Stockholm School of Economics

Department of Economics

BSc Thesis

Spring 2009

The Dimensions of Water Scarcity

A Study of Development Priorities in Sub-Saharan Africa

Abstract

Despite innumerable organisations, laws and targets committed to solving the world water crisis, millions of people still lack access to basic water and sanitation. This has widespread consequences and affects all aspects of life for those deprived of this fundamental requirement. Sub-Saharan Africa is the region estimated to be the furthest away from reaching the Millennium Development Goal of water and sanitation in 2015. The aim of this thesis is to investigate the areas that need to be focused on in order to promote water sector development in this region. By specifying a cross-country multivariate regression, we attempt to identify the factors affecting water availability on a domestic level and to determine their relative contribution to water coverage rates. The results indicate that physical resources seem irrelevant in explaining water coverage rates. Furthermore, the individual effect of internal economic growth is found to be more significant in improving water coverage than external aid, whereas the effect of the institutional variables is more ambiguous. Economic and institutional factors together appear to be highly relevant for the level of water available for household use. This supports the view of a holistic approach to water sector management, where development in a number of areas is required for a positive effect to emerge.

Authors: Johanna Modigsson, 20568

Ylva Munkhammar, 20931

Tutor: Professor Örjan Sjöberg

Abbreviations and acronyms

CESCR:	UN Committee on Economic, Social and Cultural Rights
FAO:	Food and Agriculture Organization of the United Nations
GDP:	Gross Domestic Product
IWMI:	International Water Management Institute
IWRM:	Integrated Water Resource Management
MDG:	Millennium Development Goal
NGO:	Non-Governmental Organisation
ODA:	Official Development Assistance
OECD:	Organisation for Economic Co-operation and Development
OLS:	Ordinary Least Squares
PPP:	Purchasing Power Parity
SIWI:	Stockholm International Water Institute
UN:	United Nations
UNDP:	United Nations Development Programme
UNICEF:	United Nations Children's Fund
UNU-WIDER:	United Nations University – World Institute for Development Economics Research
WHO:	World Health Organization

Table of Contents

Introduction

"The difference between what we do and what we are capable of doing would suffice to solve most of the world's problems."

This frequently quoted observation by Mahatma Ghandi captures a thought provoking truth. It also serves as the fundamental hypothesis that has inspired the topic of this thesis. Accepting this statement immediately triggers a desire to find a logical explanation. However, when it comes to the world's escalating water crisis, there is no acceptable answer to why our actions fall short of our capabilities of solving that particular problem.

Access to safe water and basic sanitation represents one of the greatest challenges facing humanity in the 21st century. The target of halving the proportion of people without sustainable access to safe drinking water and basic sanitation is part of the environmental sustainability goal - one of the eight Millennium Development Goals formulated by the UN in 2000. This goal forms complex interactions with the rest of the MDGs due to the holistic characteristics of development. In other words, access to water is crucial in the process of reducing poverty and increasing welfare, which should be the aim of any developing country.

As the UNDP points out, "the word crisis is sometimes overused in development" (2006, p. v). However, in describing the world's water situation, using this term is justified. Access to safe water is a fundamental condition for human survival. In this sense it is not a means to an end, it is an end in itself. Furthermore, the fact that water is critical to all forms of social and economic development should immediately create an increased political will to put water issues on the international agenda. Unfortunately, this is not the case.

At the time of writing this thesis, the world is in the middle of a global financial crisis, which is expected to have the most severe consequences experienced since the great depression in the 1930s. The full effects are yet to be seen, but what can be said with certainty is that world leaders have shown great abilities to cooperate and quickly implement strategies aimed at minimising the negative effects. The stimulus package of the European Union amounts to 259 billion dollars (EUbusiness 2008) whereas the estimated expenditure of the United States and China is 787 billion dollars (BBC News Online 2009) and 600 billion dollars (*The New York Times* 2008) respectively. Although cost estimates of reaching the MDG water and sanitation target should be interpreted with caution, they can be used to put into perspective the level of fiscal stimulus expenditure aimed at overcoming the global financial crisis. From 2005 to 2014 approximately 70 billion dollars

need to be spent annually on water and sanitation, more specifically on increasing coverage to the population without access to safe water as well as maintaining existing water supply facilities (Hutton and Bartram 2008). In other words, more effort and resources have been put into bailing out banks in the US alone than what is needed to reach the global MDG water and sanitation target. Reaching this target has the potential to lift millions of people out of poverty and should be a priority for both developing and developed countries, considering the benefits in terms of economic growth and increased welfare.

The right to water has been embedded in *The Universal Declaration of Human Rights* since 1948. As is stated by the UN, "the human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use", where a sufficient quantity of water should correspond to WHO guidelines (CESCR 2003, p. 1). Although it is difficult to set a universal water poverty line due to regional differences in climate and basic needs, a minimum of 20 litres a day from a source within 1 kilometre of the household has been suggested. This is the level of water that is sufficient for drinking and basic personal hygiene (WHO and UNICEF 2000).

Despite the relatively recent emergence of the financial crisis, government response in terms of implementing fiscal stimulus packages has been more or less instant. In contrast, although there are 23 UN agencies dealing with water and sanitation, it is evident that there has been an "excess of words and a deficit of action" (UNDP 2006, p. 8). Meeting the drinking water target would require that 89 percent of the population in developing regions use improved sources[1] of drinking water by 2015. Although it is expected that the target will be reached on an aggregate level, regional differences are considerable. Presently accounting for more than a third of those without improved drinking water supplies, Sub-Saharan Africa is the region estimated to be the furthest away from reaching the MDG water and sanitation target. During 1990-2004, the number of people without access to drinking water in the region has increased by 23 percent, implying that the region will not reach the desired target until 2040. This lag acts as a substantial barrier to the attainment of the rest of the MDGs in this region (UN 2008).

The severity of the situation calls for the same type of consorted actions as the ones being implemented in response to the financial crisis. However, it is less straightforward where to place the emphasis of these measures in order to counteract the escalating water crisis. The aim of this

[1] Improved water sources include household connections, public standpipes, boreholes, protected dug wells, protected springs and rainwater collection. In contrast, unimproved water sources include vendors, bottled water, tanker trucks and unprotected wells and springs (UNDP 2006).

thesis is to investigate which areas of development need to be prioritised to induce water sector improvements in Sub-Saharan Africa.

The investigation will be restricted to Sub-Saharan Africa, allowing us to focus on a set of countries that despite their differences are less heterogeneous than a global sample would be. Using a human rights approach to water, our investigation is focused toward household use rather than industrial or agricultural use. The next section discusses previous research, serving as a basis for detecting the reasons behind water scarcity in water-stressed regions. These reasons, in turn, constitute the foundation of our analysis.

Literature review

There has been extensive research conducted on the topic of water scarcity – an issue becoming increasingly relevant with respect to global development and the severe consequences that researchers are warning for. The answer to why water provision is lacking varies between regions: differences in basic conditions regarding climate and culture as well as seasonal variability affect the level of water provision. Furthermore, storage capacity and targeted efforts by communities and NGOs add to local differences (UNDP 2006). Nevertheless, several of the reasons mentioned as being relevant in the literature should have a universal effect on water provision in developing countries. Previous research in the form of scholarly articles and policy reports give us an insight to which factors may potentially cause water scarcity.

Research articles

In scholarly research articles the discussion commonly regards the issue of water pricing or water sector management. There are also a number of studies analysing the reasons behind water scarcity; these are however mainly on a local field study level.

An essential distinction has to be made between physical water scarcity and constructed water scarcity. Despite being relatively well-endowed in regards to physical resources, Sub-Saharan Africa is one of the most water-stressed regions in the world. Seeing that the water withdrawals in 2003 constituted only 3 percent of the actual available resources, there are considerable possibilities for further development (Namara, Van Koppen and Safilios-Rothschild 2005). Van Koppen (2003) calls the water problem in Sub-Saharan Africa "economic water scarcity", suggesting that there is a lack of financial resources and incentives for proper distribution rather than actual water resources. Also Mehta (2003) separates the concept of water scarcity into *real* scarcity and *manufactured* scarcity, with the latter being a consequence of socio-political and institutional factors. Using the Indian region Kutch as an example, Mehta concludes that inequality in the control of water resources can lead to the constructed aspects of water scarcity being overlooked. If pure resource availability cannot explain the level of domestic water supply within a region, the reasons behind water scarcity should thus be sought elsewhere.

Using cross-sectional data, Basani, Isham and Reilly (2008) investigate the determinants of household access to water in Cambodia. They find that financial constraints, in terms of the size of the connection fee and the level of household welfare have a significant impact on household connections. Furthermore, by analysing data from a number of transition and developing countries, Mainardi (2003) observes a significant negative effect of income inequality and poverty levels on water infrastructure development. However, when investigating water demand in rural villages in developing countries, The World Bank Water Demand Research Team (1993) find that household income is not always the most important determinant – instead the willingness to pay also depends on the nature of the existing compared to the improved system. Moreover, women are generally found to be more willing to pay for improved water provision than men.

If economic constraints indeed have an effect on water supply, aid flows should also be taken into consideration. The effect of aid has been disputed for decades. On the one hand, aid has been criticised for being misdirected, inefficient and in some cases directly contributing to corruption. Knack (2001) for example, analyses cross-country data and provides evidence that higher aid levels erode the quality of governance, as measured by indices of bureaucratic quality, corruption, and the rule of law. On the other hand, the review by Hansen and Tarp (2000) detects a lack of consensus between economists regarding the effects of aid on growth, despite the fact that a majority of the previous studies confirm a positive relationship. In part, they hypothesise this to be due to the dominance of a few highly influential studies, arguing a negative relationship, in the debate. Also, they acknowledge that the macroeconomic impact of aid cannot be fully captured in simple analytical framework. Furthermore, specific concerns have been raised regarding the effect of aid earmarked for water, since there is a possibility that a majority of the aid is invested in regions where the population to some extent already has access to water, rather than directed to improving coverage for the unserved population (Gleick et al. 2006).

Also, with water being a finite resource, rapid population growth places an increased strain on available resources. Falkenmark (1990) examines a theoretical relationship between water scarcity and population size and finds that population growth consumes some of the water potential still available to meet an increasing water demand. Thus, population growth constrains both present and future water availability, and consequently impedes development.

Moreover, institutions can affect water availability in many ways: through the level of citizen influence on political decisions, the quality of the infrastructural stock or the amount of investments undertaken in the water sector (UNDP 2006). Corruption, for example, is estimated

to cause a loss of between 20 and 40 percent of water sector finances as well as increasing transaction costs, decreasing the level of investments undertaken and undermining the legal system (Stålgren 2006). The quality of the institutions is in turn determined by for example the strength of the legal system, the political stability, the level of equality and citizen empowerment. Upon investigating the performance of rural water projects and the level of citizen influence, Isham, Narayan and Pritchett (1995) find strong statistical evidence that greater participation of aid beneficiaries lead to superior project performance. This link is extended in Isham, Kaufmann and Pritchett (1997), where the authors use cross-national data to find a causal relationship running from enhanced civil liberties to increased citizen voice to greater efficiency in government projects. Saleth and Dinar (1999) empirically analyse the relationship between water institutions and water sector performance. They find that the performance of water law and water policy has a positive and significant impact on water sector performance.

Another aspect commonly mentioned in the debate on water scarcity is the relationship between gender inequality and water sector development. As Crow and Sultana (2002) discuss, gender relations interacting with material inequalities affect access to water. Women and children spend a significant amount of time to provide household access to water, especially in rural areas of the global South. Moreover, men tend to dominate ownership of property, market access to water and decision-making in state offices and communal institutions. Consequently, they have a larger influence over different forms of water access. Since men tend to control *productive* uses of water (for example irrigation for large-scale agriculture) while women tend to manage water at the *household* level, public sector investment in water may be influenced towards prioritising productive uses rather than domestic ones. Roy and Crow (2004) confirm this pattern by providing evidence of a statistical interaction between female school enrolment, access to water and income. Moreover, they suggest that the failure of most post-colonial governments to provide sufficient water access to the domestic population reflects the inadequate representation of women and the poor in government.

Inefficient distribution has also raised the issue of whether to treat water as a social or an economic good. Winpenny (1994) is one of several researchers to conclude that water, being a scarce commodity, should be treated and priced as an economic good. The argument is that underpricing of water fails to take externalities and opportunity costs into account, thereby leading to waste of an already scarce resource. Poor management of public water services in many countries has also led to new opportunities for private sector participation. However, the results from water sector privatisation have been mixed and it is difficult to draw a general conclusion on

the effects on quality and utility (Kirkpatrick, Parker and Zhang 2006). The literature on both the issue of water pricing and the ongoing debate of water sector privatisation is extensive.

It is also evident that large disparities exist between urban and rural areas, with water availability usually being much higher in densely populated urban regions. Most of the existing infrastructure and political power is concentrated in the cities, whilst the rural population is often dispersed, poor and politically weak. Mainardi (2003) discusses the large differences between urban and rural coverage rates, most likely due to lacking infrastructure and insufficient financing in scarcely populated areas. However, he also finds that the rapid urbanisation in developing countries has put a further strain on water supply.

Policy reports

The factors mentioned in previous studies are confirmed by the policy reports and working papers published by international NGOs and interest organisations. These reports are generally empirically rather than theoretically based; nevertheless they provide useful insights on the situation and consequences of water scarcity.

Economic constraints are often mentioned as a reason for the low coverage rates, both on a national and a household level. For many countries there is a large gap between the financing requirements and the actual level of investments. Also, some of the poorer families cannot afford the fees associated with formal networks and thus have to rely on unimproved water sources with questionable quality (UNDP 2006). Water scarcity comes with great economic costs for society and has widespread consequences for the population in developing nations. Improving water availability increases the possibility of reaching all other MDGs and is thus closely linked to other development factors, such as health improvements, poverty reduction, gender equality and educational levels (Soussan 2003). This view suggests that increasing water access cannot be done within the water sector alone, and the evolvement of Integrated Water Resource Management is a step in this direction. IWRM is a process focused on coordinating development and management of water, land and other related resources across nations to achieve maximum social and economic welfare under the principles of good governance and public participation (Rahaman and Varis 2005). As Van Koppen (2003, p. 1052) puts it: "In IWRM water is not [treated] as an isolated, technical issue, but [as] part and parcel of overall societal aims for multi-sectoral development and poverty eradication".

Summary of previous research

In summary, there seem to be a number of factors hypothesised to affect water supply and many of these are likely to be intertwined. For Sub-Saharan Africa, the availability of physical resources does not seem to have a large part in explaining the scarcity. Economic resources such as GDP appear to be positive for water sector development, whereas the effect of aid on growth and development is disputed. Population growth puts an increased strain on current water resources and is likely to negatively affect the quantity available for future generations. The importance of high quality institutions is verified by the effect of corruption, citizen empowerment and legal framework on water provision effectiveness. Moreover, studies have confirmed a relationship between gender equality and water sector development. The issues of water pricing, water sector privatisation and a possible urban bias in water provision are also relevant in a discussion of water sector development. However, because of the difficulty of evaluating these issues on a non-country specific basis and with a limited scope of the thesis, they will not be addressed.

Research questions and hypotheses

The first step in defining where efforts in water sector development should be concentrated is to identify the factors affecting water availability. There is little previous research on an aggregate cross country-level examining the effect of the factors related to water scarcity. The literature gives an indication of which individual factors may potentially affect access to water, but neither the composition of the factors that impact on the outcome nor the relative importance of these factors is examined. Furthermore, the effect of some of these factors is disputed. Given the fact that the MDG deadline of 2015 is drawing closer, effort and resources must be devoted to areas where they are most effective. Using a cross-country econometric approach, we will analyse the effect of different factors on water availability in Sub-Saharan Africa. By specifying a multiple regression, we will investigate: (i) *which of the factors hypothesised to have an effect on water availability are statistically and economically significant?* (ii) *judging from these effects, are some factors relatively more important than others?* and (iii) *is there any evidence that institutional and economic factors are more relevant for explaining water availability than the level of physical resources?*

Based on the literature, we hypothesise that physical resource availability is not essential for the level of water provision and consequently that institutional and economic factors are relatively more important. Thus, we expect higher institutional quality, gender equality and improved economic capacity to affect water access positively. Given the ambiguous effect of aid expressed in the literature, we will also investigate how this factor affects water availability.

The next section is a description of the approach used in formulating the econometric regression. The empirical findings are divided into two subsections, one describing the data and the individual variables to be included and one outlining the results of the regressions. This is followed by a discussion of the results, where the outcome is compared to the hypothesised relationships. The results and conclusions are then summarised in the final section, where the scope for future research is also outlined.

Empirical approach

In the literature a number of factors are mentioned as having a role in explaining water scarcity. To carry out the analysis, we estimate a multiple regression based on the factors emphasised in previous research. The aim has been to control for as many relevant variables as possible, taking into account factors related to both actual and constructed scarcity.

Data

Since the objective has been to analyse factors that seem to have an overall impact on water availability in the Sub-Saharan region, aggregate nation-level data has been used for the variables. The sample used consists of data from 45[2] countries in Sub-Saharan Africa. The majority of the data set originates from organisations such as the UN, World Bank and WHO. Despite the legitimacy of these institutions, data from developing countries needs to be interpreted with caution, since the quality can be subject to variation between years and between countries. To increase the comparability of the data, some variables have been adjusted to population size, as calculated by WHO-UNICEF, to obtain per capita measurements. Also, to keep the sample size as large as possible, proxies are used for the variables where data for certain countries is missing.

As the dependent variable WHO-UNICEFs measurement *Total water coverage* for 2004 is used, which is measured as a percentage of the population with access to the minimum requirement, as defined by the UNs Human Rights standards previously specified. This measurement is suitable for our purposes of investigating water availability from the individual's perspective. In previous research water scarcity is often defined as being a relative concept, taking into account both availability of water as well as domestic and industrial consumption patterns in that country. The human rights approach, in line with the MDG water and sanitation target, is more straightforward, making the cross-country comparison less distorted.

To control for differences in physical resource availability between countries, data for *Total actual renewable water resources per capita* is used. The variable measures the water resources theoretically available for development from all sources within a country.

[2] For a complete list of the countries in the sample: see Table 5 in the Appendix.

Gross domestic product per capita is used as a proxy for economic capacity. This measurement is intended to capture the capacity to finance investments in water infrastructure and expenditure on water-related services.

To take into account international aid flows not included in the GDP-measurement, *Official Development Assistance to water per capita* is added as an independent variable. A majority of this aid is invested in water and sanitation projects and excludes amounts committed to large water-related infrastructures.

Annual population growth rate is included to account for the increased strain of a larger population on the available water supply. To prevent biased results in the regression, two outliers are dropped.[3]

The *Civil Liberties Index* is used as a proxy for measuring the quality of the institutional environment in a country. It measures freedom of expression, assembly, association and religion: for example the freedom of press, the ability to create trade unions, equal protection under law and property rights. The index should thus capture the effect of corruption and institutional quality found in the literature. The index ranges on a scale from 1 to 7, where 7 is the "least free".

To investigate whether there is a direct effect of gender inequality on water accessibility, *female percentage of secondary education enrolment* is used as a proxy for the level of equality. This proxy measures the extent to which women are given equal opportunities to education and can thus be regarded as an acknowledgement of their general rights in society.

To obtain a better functional form and a more suitable interpretation, some of the variables are expressed as logarithms. The variables are summarised in *Table 1* below.

[3] Rwanda and Ethiopia

Table 1. Overview of the variables

Variable name	Definition	Description	Source
WATCOV	Water supply coverage % (2004)	Access to water supply services is defined as the availability of at least 20 litres per person per day from an improved source within 1 kilometre of the user's dwelling.	WHO-UNICEF Joint Monitoring Programme
logTARWR	Total Actual Renewable Water Resources, m^3 per capita per year (2000)	An estimate of the maximum theoretical amount of water actually available for the country.	Food and Agriculture Organization of the United Nations (FAO)
logGDP	GDP per capita PPP (2003)	GDP adjusted for purchasing power parity in constant 2005 international dollar terms.	World Bank
logODA	Average annual ODA for water per capita (1990-2004)	ODA is provided by governments and official agencies for the purpose of promoting economic development and welfare. It finances a broad range of water-related projects, including water supply and sanitation, but excluding amounts committed for large water-related infrastructures.	World Water Council (Clermont)
POPGROWTH	Average annual population growth rate (1995-2004)		WHO-UNICEF Joint Monitoring Programme[4]
CIVIL	Civil Liberties Index (2004)	Measures freedom of expression, assembly, association, and religion on a scale of 1 to 7.[5] 1 = most free and 7 = least free.	Freedom House
FEM	Female percentage of secondary education enrolment (2000)	Female percentage of pupils enrolled at secondary level in public and private schools.	World Bank[6]

Although this thesis will not cover urban and rural differences in water access, the data also confirms the significant disparities in water coverage between urban and rural regions.

Since most of the measurements that are used as development indicators are closely related, we expect a certain level of correlation between the independent variables but strive to minimise the risk of multicollinearity. Because of the high correlation, it is also important to remember that the

[4] Own calculations based on data from this source.
[5] For a detailed description of the ranking: see Table 7 in the Appendix.
[6] Own calculations based on data from this source.

causality could run both ways, implying that an independent variable in itself is a consequence of the dependent variable it tries to explain. To control for the possibility of reversed causality, data from earlier years have been used for some of the independent variables.

Econometric specification and regression results

Firstly, the correlation between the variables was examined to get an indication of the relationships between all variables. The results are shown in *Table 2* below.

Table 2. Correlation matrix

	WATCOV	CIVIL	logTARWR	logGDP	POPGROWTH	FEM	logODA
WATCOV	1.0000						
CIVIL	-0.4747	1.0000					
logTARWR	-0.2172	0.2655	1.0000				
logGDP	0.4633	-0.1603	0.1039	1.0000			
POPGROWTH	-0.4879	0.2572	0.2470	-0.5866	1.0000		
FEM	0.5480	-0.4367	-0.1513	0.4119	-0.5423	1.0000	
logODA	0.4086	-0.4273	-0.3699	0.3807	-0.4446	0.1914	1.0000

Moreover, a multivariate regression was estimated to examine the relative importance of the independent variables on water coverage rates. Having established normal distribution of the data, the following regression was estimated using the method of OLS:

$$WATCOV = \beta_0 + \beta_1 \, logTARWR + \beta_2 \, logGDP + \beta_3 \, logODA + \beta_4 \, POPGROWTH + \beta_5 \, CIVIL + \beta_6 \, FEM + u$$

The results of the regression are shown in *Table 3* below.

Table 3. Results of the extended regression

Source	SS	df	MS	Number of obs =	39
				F(6, 32) =	4.68
Model	4561.1829	6	760.19715	Prob > F =	0.0016
Residual	5193.79146	32	162.305983	R-squared =	0.4676
				Adj R-squared =	0.3677
Total	9754.97436	38	256.709852	Root MSE =	12.74

WATCOV	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
logTARWR	-.9438272	1.736016	-0.54	0.590	-4.479975	2.592321
logGDP	3.758068	2.8091	1.34	0.190	-1.963882	9.480019
logODA	1.415681	2.350226	0.60	0.551	-3.371572	6.202934
POPGROWTH	-1.42872	3.817476	-0.37	0.711	-9.204665	6.347225
CIVIL	-2.654718	1.836775	-1.45	0.158	-6.396107	1.08667
FEM	.6065018	.3777227	1.61	0.118	-.1628941	1.375898
_cons	33.28548	31.67273	1.05	0.301	-31.22975	97.80071

When performing the Breusch-Pagan test, we found no evidence of heteroskedasticity. Furthermore, Ramsey's RESET test indicated a low probability of omitted variable bias. Due to missing data and correction for outliers, six countries were dropped from the regression, reducing the data set to 39 observations.[7]

Although the F-test displays a high joint significance, none of the variables are independently statistically significant at a 10 percent level. The adjusted R^2 implies that approximately 37 percent of the variation in WATCOV is explained by the model.

The relatively low degree of correlation between logTARWR and the dependent variable, as well as the counterintuitive negative sign, could imply that the variable is irrelevant to explaining water availability. Furthermore, upon examining the correlation between the independent variables, it is clear that POPGROWTH is highly correlated with the other variables. Since many of the variables

[7] Burundi, Central African Republic, Ethiopia, Rwanda, the Seychelles and Zimbabwe were dropped.

are per capita measurements, it is likely that a change in this variable directly affects the other independent variables. This was confirmed when testing the variables for multicollinearity. To estimate a model more robust to econometric constraints such as multicollinearity and model overspecification, the variables POPGROWTH and logTARWR were dropped. Thereby, a new regression was estimated:

$$WATCOV = \beta_0 + \beta_1 \, logGDP + \beta_2 \, logODA + \beta_3 \, CIVIL + \beta_4 \, FEM + u$$

The results of estimating the restricted model are shown in *Table 4* below.

Table 4. Results of the restricted regression

Source	SS	df	MS	Number of obs =	42
				F(4, 37) =	8.53
Model	5859.78448	4	1464.94612	Prob > F =	0.0001
Residual	6351.83456	37	171.671204	R-squared =	0.4799
				Adj R-squared =	0.4236
Total	12211.619	41	297.844367	Root MSE =	13.102

WATCOV	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
logGDP	4.112878	2.283011	1.80	0.080	-.512941	8.738697
logODA	2.762789	2.136775	1.29	0.204	-1.566729	7.092307
CIVIL	-2.628199	1.810416	-1.45	0.155	-6.29645	1.040052
FEM	.7414697	.3386946	2.19	0.035	.0552092	1.42773
_cons	12.18885	19.82022	0.61	0.542	-27.97073	52.34844

When dropping the two variables, the number of observations increased to 42.[8] There was no evidence of heteroskedasticity at a 10 percent significance level. The residuals were analysed and found to follow a normal distribution, implying relatively reliable coefficient estimates. Furthermore, we found a low probability of omitted variables.

[8] When excluding POPGROWTH, Ethiopia and Rwanda were again included in the data set as a consequence.

The adjusted R^2 increased compared to the previous regression, with approximately 42 percent of the variation in WATCOV being explained by the independent variables. Furthermore, the p-values of the remaining independent variables displayed a higher significance when the two variables were dropped. Testing for joint significance, we found that the remaining variables together were highly statistically significant.

Discussion

In general, the empirical findings appear to support previous research and the hypotheses outlined in the beginning of our thesis.

With the exception of logTARWR, both the degree and direction of the correlations are in line with the intuitive relationship between water coverage and the independent variables. The variables logGDP, FEM and logODA display a significant positive correlation with the dependent variable, whereas CIVIL[9] and POPGROWTH show a strong negative correlation. The correlation between logTARWR and water coverage is weaker, with a counterintuitive negative sign. This appears to support the view that physical resource availability has little explanatory power when analysing the factors determining water availability in Sub-Saharan Africa.

Having run a regression on the *extended* model, we find that the signs of the coefficients are intuitive, with the exception of logTARWR, which has a counterintuitive negative effect. Together with POPGROWTH and logODA, it is also highly statistically insignificant. Since multicollinearity, in combination with a relatively small data set and many explanatory variables, produces large standard errors, the extended model may not be optimal for determining statistical inference. Given this restriction, it could be difficult to obtain a high degree of statistical significance for our variables on some of the lower significance levels.

Despite our small sample, we find that after restricting the regression to four variables, FEM and logGDP are individually statistically significant on a 10 percent significance level. This supports the causal relationship between these variables and the dependent variable. The coefficients on these variables confirm the hypothesised direction, with GDP having a larger effect on water coverage rates compared to our proxy for gender equality.

According to our results, a ceteris paribus increase of one percentage point in GDP would improve water coverage rates by 4.11 percent. This is in line with the expected relationship between economic capacity and water coverage rates. Since water coverage rates depend on both investments in infrastructure, maintenance of existing water systems and the ability to pay for water related services, this positive impact of GDP is not surprising. Since Sub-Saharan Africa displays a range of different systems when it comes to financing and operating water distribution,

[9] Note that an increase in civil liberties ranking implies a decline in institutional quality.

the effect of an increase in GDP varies depending on the nature of the investments required for the specific region. This in turn depends on the level of existing infrastructure as well as the type of fees associated with water provision, which is explored in detail in local field studies. To further analyse the effects of GDP on water coverage rates future research could investigate the division between public and private ownership as well as public and private financing on an aggregate cross-country basis.

The variable found to be most statistically significant is FEM. The results verify the hypothesised positive effect of gender equality on the dependent variable, although the effect is found to be relatively small. It is possible that a proxy that more precisely captures the level of female empowerment will show a stronger relationship and positive effect in the regression. Increased gender equality is likely to introduce a stronger focus on water issues, thereby putting them on the political agenda to a greater extent. However, it is also plausible that the effect of an improvement in gender equality is subject to a considerable time lag. Because of this lag between improved equality and actual policy implementation, the positive effect may be underestimated in water coverage statistics.

The variable CIVIL has a negative coefficient, which is in line with the hypothesis that low quality institutions lead to lower water coverage rates. However, the variable is only statistically significant when relaxing the significance level to 20 percent. It is possible that CIVIL is not relevant in explaining the dependent variable. Given the strong emphasis on institutional quality in previous research however, it is more plausible that data limitations such as imprecise proxies and a small data set cause the insignificance of the variable. It is thus likely that having access to a larger data set would produce a more significant result. Moreover, the economic significance of the variable is relatively small. A one step ceteris paribus increase in the Civil Liberties Index, which is likely to require vast efforts and large investments, translates into a relatively small increase in water coverage rates of 2.63 percent. The small effect is surprising given the strong hypothesised relationship between institutions and water availability. This could reflect the fact that an improvement in institutional quality mainly influences the other determinants of water coverage rates and that the effect on water availability thus is captured indirectly rather than directly.

LogODA has a positive coefficient but is insignificant at both a 10 and 20 percent level. Despite having a relatively precise measurement of aid earmarked for the water sector, the variable does not seem relevant in explaining water coverage rates, which thus supports the view of aid critics. Comparing the effects of ODA and GDP, it is clear that GDP is more significant both

economically and statistically. The possibility that ODA is unevenly distributed also implies that the effect of aid in the water sector differs between regions. A closer investigation of the effects on urban and rural water coverage respectively could give an indication of whether an urban bias is present in aid distribution and how this affects water provision in different regions.

The strong joint significance of the variables signals that, together, they are highly relevant in explaining water coverage rates. Although the individual effects of the variables are less straightforward in interpretation, they appear to have a strong explanatory power altogether. This is indicative of a certain level of interdependence between these various development indicators. An understanding of the mechanisms of this interdependence could lead to useful insights of which factors produce the greatest multiplier effects in increasing water access, an important step in the process of coordinating water sector development.

Conclusion

The aim of this paper is to investigate to which fundamental factors efforts need to be devoted in order to achieve water sector development. Using aggregate cross-country data, we have attempted to explain water availability in Sub-Saharan Africa by estimating an econometric regression. The existing literature has been used as a guide to identifying the variables hypothesised to have an effect on water supply coverage.

The results show that institutional and economic factors together are highly relevant for explaining access to water. A considerable challenge in separating the effect of the included variables is their high degree of interdependence, which is a natural outcome since improvements within one area usually require improvements within other areas of development. The high level of joint significance of the included variables confirms this linkage. Regarding the individual effects, one view that can be rejected with certainty is that the problem of water scarcity in Sub-Saharan Africa is due to a lack of physical resources. Clearly, the reasons behind water scarcity are economic and institutional. Individually, an increase in GDP seems to be more effective than an increase in ODA. This suggests that economic growth within a country is a more effective way of achieving progress in the water sector than external aid. Thus, economic growth seems to be a more sustainable road to development, most likely due to a stronger focus on long-term progress.

The economic effects of improving gender equality and institutional quality are relatively moderate with the gender equality proxy being more statistically significant. On comparing the effects of gender equality and institutional quality, their relative importance is less clear as they are both rather imprecise proxies. These two variables are nevertheless likely to affect other development indicators and thus to have a positive impact on progress in general.

It is evident that reaching the MDG water and sanitation target is closely linked to the other goals of eradicating extreme poverty and improving gender equality and health. Thus, on formulating strategies to improve water coverage rates the key point of departure seems to be a holistic approach where all aspects of development are included. The difficulty of coordinating development across sectors could be an explanation to why water sector improvements are lagging behind. Solving the problem is a complex process requiring improvements in a wide range of sectors, both on a global and a local level. The objectives thus need to be adjusted for all facets of development, making the desired action plans less straightforward than a stimulus package targeted

toward boosting domestic demand. Also, as there are large regional variations, there is no strategy that can be implemented to work in all areas suffering from water scarcity.

Our investigation has shown that in order to reach the water and sanitation target, a holistic approach implemented in various development sectors is needed. It is not enough to isolate development strategies to one sector – our results show that improved institutions, gender equality and economic growth have to develop simultaneously to take advantage of the available synergy effects. The international community's increased focus on implementing IWRM effectively is a step in the right direction. Since the measures needed to achieve a successful IWRM process vary between regions, a great challenge lies in its practical implementation (Rahaman and Varis 2005). Recognising that crises in areas such as energy and food, financial markets and climate change are closely related to each other and the water crisis, a consorted global strategy flexible enough for local adaptation seems to be the road towards solving the water crisis and achieving sustainable development in other related areas in the process.

Placing the analysis on an aggregate level provides general conclusions about the region, but fails to take local differences into consideration. Future research would benefit from making a division between urban and rural water coverage, to obtain a more detailed discussion regarding the possible urban bias mentioned in the literature. Another area of interest could be to analyse whether agricultural and industrial use creates a crowding-out effect and more specifically, how this affects domestic use within a country. Furthermore, although our aggregate analysis has shown that several factors need to improve together, more specific country-level research focused on the interaction between development indicators could pinpoint the factors with the greatest multiplier effects for improved water access, which in turn would provide useful insights for development policies.

References

Acock, A.C. (2006), *A Gentle Introduction to Stata.* College Station, Texas: Stata Press.

Basani, M., Isham, J. and Reilly, B. (2008), "The Determinants of Water Connection and Water Consumption: Empirical Evidence from a Cambodian Household Survey", *World Development*, Vol. 36, No. 5, pp. 953-968.

BBC News Online (2009), "Obama Signs $787bn Stimulus Plan". Available [online]: http://news.bbc.co.uk/2/hi/business/7895078.stm [2009-05-09]

CESCR (2003), *General Comment No. 15: The Right to Water (Arts. 11 and 12 of the Covenant)*, 20 January 2003, E/C.12/2002/11. Available [online]: http://www.unhcr.org/refworld/docid/4538838d11.html [2009-05-12]

Clermont, F. (2006), *Official Development Assistance for Water from 1990 to 2004 – Figures and Trends.* Marseille: World Water Council.

Crow, B. and Sultana, F. (2002), "Gender, Class, and Access to Water: Three Cases in a Poor and Crowded Delta", *Society and Natural Resources,* Vol. 15, pp. 709-724.

EUbusiness (2008), "EU Launches 200-billion-Euro Stimulus Package". Available [online]: http://www.eubusiness.com/news-eu/1227698222.3 [2009-05-09]

Falkenmark, M. (1990), "Rapid Population Growth and Water Scarcity: The Predicament of Tomorrow's Africa", *Population and Development Review,* Vol. 16, pp. 81-94.

FAO (2009), *Summary table: Renewable water resources in the world by country.* Rome: FAO Land and Water Development Division. Available [online]: http://www.fao.org/nr/water/aquastat/water_res/waterres_tab.htm [2009-02-05]

Freedom House (2009), *Environmental Governance and Institutions,* Earth Trends. Washington: World Resources Institute. Available [online]: http://earthtrends.wri.org/searchable_db/index.php?theme=10 [Accessed 2009-03-31]

Gleick, P. et al. (2006), *The World's Water 2006-2007 – The Biennial Report on Freshwater Resources.* Washington D.C: Island Press.

Hansen, H. and Tarp, F. (2000), "Aid Effectiveness Disputed", *Journal of International Development,* Vol. 12, No. 3, pp. 375-98.

Hutton, G. and Bartram, J. (2008), "Global Costs of Attaining the Millennium Development Goal for Water Supply and Sanitation", *Bulletin of the World Health Organization,* Vol. 86, No. 1, pp. 13-19.

Kirkpatrick, C., Parker, D. and Zhang, Y. (2006), "An Empirical Analysis of State and Private-Sector Provision of Water Services in Africa", *The World Bank Economic Review,* Vol. 20, No. 1, pp. 143-163.

Knack, S. (2001), "Aid Dependence and the Quality of Governance: Cross-Country Empirical Tests", *Southern Economic Journal*, Vol. 68, No. 2, pp. 310-329.

Isham, J., Kaufmann, D. and Pritchett, L. (1997), "Civil Liberties, Democracy and the Performance of Government Projects", *The World Bank Economic Review*, Vol. 11, No. 2, pp. 219-242.

Isham, J., Narayan, D. and Pritchett, L. (1995), "Does Participation Improve Performance? Establishing Causality with Subjective Data", *The World Bank Economic Review,* Vol. 9, No. 2, pp. 175-200.

Mainardi, S. (2003), "Water Availability and Infrastructure Development: Cross-Country Econometric and Neural Network Estimates", *Desalination,* Vol. 158, No. 1-3, pp. 242-254.

Mehta, L. (2003), "Contexts and Constructions of Water Scarcity", *Economic and Political Weekly,* Vol. 38, No. 48, pp. 5066-5072.

Namara, R., Van Koppen, B. and Safilios-Rothschild, C. (2005), *Reducing Poverty through Investments in Agricultural Water Management* (*Part 2. Synthesis of Sub-Saharan Africa Case Study Reports by Peacock, Omilola and Kamara et al.*), Working Paper 101. Colombo, Sri Lanka: IWMI.

The New York Times (2008), "China Unveils Sweeping Plan for Economy". Available [online]: http://www.nytimes.com/2008/11/10/world/asia/10china.html?scp=1&sq=china%20stimulus%20package&st=cse [2009-05-09]

Rahaman, M. M. and Varis, O. (2005), "Integrated Water Resources Management: Evolution, Prospects and Future Challenges", *Sustainability: Science, Practice & Policy,* Vol. 1, No. 1, pp. 15-21.

Roy, J. and Crow, B. (2004), *Gender Relations and Access to Water: What We Want to Know about Social Relations and Women's Time Allocation*, Working Paper 2004-5. Santa Cruz, California: Center for Global, International and Regional Studies, University of California.

Saleth, M.R. and Dinar, A. (1999), *Evaluating Water Institutions and Water Sector Performance,* World Bank Technical Paper No. 447. Washington: World Bank.

Soussan, J. (2003), *Poverty, Water Security and Household Use of Water*. Muldersdrift, South Africa: International symposium on Water, Poverty and Productive Uses of Water at the Household Level, 21-23 January 2003. Available [online]: http://www.musgroup.net/content/download/449/4751/file/proceeding_19.pdf [2009-05-10]

Stålgren, P. (2006), *Corruption in the Water Sector: Causes, Consequences and Potential Reform*, Swedish Water House Policy Brief No. 4. Stockholm: SIWI.

UN (2008), *The Millennium Development Goals Report 2008*. New York: United Nations.

UNDP (2006), *Human Development Report 2006*. New York: Palgrave Macmillan.

Van Koppen, B. (2003), "Water Reform in Sub-Saharan Africa: What is the Difference?", *Physics and Chemistry of the Earth*, Vol. 28, No. 20-27, pp. 1047-1053.

Winpenny, J. (1994), *Managing Water as an Economic Resource.* London: Routledge.

Wooldridge, J.M. (2006), *Introductory Econometrics – A Modern Approach,* 3rd Edition. Mason, Ohio: Thomson South-Western.

World Bank (2009), *GenderStats*. Washington: World Bank. Available [online]: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTGENDER/EXTANATOOLS/EXTSTATINDDATA/EXTGENDERSTATS/0,,contentMDK:21347401~menuPK:4851945~pagePK:64168427~piPK:64168435~theSitePK:3237336,00.html [Accessed 2009-03-02]

World Bank (2009), *World Development Indicators,* WDI Online. Washington: World Bank. Available [online]: http://0-ddp-ext.worldbank.org.inn.hhs.se/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=6 [Accessed 2009-03-02]

World Bank Water Demand Research Team (1993), "The Demand for Water in Rural Areas: Determinants and Policy Implications", *The World Bank Research Observer,* Vol. 8, No. 1, pp. 47-70.

WHO and UNICEF (2000), *Global Water Supply and Sanitation Assessment 2000 Report.* Geneva: WHO, New York: UNICEF.

WHO and UNICEF Joint Monitoring Programme (2009), *Water Supply Data.* Geneva: WHO, New York: UNICEF. Available [online]: http://www.wssinfo.org/en/watquery.html [Accessed 2009-01-30]

World Water Assessment Programme (2009), *The United Nations World Water Development Report 3: Water in a Changing World.* Paris: UNESCO, London: Earthscan.

Appendix

Table 5. List of countries

1. Angola
2. Benin
3. Botswana
4. Burkina Faso
5. Burundi
6. Cameroon
7. Cape Verde
8. Central African Republic
9. Chad
10. Comoros
11. Congo
12. Congo (Democratic Republic of the)
13. Côte d'Ivoire
14. Equatorial Guinea
15. Eritrea
16. Ethiopia
17. Gabon
18. Gambia
19. Ghana
20. Guinea
21. Guinea-Bissau
22. Kenya
23. Lesotho
24. Liberia
25. Madagascar
26. Malawi
27. Mali
28. Mauritania
29. Mauritius
30. Mozambique
31. Namibia
32. Niger
33. Nigeria
34. Rwanda
35. São Tomé and Principe
36. Senegal
37. Seychelles
38. Sierra Leone
39. South Africa
40. Swaziland
41. Tanzania
42. Togo
43. Uganda
44. Zambia
45. Zimbabwe

Table 6. Summary statistics of the variables

Variable	Obs	Mean	Std. Dev.	Min	Max
WATCOV	45	65.66667	17.02004	22	100
CIVIL	45	3.888889	1.385349	1	6
logGDP	44	7.238483	1.073477	5.513429	9.897368
POPGROWTH	43	2.391395	.8427692	.68	4.71
FEM	43	42.69535	7.201486	22.1	56.8
logODA	45	.3253783	1.113934	-3.073002	2.382161
logTARWR	44	8.640886	1.468134	6.338594	12.52699

Table 7. Civil Liberties Index ranking, detailed

1 Countries generally have an established and equitable rule of law with free economic activity.
2 Indicates some deficiencies, but these countries are still relatively free.
3, 4, or **5** Countries with these ratings experience varying degrees of censorship, political terror, and prevention of free association.
6 In general citizens experience severely restricted expression and association coupled with political terror
7 Indicates virtually no freedom. A poor rating for a country "is not necessarily a comment on the intentions of the government, but may indicate real restrictions on liberty caused by non-governmental terror."