98)	(22.14)	(114.03)
Observations	204	202	836	197	195	816
Number of countries	50	50	51	48	48	49
R-squared	0.3112	0.4311	0.5312	0.3660	0.5014	0.6140

Standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.
Sources: Authors' preparation from the World Development Indicators Database.

Table 5: Country fixed-effects regression of school enrolment

Explanatory variables	School enrollment, primary (% net)	School enrollment, secondary (% net)	School enrollment, tertiary (% gross)	School enrollment, primary (% net)	School enrollment, secondary (% net)	School enrollment, tertiary (% gross)
% of population with access to improved water source	0.1919**	-0.0179	0.0141	0.1935**	-0.0048	-0.0387
	(0.0972)	(0.0873)	(0.0243)	(0.0976)	(0.0859)	(0.0249)
Log of per capita GDP (2005 constant PPP$)				3.3489	8.2965***	3.3261***
				(2.6036)	(2.9450)	(0.8154)
Population ages 0-14 (% of total)	1.5266***	-0.9855***	-0.3601***	1.5463***	-0.9429***	-0.2798***
	(0.2748)	(0.2401)	(0.0772)	(0.2769)	(0.2364)	(0.0750)
Population ages 65 and above (% of total)	-0.0417	0.1470	4.5840***	-0.1847	0.0920	4.3778***
	(1.7189)	(1.7719)	(0.4011)	(1.7241)	(1.7411)	(0.4029)
Population density (people per sq. km of land area)	0.0618	-0.0431	0.0248***	0.0664	0.0015	0.0203***
	(0.0413)	(0.0364)	(0.0071)	(0.0414)	(0.0391)	(0.0069)
Dummies of year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	6.222	72.832***	5.464	-20.305	6.7692	-17.454**
	(17.428)	(15.546)	(4.373)	(27.147)	(27.986)	(6.892)
Observations	570	256	564	569	256	559
Number of countries	48	37	50	48	37	49
R-squared	0.5840	0.6017	0.7069	0.5850	0.6174	0.7328

Standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.
Sources: Authors' preparation from the World Development Indicators Database.

Table 6: Country fixed-effects regression of poverty indexes

Explanatory variables	Log of per capita GDP (2005 constant PPP$)	Poverty gap at $1.25 a day (PPP) (%)	Poverty headcount ratio at $1.25 a day (PPP) (%)	Poverty gap at $1.25 a day (PPP) (%)	Poverty headcount ratio at $1.25 a day (PPP) (%)
% of population with access to improved water	0.0002	-0.811***	-1.291***	-0.822***	-1.253***
	(0.0014)	(0.2047)	(0.2444)	(0.2142)	(0.2552)
Log of per capita GDP (2005 constant PPP$)				1.2185	-4.1637
				(6.4496)	(7.6847)
Population ages 0-14 (% of total)	-0.0023	-0.1884	-0.3552	-0.1879	-0.3570
	(0.0043)	(0.5837)	(0.6968)	(0.5879)	(0.7004)
Population ages 65 and above (% of total)	0.0753***	3.9117	-2.4056	3.7397	-1.8178
	(0.0237)	(3.1053)	(3.7070)	(3.2571)	(3.8808)
Population density (people per km2 of area)	-0.0004	-0.0033	-0.0599	-0.0057	-0.0517
	(0.0004)	(0.0711)	(0.0849)	(0.0727)	(0.0866)
Dummies of year	Yes	Yes	Yes	Yes	Yes
Constant	7.4420***	66.704*	155.1***	59.085	181.1***
	(0.2465)	(39.495)	(47.148)	(56.642)	(67.489)
Observations	1035	140	140	140	140
Number of countries	49	46	46	46	46
R-squared	0.3353	0.6186	0.6174	0.6188	0.6190

Standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.
Sources: Authors' preparation from the World Development Indicators Database.

5. Policy implications

Incorporating human capital development in water sector operations would increase the competitiveness of the stakeholders, increase job opportunities, foster inclusive growth and development, and improve the quality of sector services. The guiding principles are the consideration of national human capital development aspects in the design of water sector operations, increased participation of the private sector and improvement of accountability and service delivery in the sector. To meet these guidelines, several policies may be recommended targeting to foster the human capital dividend of the water sector.

5.1. Strengthening institutional arrangements and capacity

Many countries have long-term Human Capital Development Strategies and Water Sector Strategies. Diagnosing the human resources needs in the water sector is a critical step that could integrate of HCD actions and strategies of African countries. The definition and the elaboration of an operational framework for the integration of HCD measures in the water sector; and the creation of joint multidisciplinary teams and the launching of operations that demonstrate the value addition in water sector development outcomes of incorporating HCD components in the sector operations. At the same time, institutions in charge of Water management need strong training and capacity building. Strengthening the capacities of institutions specialized in training engineers and technicians working in the water sector in the areas of financial management, civil engineering, hydrogeology and others, by introducing these fields or strengthening existing ones in national universities and in regional centers of excellence is highly recommended. Strengthening the computerization of institutions responsible for water management and training staff to work with up to date information technology systems for the technical, financial and commercial management of water services should improve service delivery and accountability in the sector operations. Public Expenditure Tracking Surveys and Quantitative Service Delivery Study to track resource flows and examine the efficiency of public spending compared to service delivery indicators can be implemented since then. These measures could partly help to address the pervasive corruption in the water sector.

5.2. Reinforcing the positive impacts of water sector operations on Health

Water sector operations can improve access to basic services and economic opportunities. But major water development projects like multipurpose dams could increase the risks of HIV transmission as large numbers of workers move into new areas and the change of the regime of downstream rivers and streams can cause lasting damage to ecosystems that depend on the dammed river. Thus, in major projects of this nature for instance, HIV sensitization campaigns and provisions for

the treatment of AIDS patients and care for AIDS orphans need to be incorporated to protect communities living near these projects. Collaboration would help incorporate these social safeguard measures in water sector operations and thus improve the development outcomes of the operations. *Reduce the risks of transmitting HIV and sexually transmitted diseases*. Workers and people near major projects are at risk. Such projects thus provide the opportunity to initiate sensitization campaigns to protect against sexually transmissible diseases including HIV. The campaigns should target these vulnerable groups that include sex workers, and the projects should make provisions for making treatment available for AIDS patients in the area and their reintegration into their communities.

5.3. Create employment opportunities in the Water sector

The construction and maintenance of water infrastructure should be labor intensive. Rather than using machines for pipeline excavation—and batching and mixing plants for concrete production—using smaller machines and hand tools could increase job opportunities. Promoting this approach will require training small and medium-size enterprises on the approach and preparation of operations manuals to guide the implementation of the approach. Encouraging small manufacturing of water supply and irrigation equipment such as treadle pumps and wind and solar pumps nationally or regionally could boost employment opportunities in the water sector. Promoting the manufacture of spare parts nationally or regionally will equally create opportunities for entrepreneurship and job creation. Developing multiuse water supply schemes and promoting water-related income-generating activities would improve job-creation opportunities in agricultural food production, horticulture, fishery and agribusiness. And increasing research in the sector could introduce new and more efficient technologies and methodologies. Improving the possibilities for small enterprises to engage in the construction and maintenance of water infrastructure promotes the generation of revenues in local communities. This could be done by training local entrepreneurs in technical norms, entrepreneurship skills and business management aspects relevant to the water sector.

5.4. Contribute to promoting Research and Development in the water sector

National research institutes and universities have been engaged in the past to evaluate the socioeconomic development impacts of water sector operations in the target localities. The collaboration could be by investigating the training needs of project stakeholders or other stakeholders in the country that are having difficulties with maintaining their water infrastructure and designing operations to address these needs. Developing science and technology, cooperation can enable the following activities to be mainstreamed in water sector operations: support to institutions that train water sector engineers and technicians; support specialized

training in the sector (satellite imagery, telemetry, water information systems, Geographic Information Systems, climate change risks modeling and management, renewable energy systems for the water sector). These new areas provide ample opportunities for job creation.

6. Conclusion

Africa's water and sanitation infrastructure deficit remains a serious challenge for the continent's growth prospects and socio-economic development and partly accounts for the continent's weak competiveness. According to the 2012 UNICEF/WHO Joint Monitoring Programme report, as of 2010 only 66% of Africa's population had access to safe water, and 40% to improved sanitation. Weak human capacity, inefficiencies in services delivery and poor transparency and accountability contribute in part to this situation. The implementation of the Human Capital Development Strategy (HCDS) through the water sector will have the dual benefit of developing human capacity on the continent as a whole and of improving access to water and sanitation as well as improve the sustainability of the outcomes of water sector operations.

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Appendix: Summary statistics of variables

Variables	Obs.	Mean	Std. Dev.	Min	Max
% of population with access to improved water	1086	64.9	19.5	13.6	99.8
Life expectancy at birth, total (years)	2666	50.5	8.7	26.8	74.8
Mortality rate, infant (per 1,000 live births)	2536	97.2	41.7	11.2	237.4
Mortality rate, under-5 (per 1,000 live births)	2536	159.9	78.8	13.1	486.0
School enrollment, primary (% net)	930	66.5	22.2	9.7	100.0
School enrollment, secondary (% net)	371	25.1	21.0	0.1	97.6
School enrollment, tertiary (% gross)	1181	3.9	5.7	0.0	37.1
Malnutrition prevalence, weight for age (% of children under 5)	239	20.4	9.4	3.1	45.0
Malnutrition prevalence, height for age (% of children under 5)	245	38.7	11.1	7.7	69.6
Health expenditure per capita, PPP (constant 2005 international $)	847	150.3	204.6	0.0	1806.5
Poverty gap at $1.25 a day (PPP) (%)	157	19.8	14.8	0.0	63.3
Poverty gap at $2 a day (PPP) (%)	157	33.3	18.6	0.0	75.6
Poverty headcount ratio at $1.25 a day (PPP) (% of population)	157	45.3	25.7	0.0	92.6
Poverty headcount ratio at $2 a day (PPP) (% of population)	157	64.5	25.4	0.0	98.5
Per capita GDP (constant 2005 international $)	1557	2851.3	3904.3	101.6	27346.4
Population ages 0-14 (% of total)	2756	43.5	4.4	20.2	50.3
Population ages 65 and above (% of total)	2756	3.3	1.0	1.1	8.4
Population density (people per sq. km of land area)	2601	56.9	87.7	0.7	633.5

Sources: Authors' preparation from the World Development Indicators Database.

[1]Bank Water Sector activities and initiatives in 2011, AfDB/OWAS, 2011.