Chapter Six

Water Poverty and Rural Development: Evidence from South Africa

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Abstract

Using household data from the 2009 General Household Survey, this paper examines the role of natural resource scarcity in rural development in South Africa, with a particular focus on water scarcity. It seeks to examine whether there is a direct link between household water and economic poverty of rural households, with households' total monthly income used as an indicator of economic poverty. An adaptation of a comprehensive water poverty index, which considers water access, quality, use, and water-related environmental aspects is used to measure household-level water poverty. The empirical analysis uses an instrumental variable estimation framework in order to deal with the potential endogeneity between water and economic poverty. Results support the existence of a direct link between water and economic poverty, with water-poor households likely to be economically poor. In particular, the results suggest that access to good quality water from a reliable source significantly enhances rural households' economic status. Also, access to water determines the realized impact of overall water poverty on a household's economic status. The paper thus cautions development policy not to treat water and economic poverty in isolation; there is need for development policy in South Africa to streamline water use in rural development. In addition, development policies need to take into account the role of household heterogeneity in conditioning both household water and economic poverty levels.

Keywords: Water, Poverty, Rural development, South Africa

1. Introduction

Empirical research highlights how poor water provision retards rural development through, for example, a significant distortion of household resource allocation decisions as well as poor health (see for example, Sullivan and Meigh, 2003; Kemp-Benedict et al, 2008). The linkages between households' access to water and development have also been shown to apply to South Africa, much in keeping with the rest of Africa (Hanjra and Gichuki, 2008). However, existing studies have tended to focus on water for agricultural production and have not taken into account the multiple uses of water in rural households (Moriarty et al, 2004; Moriarty and Butterworth, 2003; Soussan et al, unpublished). The complexity of household and community water poverty necessitates the need for it to be indexed on interdisciplinary indicators for it to be comprehensive.

This paper borrows from existing efforts in literature that attempt to develop and improve on a holistic Water Poverty Index (WPI) as a tool to measure water stress at household and community levels. Using household data from the 2009 South African General Household Survey, this paper examines the role of water scarcity in poverty reduction in South Africa, with a focus on rural households. This is especially important since it is widely recognized that South Africa will face water scarcity in the future, and the country is battling an ever growing poor population that lacks access to water, among other basic services. A particular objective of the paper is to establish whether there is a direct link between household water and economic poverty. Linked to this, the paper also examines how socio-economic characteristics predispose households to water and economic poverty.

The next section provides a brief literature review that summarizes existing findings or knowledge on the link between water poverty and rural development, with an emphasis on Sub-Saharan Africa as a whole and South Africa in particular. This is followed by a discussion of the data used in the empirical analysis in section 3. Section 4 outlines the methodology employed in the empirical analysis, while section 5 presents and discusses the empirical results. Lastly, the conclusions, together with relevant policy implications are presented in section 6.

2. Water and Rural Development

Despite the reportedly satisfactory progress towards the attainment of the drinking water target for the Millennium Development Goals spurred partly by the recognition that water is an essential developmental tool, Sub-Saharan Africa (SSA) continues to face significant water provision challenges. Nearly 900 million people in Sub-Saharan Africa, comprising 40% of the region's population, lack access to adequate water, the majority of them poor (WHO/ UNICEF, 2010). Needless to say, this has implications for the health of the affected people, their food security and the natural resources on which their livelihoods depend.

Existing studies have demonstrated how high levels of poverty are strongly linked to poor exploitation of water resources (Savenije, 2000; Hanjra and Gichuki, 2008). In addition, specific linkages have been made between water poverty and general socio-economic poverty rankings. This is of particular relevance to Sub-Saharan Africa where rural development is characterized by a significant reliance on agricultural production. In Sub-Saharan Africa, it is estimated that 75% of the population lives in rural areas, where rain-fed agriculture is the main source of livelihood. This means that water is a critical element not only for production purposes, but also for reproductive and consumption purposes.

The complex linkages among water, the environment, and poverty have attracted some attention amongst development practitioners, researchers and policy makers. There is general consensus that while, to date, increases in agricultural productivity that have had some impact on poverty have been due to expansion in cropped land, there is need to focus on raising productivity through improved efficient practices that increase per unit yields (Hanjra and Gichuki, 2008). This includes efficient use of agricultural water.[1] The limited research and policy attention given to the multi-source multi-purpose nature of agricultural water can compromise sustainable rural development (Moriarty and Butterworth, 2003: 6). In cognisance of the multiple purposes or demands on rural water supply, the programmatic focus of interventions is perhaps aptly summed in a working document advocating for the establishment of the 'End Water Poverty' initiative that states "*Rural water and poverty actions must be further integrated into the policies and programs of developing countries, to directly target improvements in the water security of the rural poor, including increased investments in pro-poor rural water and poverty programs. These investments must address the following three main areas: (i) rural water supply, hygiene promotion, and sanitation; (ii) water for production and sustainable rural livelihoods, including pro-poor irrigation, as well as watershed and ecosystems management; and (iii) prevention and mitigation of water-related disasters in rural areas*". This highlights the centrality of water in poverty alleviation efforts that address the needs of rural households in a holistic and integrated manner.

In the case of South Africa, an evaluation of the policy and planning framework indicated that although a basic framework for the productive use of water existed in the country, it was not sufficiently comprehensive or explicit to facilitate implementation (Naidoo et al, 2009). Consequently, South Africa faces a number of challenges in community and household supply of drinking water, although it has to be pointed out that the whole sub-region is faced with water scarcity and poverty. The mandate for the provision of water services in the country rests with Water Service Authorities (WSAs) at the local government level as provided in the Municipal Structures Act of 1998. Thus, according to the Strategic Framework for Water Services, WSAs

1. It is acknowledged that while access to, and efficient use of agricultural water is necessary for optimal poverty reduction, it is not on its own sufficient to break the poverty trap, as the impact of interventions depends on a wider set of factors.

have to ensure the progressive realization of the right to water for all people within their area of jurisdiction (Department of Water Affairs and Forestry, 2003). In South Africa, basic water supply is defined as 25 litres per person per day, within 200 metres of the home, and the water should be of acceptable quality. The adequacy of this amount for the rural household has itself been questioned (Naidoo et al, 2009). Nonetheless, there are indications in present day South Africa that these basic water supply services are provided in an ad hoc manner by WSAs, at widely varying compliance rates with national standards as the authorities face numerous challenges in fulfilling their mandate (Department of Water Affairs and Forestry, 2003).

The WSA or municipality typically provides taps throughout rural communities. However, the distribution of water to these taps is infrequent, sometimes only once or twice a month, thus failing to provide an adequate supply of portable water (Harshfield et al, 2009). In some cases, the communal taps that have been installed are not operational due to lack of maintenance, forcing communities to obtain water from unsafe sources such as rivers and dams. In the recently published 'State of Local Government' report, the rural WSAs appear to be harder hit in terms of service provision (Department of Co-operative Governance and Traditional Affairs, 2009).

In 2007, the then Department of Water Affairs and Forestry (DWAF) forecasted that water service delivery backlogs would be eliminated by 2011, and sanitation backlogs by 2013. However, by 2008, the official estimate was that six million South Africans, nearly 14% of the population, did not have access to a reliable source of safe drinking water, while 13 million did not have access to adequate sanitation. The majority of the affected people were and still are in the "hard to reach communities" that are in remote rural areas characterized by difficult terrain, as well as in unplanned peri-urban settlements (Statistics South Africa, 2008). As further indication of the challenge in effectively and sustainably reaching these communities, the percentage of households with access to safe off-site water sources (neighbour's tap, communal tap or offsite borehole) increased from 16.7% in 2002 to 20.1% in 2008 (Statistics South Africa, 2008). Furthermore, even though there have been annual fluctuations, the percentage of households who received piped water supplies from their WSAs decreased from 78.9% in 2004 to 74.8% in 2008 (Statistics South Africa, 2008).

The communities with the lowest rates of access to safe water are in some of the poorer provinces of the country, namely Eastern Cape, KwaZulu-Natal and Limpopo. They all fall below the national average (88.9%) of access to piped water (Statistics South Africa, 2008) and have the higher proportion of rural communities. Limpopo Province has the greatest proportion of rural communities (90%) followed by Northern Cape (80%), Eastern Cape (62%), Mpumalanga (61%) and lastly KwaZulu-Natal (55%). Overall, approximately 40% of South Africa's population resides in rural areas (University of Witwatersrand, 2008).

Rural water supply in South Africa has historically been a challenge due to accessibility issues and settlement patterns that increase the cost of service delivery relative to the urban scenario. This is evident in these 'hard to reach' or remote rural communities. Thus, in recognition of this and the linkages between poverty, water scarcity and development, it is imperative to comprehensively understand the nature and implications of water scarcity for sustainable rural development in South Africa.

In particular, the multi-faceted nature of water poverty implies that creating this understanding requires a holistic approach. In line with this, researchers and development practitioners have attempted to construct a water poverty index that comprehensively summarizes the multiple factors that contribute to community and household water poverty.

2.1 Water Poverty Index

The Water Poverty Index (WPI) is principally designed to assist decision makers at different levels in developing and targeting interventions that aim to increase water security for the poor. Although initial theoretical approaches of the index emerged at the turn of this century (Sullivan 2001, 2002), the index has subsequently been further developed through participatory consultations with stakeholders. The WPI stems from a realization that assessing households' access to water requires a holistic approach that takes into consideration not only whether or not a household has access to water, but also issues relating to water quality and variability, multiple uses of water, households' capacity to manage water, as well as environmental and spatial scale aspects related to water. In proposing a WPI that takes into account these aspects, Sullivan et al (2003) identify, via a community participatory approach, the following five components as key to a holistic WPI:

(i) *Resources*: this captures physical availability of both surface and groundwater,

(ii) *Access*: this considers access to water for human use (drinking and non-drinking),

(iii) *Capacity*: this relates to the ability of people to manage water,

(iv) *Use*: this considers the multiple uses of water, and

(v) *Environment*: this seeks to factor in environmental integrity related to water resources.

These five components are used to construct a WPI. Sullivan et al (2003) argue that the construction of the WPI should follow a structure similar to that of the Human Development Index (HDI). Specifically, each component is constructed via the following general formula:

$$WPI = \frac{\sum_{i=1}^{N} w_i X_i}{\sum_{i=1}^{N} w_i}, \qquad (1)$$

where for each household, WPI refers to the Water Poverty index; X_i refers to component i of the household's WPI, with

$i = Access, Capacity, Use,$ and $Environment$, while w_i is the weight applied to that particular component.

Application of the WPI at the community level has been tested in three countries − South Africa, Tanzania and Sri Lanka− in a combination of urban and rural settings (Sullivan et al, 2003). Since then, the index has been improved and applied in different settings with recommendations for improvement for further application.

The concept of a WPI is based on the view that poverty is a lack of at least one of the basic prerequisites to a safe, healthy and productive life (Sullivan et al, 2003). Water is interpreted as one such prerequisite, lack of which has adverse consequences such as poor health, partly as a result of compromised hygiene, as well as limited productivity, which would then impact on food security and wider economic performance. Thus, the application of a WPI presents an opportunity to incorporate the socio-economic status of rural households into an understanding of households' access to water resources.

3. Methodology

3.1 Data and Description

The empirical analysis of this paper is based on data from the 2009 General Household Survey (GHS).The GHS is a household survey conducted annually by Statistics South Africa since 2002. The rationale for the GHS stems from the government's need to regularly determine the level of development in the country and to assess the performance of programmes and projects. The GHS questionnaire focuses on six broad areas, namely: education, health, social development, housing, household access to services and facilities, food security and agriculture. A multi-stage stratified random sampling framework that uses probability-proportional-to-size principles in which the first level stratification is based on province and second-tier stratification on district council is used. The effective sample for 2009 comprises

25,361 households.[2] Of these, 6,002 are agricultural households while the rest are non-agricultural. We treat the agricultural households as rural agricultural households.[3]

Our measure of household water poverty is an adaptation of that of Sullivan et al (2003), which, as discussed in the preceding section, is a holistic multi-faceted measure. While analysis by Sullivan et al (2003) is at community level, our analysis is at household level. The disadvantage with a community level analysis is that it might overlook the micro-level dynamics related to water poverty; thus our analysis seeks to overcome this challenge by focusing on households. However, this means that the first component (resources) is lost due to unavailability of complete data relating to physical water availability per household. We accordingly focus on the remaining four components: that is: *Access*, *Capacity*, *Use*, and *Environment*. In addition, we introduce dummy variables for provinces in which the household is located with the aim of capturing water resource availability, as well as other provincial level characteristics such as rainfall and institutional variation.

Table 1 presents the summary statistics for the variables used for each WPI component (see Sullivan et al, 2003) for details on the rationale for the choice of these variables. [4] The variables used for the four WPI components are chosen to capture water poverty in terms of physical, social and environmental characteristics. Table 1 indicates that the concept of water poverty in our analysis is captured via the use of dummy variables. These are variables with a value of one if the answer is in the affirmative, and zero if otherwise. The construction of these variables is such that a value of one indicates a position that is superior to a value of zero. In particular, note that the dummy variables used to capture the environmental integrity related to water are such that a value of one indicates that a household does *not* experience the specified environmental problem. While our main focus group is rural agricultural households, Table 1 presents the statistics for both rural agricultural and non-agricultural households separately, as well as for the pooled sample. Two-sample *t*-tests to test for differences between the rural agricultural and non-agricultural groups are conducted.

The summary statistics suggest that non-agricultural households exhibit higher and statistically significant levels of access to water than their rural counterparts. Specifically, while 76% of non-agricultural households report a tap as their main source of drinking water, this is only 45% for the rural group; 94% of non-agricultural households have access to safe drinking water compared to 85% in the rural agricultural group. These differences between rural agricultural households and non-agricultural households are also evident in the quality of water accessible to

2. The original sample size was 32,636 households. However, due to non-response and out-of-scope (e.g. when a dwelling unit became vacant) cases, only 25,361 household interviews were successfully completed.
3. Agricultural households are those that have access to land and are thus assumed to be rural. This assumption is inevitable given that the data does not have an explicit rural-urban classification.
4. Note that the indicators used for the Use sub-component are reported only for rural households, for which agricultural activities were reported.

them, with 93% of non-agricultural households reporting the water they have access to as clear compared to 85% in the agricultural group. Also, 94% of non-agricultural households report the water as free from bad smells compared to 85% in the rural agricultural group. In terms of management of water supply, the summary statistics indicate that 88% of non-agricultural households have their water supplied by the municipality compared to 67% in the rural group, and 65% of non-agricultural households use flush toilets compared to only 23% in the rural agricultural group.

Our *capacity* indicators suggest that the heads of non-agricultural households tend to be more educated than their counterparts in rural areas: 89% of non-agricultural household heads have some level of formal education compared to 75% of rural agricultural households. With regard to poverty status, proxied by whether or not the household is registered as an indigent or impoverished household, these indicators reveal no statistical differences between the two groups. Summary statistics on *use* indicators suggest that the most prevalent agricultural activity is grain production (51% of rural agricultural households are engaged in grain production) followed by fruit production (47%), poultry (30%), and then livestock (27%) production.

Table 1 also reveals that non-agricultural households are less likely to be affected by problems relating to waste removal, litter, water pollution as well as land degradation. For non-agricultural households, 82%, 73%, 88%, and 79% indicate that they have no problems related to waste removal, litter, water pollution as well as land degradation, respectively. The corresponding figures for rural agricultural households are 75%, 65%, 87%, and 65%. These huge disparities suggest that not only are rural households disadvantaged in terms of physical access to water, but they tend to have access to lower quality water, which is typically from an unreliable source.[5] These differences have immediate implications for rural development, given the centrality of water resources to the development process.

In constructing the WPI, we started by constructing WPI components (*Access, Capacity, Use, and Environment*) separately based on variables presented in Table 1. In line with Sullivan et al (2003), the construction of each of the WPI components follows a structure specified in equation (1), such that for each WPI component, we have:

$$WPI_m = \frac{\sum_{h=1}^{N} \gamma_h D_h}{\sum_{h=1}^{N} \gamma_h}, \quad (2)$$

5. The simple implicit assumption here is that getting water from an institutionalized body, such as the municipality, indicates access to a relatively reliable or consistent source of water.

Table 1:Summary statistics of water related variables used in the empirical analysis

Variable name	Description	**Non-agricultural (n= 19 136)**	**Rural agricultural (n=6002)**	**t-tests**	**Pooled (N= 25 138)**
	Access indicators				
Piped	1=main source of drinking water is a tap; 0 otherwise	0.76	0.45	***	0.69
Safe	1=water safe to drink: 0 otherwise	0.94	0.85	***	0.92
Clear	1=water is clear; 0 otherwise	0.93	0.85	***	0.91
No taste	1=water has good taste; 0 otherwise	0.93	0.83	***	0.90
No smell	1=water free from bad smells; 0 otherwise	0.94	0.85	***	0.92
Municipal supply	1=household's drinking water supplied by municipality; 0 otherwise	0.88	0.67	***	0.83
Flush toilet	1= household uses flush toilet; 0 otherwise	0.65	0.23	***	0.55
	Capacity indicators				
Education	1=head of the household has some level of formal education; 0 otherwise	0.89	0.75	***	0.86
Indigent	1=household is *not* registered as an indigent household with the local municipality; 0 otherwise	0.90	0.90		0.90
	Use indicators				
Livestock	1=household involved in livestock production; 0 otherwise		0.27		
Poultry	1=household involved in poultry production; 0 otherwise		0.30		
Grains	1=household involved in grain production; 0 otherwise		0.51		
Fruits	1=household involved in fruit and vegetable production; 0 otherwise		0.47		
	Environment				
Waste removal	1=household does not experience problems of irregular or no waste removal; 0 otherwise	0.82	0.75	***	0.81
Litter	1=household does not experience problems of litter; 0 otherwise	0.73	0.65	***	0.71
Water pollution	1=household does not experience problems of water pollution; 0 otherwise	0.88	0.87	***	0.88
Land degradation	1=household does not experience problems of land degradation; 0 otherwise	0.79	0.65	***	0.75

Source: Authors' own complication. *Difference significant at 10%; **significant at 5%; *** significant at 1%.

Where each household, WPI_m refers to component m of the WPI, with

$m = Access, Capacity, Use,$ and $Environment$. D_h refers to the relevant dummy

variable h used in the construction of each component, while γ_h is the weight applied

to that particular variable.

Note that while equation (1) is for the overall WPI, equation (2) is for each component that goes into the construction of WPI. We chose to explicitly report the results on both the sub-components and the overall WPI in order to examine how each of the sub-components of WPI as well as the overall WPI affects household economic poverty.

We used Principal Components Analysis (PCA) to construct an overall indicator of each of the WPI components: *Access, Capacity, Use, and Environment.* This allows us to utilize all the information gathered, without losing too many degrees of freedom. PCA statistically weighs the three indicators in order to calculate an aggregate index of each of the WPI components (see Jolliffe, 1986 for details on the PCA). This method is specifically used to generate the weights, γ_h associated with each variable in D_h. In all PCA constructions, we retained components with the highest Eigenvalue, which happened to be greater than one in all cases.

Note that equation (2) implies that the indices for each component are standardized, such that they range from zero to one, with the highest value, one, taken to be the best situation while zero is the worst. The overall WPI, denoted *WPI*, is defined as the average of the four indicators. It also ranges from zero to one, with the highest value, one, taken to be the best situation (or the lowest possible level of water poverty), while zero is the worst. However, WPI is reported only for rural agricultural households, since *Use* indicators were not reported for non-agricultural households. A summary of the PCA results is presented in Figure 1.

Figure 1: Summary statistics of WPI components computed using PCA

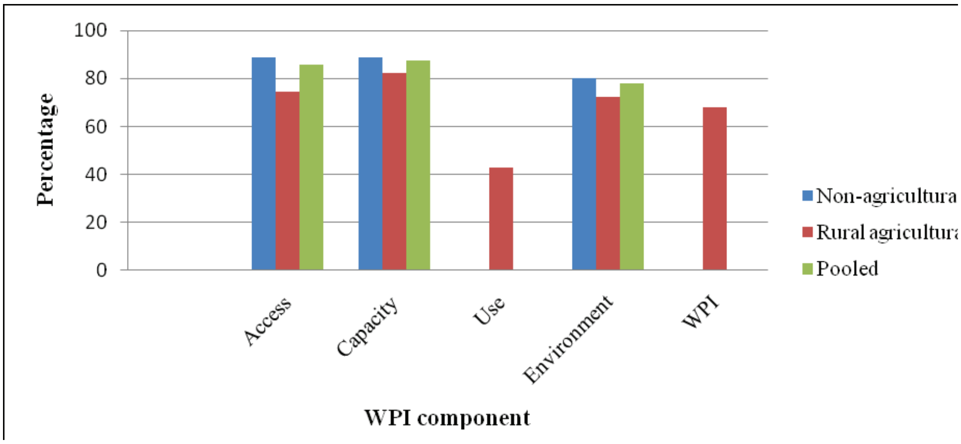
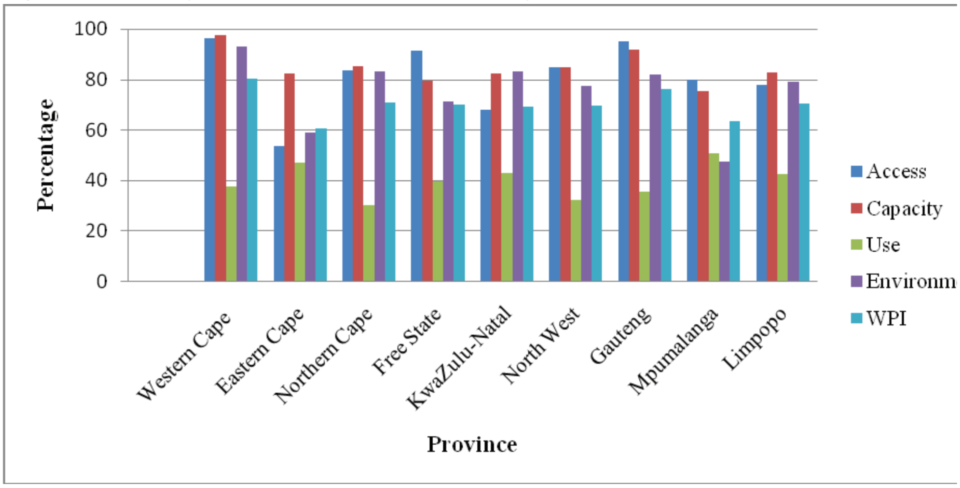


Figure 1, in line with indicators in Table 1, reveals that non-agricultural households have significantly better access to water. Furthermore, non-agricultural households have higher scores on indicators that enhance their effectiveness to manage water, and also suffer less from environmental problems that might affect the amount and quality of water resources they receive. This is of particular concern for rural development, since the fact that rural households have lower access to good quality water makes their capacity to manage water, which is shown to be lower than that of non-agricultural households, more pertinent for rural development.

To have an idea of the spatial distribution of the water indices, we tabulated the indices for rural agricultural households by province. The results, presented in Figure 2, point to differences across provinces with respect to the different components of WPI, as well as the overall indicator of WPI. The Western Cape Province has the highest score when it comes to water access indicators, followed by Gauteng, while the province that scores the least is the Eastern Cape. Similarly, the Western Cape Province has the highest average *Capacity* score followed by Gauteng, while the province with the least average *Capacity* score is Mpumalanga. The fact that Mpumalanga has the highest *Use* score suggests more diversified agricultural activities among rural households in the province. The least diversified agricultural system is found in the Northern Cape. The Western Cape is revealed as the province with the least environmental problems, while households in Mpumalanga have the highest concerns for environmental problems. Overall, the province with the least incidence of water-poor rural agricultural households is Western Cape (this province has the highest WPI score), while Eastern Cape has the highest incidence of water-poor rural agricultural households.

Figure 2: Summary statistics of WPI components by province



The foregoing highlights the existence of significant differences between rural agricultural and non-agricultural households, with rural households facing significant challenges with physical access to water as well as access to good quality water from reliable sources, compared to their non-agricultural counterparts. In addition, the findings suggest cross-province variation of these indicators among rural households. Needless to say, this high prevalence of water poverty among rural households has immediate adverse implications for their economic welfare.

This study hypothesizes that increased water poverty is associated with increased economic poverty. We used total monthly household income to capture economic poverty. This is measured on a continuous scale, in South African Rands (SAR). In addition to water poverty indicators discussed above, we also controlled for other household level variables that have been postulated both in theoretical and empirical literature to affect household income. The control variables used in the analysis are summarized in Table 2. This is done only for rural agricultural households, who are the focus of the rest of the paper.

Table 2 indicates that an average rural agricultural household has a total monthly income of ZAR 3,269. Taking into consideration differences with respect to household size (which is an average of 5 members) indicates a per capita income average of ZAR 972. The household head is, on average, 54 years old, with 48% of the group being headed by a male head. 26% of household heads work for a wage, commission or salary. 39% of the households have at least one member who receives social grant(s) from the government. The next section outlines the empirical methodology adopted in our analysis.

Table 2: Summary statistics

Variable name	Description	Mean
Dependent variables		
Income	Total household monthly income, in ZAR	3269.03
Income per capita	Total household monthly income per capita, in ZAR	972.18
Socio-economic characteristics		
Age	Age of household head	53.54
Gender	1=household head male; 0=female	0.48
Black	1= household head Black; 0 otherwise	0.94
Coloured	1=household head Coloured; 0 otherwise	0.02
Asian	1=household head Asian; 0 otherwise	0.01
White	1=household head White; 0 otherwise	0.04
Married	1=household head married; 0 otherwise	0.52
Divorced	1=household head divorced; 0 otherwise	0.05
Widowed	1=household head widowed; 0 otherwise	0.25
Single	1= household head single; 0 otherwise	0.18
Employed	1=household head working for a wage, commission or salary; 0 otherwise	0.26
Household size	Total number of household members	4.55
Social grant	1=at least one household member receives social grant(s) from the government; 0 otherwise	0.39
Dummies for Provinces		
Western Cape	1= household resides in Western Cape Province; 0 otherwise	0.01
Eastern Cape	1= household resides in Eastern Cape Province; 0 otherwise	0.20
Northern Cape	1= household resides in Northern Cape Province; 0 otherwise	0.03
Free State	1= household resides in Free State Province; 0 otherwise	0.13
KwaZulu-Natal	1= household resides in KwaZulu-Natal Province; 0 otherwise	0.20
North West	1= household resides in North West Province; 0 otherwise	0.05
Gauteng	1= household resides in Gauteng Province; 0 otherwise	0.05
Mpumalanga	1= household resides in Mpumalanga Province; 0 otherwise	0.10
Limpopo	1= household resides in Limpopo Province; 0 otherwise	0.24

3.2 Empirical Model

To test empirically whether there is a direct link between household water and economic poverty of rural households, we focused on total monthly household income of the household as an economic poverty indicator. This measure is chosen not only because income is an indicator of household welfare but also for simplicity and data availability considerations (see, for example Myles and Garnett, 2000; Kuan and Osberg, 2002) and Osberg and Kuan, 2008) for a discussion of different measures of poverty and how they compare to income measures). The empirical analysis entails estimating an equation for income, with water poverty indices as one of the explanatory variables. Specifically, this is premised on the estimation of the following equation:

$$Income_j = \alpha_0 + \alpha_1 Access_j + \alpha_2 Capacity_j + \alpha_3 Use_j + \alpha_4 Environment_j + \mathbf{\acute{a}}_5 \mathbf{Z_j} + \varepsilon_j , \quad (3)$$

for $j = 1,.....,6002$ rural households.[6] The variables are as defined in Tables (1) and (2). The vector $\mathbf{Z}_{\mathrm{j}}$ consists of variables defined in Table (2); that is, the age, gender, ethnicity/race, marital and employment status of household head as well household size, and whether or not the household has at least one of its members receiving social grant(s) from the government. In addition, the vector $\mathbf{Z}_{\mathrm{j}}$ contains dummy variables for the nine provinces included to control for characteristics that might vary across provinces and subsequently determine total monthly household income. The (vector of) parameters to be estimated are α_0, $\alpha_1, \alpha_2, \alpha_3, \alpha_4$, and á$_5$. The error term ε_j is assumed to be independently, identically, and normally distributed with zero mean and standard deviation equal to one (Wooldridge, 2002). Given that $Income_j$ is measured on a continuous non-zero (and non-negative) scale, we estimated equation (3) via Ordinary Least Squares (OLS).[7] To take into account the variation in income levels arising from variations in household size, we used income per capita as the dependent variable.

A major issue that could affect the robustness of our results is the endogeneity of water poverty due to possible bi-directional causality between water and economic poverty. For example, wealthier households (as proxied through income) might be more likely to afford improved access to water or are better able to manage water. In addition, there could be factors that affect both water poverty and economic poverty, which are not explicitly controlled for in our analysis, and which could be a source of endogeneity. Disregarding this potential endogeneity could thus give erroneous estimates of the impact of water poverty on economic poverty.

We adopted an instrumental variables (IV) estimation framework to overcome this problem. This is done in two steps: in the first stage we estimated each component of the water poverty indices (*Access*, *Capacity*, *Use*, *Environment*, and the overall *WPI*) using OLS with all explanatory variables in the system. In the second stage, we estimated equation (3) via OLS, with residuals

6. Correlation matrices of the *Access*, *Capacity*, *Use*, and *Environment* indicators show that they are not highly correlated, hence the decision to include them simultaneously as explanatory variables.
7. For more details on the OLS estimation method, see for example, Wooldridge (2002).

from the first stage as additional explanatory variables. The results we obtained from the estimation of equation 3 are reported and discussed in the next session.

4. Empirical Results

In Table 3, the first stage OLS regression results for *Access*, *Capacity*, *Use*, *Environment*, and the overall *WPI* are presented. While our primary interest is to examine how water poverty determines economic poverty, the first stage results are useful in giving us insights into how different socio-economic characteristics determine the water poverty status of the household. In particular, the results in Table 3 allow us to appreciate how these characteristics determine each of the components of the WPI, as well as the overall WPI.

Focusing on the overall water poverty index, *WPI*, and keeping in mind that higher *WPI* levels indicate reduced water poverty, the results suggest that the age of the head of the household is associated with reduced household water poverty. Relative to households with a coloured household head, households with a black household head tend to have higher water poverty levels. Households for which the head is married enjoy reduced water poverty levels than households with a head who is single. In addition, water poverty levels decline when the household head has some level of formal education, as well as when the head is employed. Water poverty levels are shown to increase with household size. The result that households that have at least one of their members receiving social grant(s) from the government tend to be less water-poor than those without lends support to the importance of social grants in reducing water poverty. In sum, the results underscore the importance of household heterogeneity in shaping the differences among households with respect to water poverty.

Table 4 presents results from an IV estimation of *Income per capita,* in which model (*a*) presents results for the case in which the four components of the WPI: *Access*, *Capacity*, *Use*, and *Environment* are controlled for separately. Model (*b*), on the other hand, controls for the overall Water Poverty Index, *WPI*, to examine how an aggregated index of water poverty affects economic poverty.[8]

The results from Model (*a*) show that, among the four water poverty indicators, only those relating to water access matter significantly for household per capita income. Specifically, the results suggest that the better the household's access to good quality water, the higher its per capita income. Controlling for the overall WPI in model (*b*) confirms the importance of water in alleviating poverty: an increase in the WPI (meaning a reduction in household water poverty) is associated with increased per capita income. Taken together, the results of model *(a*) and (*b*)

8. Note that although we base the discussion of the results on the IV models that overcome the challenges arising from the potential endogeneity of water and economic poverty, a simple OLS using the original water poverty indices generated from PCA gave results that are similar to the ones from the IV estimations.

suggest that the importance of water access drives the realized impact of overall water poverty on household income. These findings, consistent with Molden et al (2001), underpin the crucial role of water access in the welfare of rural households.

Table 3: OLS estimation of water poverty indicators

Variable	Access		Capacity		Use		Environment		WPI	
	Coefficient	Robust std. error	Coefficient	Robust std. error	Coefficient	Robust std. error	Coefficient	Robust std. error	Coefficient	Robust std. error
Socio-economic characteristics										
Age	0.001**	0	-	0	0.001**	0	0.001**	0	0.001**	0
Gender	0.010	0.009	-0.005	0.005	0.007	0.006	0.008	0.01	0.005	0.004
Black	-	0.019	-0.003	0.02	-0.026	0.019	-	0.028	-	0.012
Asian	0.107**	0.03	0.001	0.03	-	0.04	0.035	0.037	0.012	0.016
White	-	0.022	0.029	0.02	-0.018	0.021	0.019	0.029	-0.014	0.012
Married	-	0.011	0.025**	0.006	0.030**	0.008	0.005	0.012	0.009*	0.005
Divorced	-0.001	0.017	-0.010	0.012	0.022*	0.013	0.001	0.021	0.003	0.008
Widowed	-	0.012	0.004	0.008	0.025**	0.009	-0.005	0.014	0.000	0.006
Education	0.060**	0.01	0.494**	0.005	0.011	0.007	0.029***	0.01	0.150**	0.004
Employed	0.057**	0.009	0.009*	0.005	-	0.006	0.023**	0.01	0.017**	0.004
Household	-	0.002	-	0.001	0.004**	0.001	-0.003**	0.002	-	0.001
Social grant	0.025**	0.011	0.005	0.006	-0.011	0.008	0.009	0.012	0.008*	0.005
Province dummy variables										
Western	-0.025	0.016	0.021	0.017	-0.012	0.024	0.022	0.028	-0.005	0.011
Eastern	-	0.014	-0.010	0.01	0.101**	0.012	-	0.019	-	0.007
Northern	-	0.016	-0.002	0.014	-	0.016	-0.001	0.024	-	0.009
Free State	-	0.009	-	0.012	0.037**	0.011	-	0.019	-	0.007
KwaZulu-	-	0.012	0.013	0.01	0.064**	0.012	0.040**	0.017	-	0.007
North West	-	0.012	-0.002	0.013	-	0.014	-0.039*	0.022	-	0.008
Mpumalang	-	0.012	-	0.011	0.146**	0.013	-	0.02	-	0.007
Limpopo	-	0.01	0.027**	0.009	0.064**	0.012	0.001	0.018	-0.011	0.007
Constant	0.917**	0.028	0.481**	0.024	0.311**	0.025	0.812***	0.038	0.631**	0.015
Adjusted R-		0.201		0.673		0.068		0.151		0.291
Observation	5894		5746		5919		5919		5723	

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.

The direction of impact of the rest of the control variables is robust between the two models. The control variables suggest that the older the head of household, the higher the household's level of total monthly income. Older households tend to have more work-experienced household members, and this could give them an advantage in income-generation compared to households headed by younger individuals.

Male-headed households have significantly more per capita total monthly incomes than their female-headed counterparts. These gendered income differences could be pointing to the existence of socio-economic factors that affected male- and female-household heads differently, resulting in differences in their

Table 4: Instrumental variable estimation of income per capita

Variable	A		b	
	Coefficient	Robust std. error	Coefficient	Robust std. error
	Water poverty indicators			
Access residuals	0.227***	0.06		
Capacity	0.156	0.118		
Use residuals	0.089	0.091		
Environment	-0.105	0.075		
WPI residuals			0.247*	0.14
	Socio-economic characteristics			
Age	0.007***	0.002	0.006***	0.002
Gender	0.246***	0.054	0.247***	0.054
Black	-0.110	0.213	-0.106	0.213
Asian	1.586***	0.43	1.588***	0.428
White	3.687***	0.371	3.692***	0.372
Married	-0.157*	0.081	-0.156*	0.081
Divorced	-0.033	0.145	-0.032	0.144
Widowed	-0.093	0.067	-0.092	0.067
Education	0.156***	0.027	0.155***	0.028
Employed	0.934***	0.065	0.934***	0.065
Household size	-0.128***	0.008	-0.128***	0.008
Social grant	-0.035	0.053	-0.035	0.053
	Province dummy variables			
Western Cape	0.570	0.499	0.570	0.499
Eastern Cape	-0.511***	0.15	-0.512***	0.15
Northern Cape	-0.089	0.244	-0.091	0.244
Free State	-0.511***	0.168	-0.509***	0.168
KwaZulu-Natal	-0.397***	0.151	-0.398***	0.151
North West	-0.245	0.2	-0.245	0.201
Mpumalanga	-0.501***	0.15	-0.499***	0.149
Limpopo	-0.509***	0.15	-0.510***	0.15
Constant	1.241***	0.27	1.240***	0.27
Adjusted R-	0.35		0.35	
Observations	5,346			

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.

ability to generate income or facilitate their household's generation of income.

There are distinct ethnic differences between households with Asian and White heads found to exhibit significantly higher income levels relative to households with Coloured/mixed-race household heads. Relative to households with single heads, the results indicate that households with married heads are worse off in terms of total monthly income. This might be suggesting that single household heads tend, on average, to allocate more time to income generating activities than married household heads.

As expected, the education of the head of the household has a positive effect on the household's total monthly income. This shows that education is a proxy for the level of human capital in the household and, as a result, it translates into the household's productive capacity, which implies higher household earning capacity. Similarly, as expected, households for which the heads are gainfully employed are better off in terms of income levels than those for which the heads are not gainfully employed. Another important finding is that per capita total monthly income increases with the size of the household, suggesting that as households get bigger, they have more members who contribute to total household income.

The significance of province dummies highlights the impact of cross-province differences that contribute to differences in households' total monthly income. Specifically, results indicate that households in the Eastern Cape, Free State, KwaZulu-Natal, Mpumalanga and Limpopo provinces have significantly less incomes than households in Gauteng.

5. Conclusions

Water, both for production and consumption, plays a critical role in any population's development. As a result, any development policy needs to be crafted from a comprehensive understanding of the diverse factors that condition households' water-related poverty and how this water poverty affects the welfare of those particular households. The Water Poverty Index (WPI), an inter-disciplinary measure that links household welfare with water scarcity or availability, is a useful tool that can be used to indicate the degree to which water scarcity affects household welfare and subsequently development.

This study used an adaptation of a comprehensive WPI, which considers water access, quality, use, and water-related environmental aspects to measure household-level water poverty to establish a link between water poverty and household economic welfare. It uses data from the 2009 General Household Survey (GHS). An instrumental variable estimation framework that deals with the potential endogeneity between water and economic poverty is used. Our results support the existence of a direct link between water and economic poverty, with water poverty found to be associated with reduced economic welfare. The better-off the household's access to good quality water, the higher the reported total household monthly income. Water is, therefore, found to be central to enhancing the welfare of rural households. This indicates that policy interventions that seek to reduce household water poverty should be considered key to overall poverty alleviation and rural development in South Africa. In particular, the results suggest that access to good quality water from a reliable source is crucial for rural households' welfare.

Results obtained from this study thus caution development policy not to treat water and economic poverty in isolation. This implies that there is need for development policy in South Africa to streamline water use in rural development. In addition, development policies need to take into account the role of household heterogeneity, since the impact of the index is different between differentially constituted households. For example, age, marital status, gender and ethnicity of the head of household head, access to government social grants, and location of households are significant determinants of both the water and economic poverty status of the household. Therefore, policy intervention for sustainable rural development needs to take a differential approach along household characteristics and location.

Government intervention through social grants reduces water poverty. This reflects the positive role that policy intervention can play when directed to the core areas of a population's production and consumption constraints. This result indicates that, if well targeted, such government intervention could reduce household water poverty and subsequently boost socio-economic development of water-poor areas in a sustainable way.

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