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Water Poverty Mapping and its Role in Assisting Water Management

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Abstract

Water scarcity occurs when the ways in which we use and distribute water cannot fully meet the demand from the environment, industry, farms and households. On a worldwide scale, the World Bank estimates that roughly 166 million people in 18 countries are affected by water scarcity and another 270 million people in 11 countries are water stressed (Hemson *et al.*, 2008). Given these figures, it is easy to see why we can refer to the existence of a so-called global water crisis.

The purpose of this paper is to document how water poverty mapping can assist the water management in three towns in South Africa. It should assist with as many as possible of the following aspects: the collection and analysis of all relevant information regarding the availability of water, its various uses, current supply status, future prospects, current water allocation details and the state and processes of water deprivation, and dissemination of information and messages arising from the analysis thereof to all concerned. It recommends that water poverty mapping be used as a managing tool by governments, water service providers and local municipalities. It can also form part of a local municipality's master plan, which in turn, guides town expansion and infrastructure development. All three entities can use water poverty mapping as part of their water management strategy to replace, supplement or validate their water demand predictions so that future supply can be guaranteed.

Keywords: Water Poverty Mapping, Water Management, Water Poverty Index.

Introduction

South Africa, being a water-stressed country, with less than 1700 m^3 of water for each person per year (Rand Water, 2008), has limited fresh water resources and budgets for the supply of basic infrastructure services. Currently over 6 million people in South Africa are without access to even a basic level of water supply or have a very limited level of access (Cullis, 2005). The norm has been to think of water poverty merely in terms of a lack of the actual resource, whereas Sullivan *et al.* (2003) and Sullivan (2005) have shown that water poverty should be expressed in terms of resource, access, capacity, use and environment. These five components are contained in the Water Poverty Index (or WPI), as developed by Sullivan *et al.* (2002), and refined by researchers at the Centre for Ecology and Hydrology in Wallingford, UK. Graphical representations of the WPI are a very effective and understandable way of communicating information as no knowledge of the underlying data and its transformation is required. These graphical representations of the WPI are known as water poverty maps.

Water Management

During recent years the two major shortcomings of water management that have been widely recognized are, firstly,

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very little or no pollution control, and secondly inefficient utilization. According to Pallett (1997), the aim of water management should be to supply people with essential water supplies whilst ensuring that water continues to be shared amongst all the components of the human and the natural environment in a river basin. Water and poverty interface in more than one way (Ahmad, 2003), and the management of water resources is, therefore, a vital process element of sustainable human development. If we continue to use our water resources as we currently do, the world will be facing a severe water shortage as early as 2025 (Clarke *et al.*, 2004). This will lead to reduced food production, which in turn will lead to malnutrition and disease, and also to increased ecological damage.

The Water Poverty Index

The conventional methods to assess water management were purely deterministic relying on the availability of large-scale data. A method that was easy to calculate, cost effective to implement, based mostly on existing data, and that uses a transparent process (i.e. easy to understand), was needed. This motivated Sullivan *et al* (2002) to design the Water Poverty Index (WPI). The WPI has the following advantages over conventional methods:

- It provides a better understanding of the relationship between the physical availability of water, its ease of abstraction, and the level of welfare;
- It is a mechanism to prioritize water needs;
- It is a tool for monitoring progress in the water sector;
- The WPI is mainly designed to help improve the situation for people facing poor water endowments and poor adaptive capacity.

The WPI allows the use of different scales to be applied for different needs and defines water poverty according to five components. These components are:

- **Resources**. The availability of water, taking into account the variations in seasonal and inter-annual fluctuations and water quality.
- **Access**. The accessibility of water for human use.
- **Capacity**. Capacity is interpreted in the sense of income to allow purchase of improved water, and education and health, which interact with income and indicate a capacity to lobby for and manage a water supply (Cullis, 2005; Lawrence *et al.*, 2002).
- **Use.** Captures the actual amount of water being used and extracted from the system.
- **Environment.** This variable captures the environmental impact of water management (Lawrence *et al.* 2002).

Each of the five components consists of a number of sub-components and a weighting (see section 8) can be applied to each component to indicate the component's importance. The components are standardized to fall in the range 0 to 100, resulting in a final WPI value between 0 and 100. The highest value 100 is taken to be the best situation and 0 being the worst.

The five key components are combined together in a general expression:

$$WPI = \frac{w_r R + w_a A + w_c C + w_u U + w_e E}{w_r + w_a + w_c + w_u + w_e}$$

Where

WPI = Water Poverty Index score of a particular location

R = Resources component

A = Access component

C = Capacity component

U = Use component

E = Environment component

w = weighting factor for each component

The WPI was the preferred indicator for this study, although other indicators like the Water Stress Index (Gleick, 2002), the Water Scarcity Index (Asheesh, 2004), etc. were considered. However these indicators did not provide sufficient detail, especially when working on a smaller scale. A high level of detail is required to allow targeting of resources to address specific problems.

The South African Context

South Africa's water resources are limited and in global terms are scarce (Hemson *et al.*, 2008), and has been rated as one of the 20 most water-deficient countries in the world (Meyer, 2007). South Africa also has a high unemployment rate, which means that many people simply cannot afford to pay for basic water and sanitation (Holland, 2005), and many people who can afford to pay simply don't pay for public services because they consider it a right.

The free basic supply of water regulation was introduced in 2001. According to the World Health Organization, a person requires roughly 25 liters of water per day to promote healthy living. Under the assumption of 8 people per household, the standard was set at 6000 liters of free water per household per month (Hemson *et al.*, 2008). Unfortunately, many municipalities experienced difficulties in implementing the free basic water supply regulation and by 2002 only 57% of the population was receiving their free basic water supply (Holland, 2005).

In 2005 the Department of Provincial and Local Government (or DPLG) created a policy that provides a basis for the provision of free basic services to the indigent. These basic services include free basic water and sanitation, free basic electricity, and the property rates act, which provides for a zero rating of low value properties (DPLG, 2005). According to this policy, an indigent is someone who "*lacks the necessities of life*". In a broad sense, these necessities include, amongst others:

- Sufficient water.

- Basic sanitation.

Under this policy, people that have been classified as being indigent and that have undergone a successful registration process will receive their basic services free of charge. Instead of the local municipality carrying this financial burden, they will be reimbursed by the state. In the region of 21 000 indigents were registered at one of the major local municipalities in the area under consideration on 30 June 2009 (the end of their financial year).

Water Poverty Mapping

Water poverty mapping is used to identify areas of high levels of water poverty with the aim to assist in the targeting of water related policies. This ensures the most efficient use of resources to meet the development objectives of the country. The strengths of the Water Poverty Index (WPI), poverty mapping and geographic targeting are combined in water poverty mapping (Cullis, 2005). The concept of water poverty mapping was introduced by Cullis in 2002 when he constructed a water poverty map for the town of Escort in the Kwazulu-Natal province of South Africa. In 2005. Cullis expanded the concept by constructing the water poverty map for the Eastern Cape Province in South Africa.

Data Sources

The data for this study was obtained from three sources. The first source is an analysis that was done into the current operations of the local municipality and the local water services provider. The second source is the Census data from 2001, which can be accessed through the website of Statistics SA (http://www.statssa.gov.za). The third source is the Water Situation Assessment Model (or WSAM) version 5.001, which was released on 1 October 2008 and is available from the Department of Water Affairs and Forestry (DWAF). All the data in the WSAM is at the 98% assurance level. Table 1 lists the WPI components and the respective data source.

Table 1 WPI Component Data Sources

Component	Source
Resource	Analysis
Access	Census
Capacity	Census
Use	WSAM
Environment	WSAM

Component Calculation

The following sections will discuss the calculation method for each of the component values, its benchmark level, and the calculation of the final score that will be used to calculate the WPI. The indicators to be used for the various components as well as the benchmark levels have been selected according to the guidelines developed by Cullis (2005).

Resource

After an analysis of the operations of the local municipality and the local water services provider, it was identified that looking at the total resource availability in an area in terms of groundwater and surface water availability is an irrelevant method for the Vaal Triangle (collective term for Vanderbijlpark, Vereeniging and Sasolburg) area that is under consideration in this study. The method suggested by the analysis is motivated firstly by the fact that it is the method currently used by management when looking at total resource availability, and secondly because it is a method that supports prediction. It recommends that the resources of the area should be expressed in terms of the percentage of water that the service provider actually extracts from the water system in comparison to the amount of water that may be extracted.

Due to the sensitive nature of the actual figures, the input for this component will be the percentage of the allowance that is actually extracted. The minimum benchmark level for this component is 0 and the maximum benchmark level is 100. The value of the optimum extraction rate has been set at 90%, as this is the current extraction rate that satisfies the total demand. A resource component score of 100 indicates an optimum extraction rate of 90%. Any value above or below this optimum level is adjusted so that it reflects consumption in terms of a percentage of the optimum level. Table 2 lists the resource component score for each of the three towns in the study.

The values for the three towns under consideration are the same because all three towns receive their water from the same water system.

Table 2 Resource Component Calculation

	Value (Extraction rate %)	Score (%)
Vanderbijlpark	90	100
Vereeniging	90	100
Sasolburg	90	100

Access

The access component value is calculated as

$$A = \frac{\text{Households with access to secure water source}}{\text{Total households}}$$

A secure water source is defined as being piped water either inside the dwelling or inside the yard. This study is limited to these two sources of water as there are too many factors influencing access to a communal water source such as certain community factions monopolizing the facility, etc. The minimum benchmark level for Access is 0% and the maximum level is 100%. Table 3 lists the access component score for each of the three towns in the study.

Table 3 Access Component Calculation

	Households With Safe Water Source	Total Households	Value (Proportion)	Score (%)
Vanderbijlpark	25 422	26 602	0.955	95.564
Vereeniging	21 103	22 884	0.922	92.217
Sasolburg	7 456	7 644	0.975	97.541

Capacity

The capacity component consists of Educational Capacity as well as Income Capacity. The Educational Capacity value is calculated as

$$EC = \frac{\text{People with education greater than grade 4}}{\text{Urban population}}$$

and the Income Capacity value is calculated as

$$IC = \frac{\text{Households with income greater than R26400 per annum}}{\text{Total households}}$$

Grade four is the educational level at which information regarding responsible water use is disseminated to learners (Cullis, 2005). As the same education plan is still in place, grade 4 was used as the threshold level for educational capacity. According to the WSDP (water service development plan which is available from DWAF), the average person is willing to spend roughly 5% of their disposable income on services. After an analysis at the local municipality, it was determined that a basic suite of services costs approximately R110 per household per month, or R1 320 per household per year. If R1 320 equals 5% of disposable income, 100% will equate to R26 400, the threshold level for income capacity.

The two sub-components used for the capacity component have been assigned equal importance (Cullis, 2002; 2005). The capacity component value is therefore merely the average of the two sub-components and is calculated as

$$C=\frac{EC+IC}{2}$$

The minimum benchmark level for capacity is 0% and the maximum level is 100%. Table 4 lists the capacity component score for each of the three towns in the study.

Table 4 Capacity Component Calculation

	People With Education > Grade 4	**Total Population**	**Education Capacity (%)**	**Households With Income > R26 400**	**Total Households**	**Income Capacity (%)**	**Score (%)**
Vanderbijlpark	63 529	474 081	13.4	18 432	26 602	69.288	41.344
Vereeniging	58 649	497 600	11.786	15 135	22 884	66.14	38.963
Sasolburg	19 906	141 000	14.118	6 220	7 644	81.371	47.745

Use

The use component value is calculated as

$$U=\frac{\text{Direct requirement urban}}{\text{Urban population}}*\frac{10^9}{365}$$ l/c/d (liters/capita/day).

The minimum benchmark levels for the use component are 0 l/c/d and 320 l/c/d (as an optimum level is used) and according to Cullis (2005), the maximum (optimum) level for use in the South African environment is 160 l/c/d. A use component score of 100 indicates an optimum consumption level of 160 l/c/d. Any value above or below this optimum level is adjusted so that it reflects consumption in terms of a percentage of the optimum level.

As this study and water poverty mapping generally focus on residential water poverty alleviation, it is important to differentiate between residential and non-residential water use. The local municipality indicated that, on a month-to-month basis, residential water use tends to fluctuate between 50% and 55% of the total water use and non-residential between 45% and 50% of the total water use. Therefore, a figure of 52% will be used for residential use, and 48% for non-residential use.

From the three towns under consideration, Vanderbijlpark was the only town where the use component value was not adjusted, as the major non-residential water consumer in the town obtains their water directly from the local water services provider, and not from the local municipality. This is however not the case for Vereeniging and Sasolburg, as both these towns have major non-residential water consumers that obtain their water from the local municipality, and including these two towns in the usage figures corrupts the use component score. Table 5 lists the use component score for each of the three towns in the study.

Table 5 Use Component Calculation

	Direct Requirement Urban	Population	Value (l/c/d)	Score (%)
Vanderbijlpark	22.26	474 081	128.641	80.401
Vereeniging	25.896	497 600	142.58	89.113
Sasolburg	10.598	141 000	205.926	71.296

Environment

The environment component value is obtained directly from the WSAM and no calculation is required to determine the component value. The minimum benchmark level for Environment is 0 and the maximum level is 5, as it is the exact measurement scale used by DWAF to express the present ecological class in the WSAM. The environment component score is then calculated by multiplying the component value with 20, as this expresses the component as a score out of 100, and therefore, as a percentage. It has a range of 0 to 5, with 0 indicating a "very poor" ecological state and 5 a perfect ecological state. Table 6 lists the environment component score for each of the three towns in the study.

Table 6 Environment Component Calculation

	Index (Rating)	Score (%)
Vanderbijlpark	4.086	81.72
Vereeniging	3.641	72.82
Sasolburg	3.856	77.12

Component Weighting

The option of adding different weightings to the components has been included in the WPI to compensate for different priorities and circumstances. When deciding which weightings to use for the calculation of the WPI, the hydrological and economic conditions, as well as the national/regional, priorities of the specific area need to be considered. Table 7 contains the various weighting groupings as compiled by Sullivan *et al.* (2002).

The second combination of weightings will be used as it has been proven to be effective in previous studies on a similar scale (Cullis, 2005), i.e. 1 for resource, 2 for access, 2 for capacity, 1 for use and 1 for environment. The descriptors that are related to the chosen weightings are also the closest match to the conditions found in the area under consideration.

Table 7 Weighting Options for the WPI

Local condition descriptors			Component weights				
Hydrological condition	Economic condition	National priorities	Resource	Access	Capacity	Use	Environment
Very good	Unknown	Agriculture, Industry & Social	1	2	2	3	1
Average	Average	Social	1	2	2	1	1
Very good	Good	Environment & Social	1	2	2	1	2
Unknown	Unknown	Industry & Agriculture	1	2	2	2	1

Index Calculation

After calculating each of the individual component scores, the weightings have to be used to calculate the final WPI for each town. The formula to be used for the final calculation of the WPI is given below.

$$WPI = \frac{w_r R + w_a A + w_c C + w_u U + w_e E}{w_r + w_a + w_c + w_u + w_e}$$

Table 8 summarizes the component scores and final WPI scores for each of the towns in the study

Table 8 WPI Calculation

	Resource (Weighting =1)	Access (Weighting =2)	Capacity (Weighting =2)	Use (Weighting =1)	Environment (Weighting =1)	WPI
Vanderbijlpark	100	95.564	41.344	80.401	81.72	76.562
Vereeniging	100	92.217	38.963	89.113	72.82	74.899
Sasolburg	100	97.541	47.745	71.296	77.12	76.998

When working with water poverty mapping and the water poverty index as mentioned earlier, the contributions of each of the components to the final index value is just as important as the final index value itself. Figure 1 is a graphical representation of the component contributions and water poverty indexes of the three towns in the Vaal Triangle.

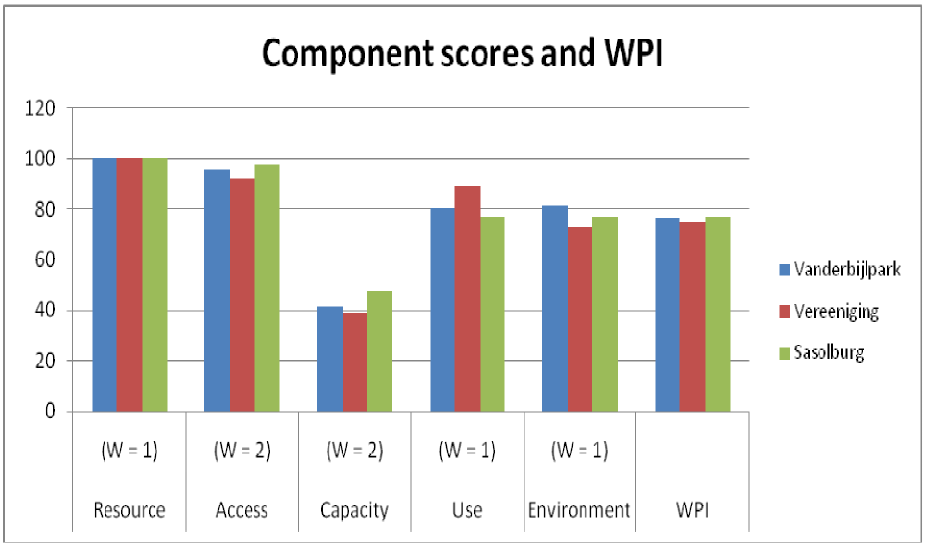

Figure 1 Graphical Representation of Component Scores and WPI

A WPI of 100 indicates that there are no water related problems in an area. The worst WPI that an area or region can have is 0, which indicates that there are numerous water related problems and that a lot of time and money will have to be spent in an effort to rectify the situation. The three towns in this study all have a WPI value in the high seventies, which is relatively high seeing that the entire country had a WPI of only 52. The capacity component score was the lowest, therefore, improving educational and income capacity in each of the towns could be a key factor for improving the water poverty in the region.

Map Construction

After calculating the various water poverty indexes, the next step in the process is to construct the water poverty map. For the purpose of this study, the image of the area under consideration was obtained using Google Earth, and the mapping was done using Map Maker version 3.5. Figure 2 represents the WPM that was constructed for this study.

On the map the various colors indicate the boundaries of the three towns, namely Vanderbijlpark in white, Vereeniging in yellow, and Sasolburg in green. The three numbers on the map represent the water poverty indexes for each of the towns.

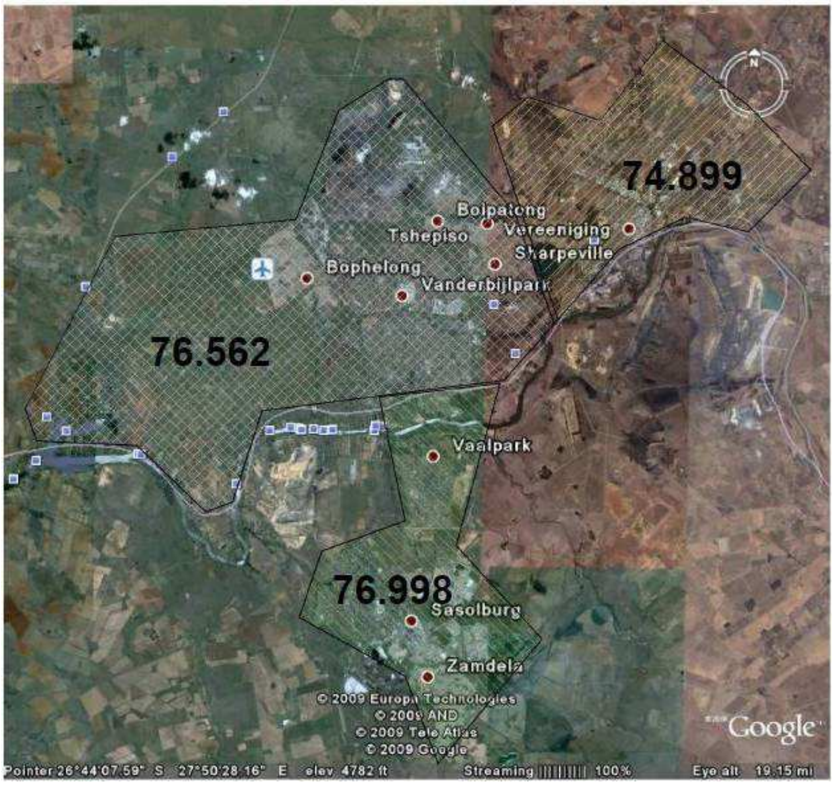

Figure 2 Water Poverty Map for the Vaal Triangle

Recommendations

When planning for the future, local municipalities, water service providers and governments have to ensure that they can keep up with the rate of growth and development. This is particularly important when it comes to water and the demand for water, as it is an extremely valuable but also very limited resource. The following recommendations are aimed towards various water management entities.

Recommendation to Local Municipality

A local municipality has to predict its future water requirements on a regular basis. These predictions are given to the water services provider so that they can ensure that they can meet the demand for water.

Currently these predictions are based on two measurements, the trend of demand for water as well as the population growth rate. The demand and the growth figures are available on a month-to-month basis, and when determining the value for the prediction, the average of the two measurements is used. These demand predictions are also used when determining the relevant tariff that the end user will be charged. In the long-term, these predictions are used to plan ahead for projects like infrastructure improvement, maintenance, expansion, etc.

The result of an analysis of the processes of the local municipality was that the Use component of the WPI and the water poverty map can immediately form part of their predictions, and that if water poverty maps can be constructed on regular intervals they even have the potential to completely replace the current prediction-system. Currently, when determining overall demand, the municipality looks at the total number of kiloliters that was supplied to them by the water service provider. Unfortunately, this total also contains the water that has been lost, for example through leaking pipes, and this affects the accuracy of the information. By taking the usage (measured in l/c/d) and multiplying it with the population size, it can be used as a more accurate measure of overall demand, or it can be used to confirm whether the earlier obtained overall demand is reasonably accurate or not. It was also highlighted that if water poverty maps were to be constructed on a relatively regular basis, using the most recent data, the maps could become the sole basis of their predictions. With a series of regularly constructed maps, it will become much easier to measure the impacts of development, and it will also provide users with a relevant and up to date overall picture, considering not only the resource, but also the factors influencing its responsible usage.

The WPM can also be included in a municipality's master plan. A master plan is a document that a municipality has to compile for every developed area under its jurisdiction. It is typically a document that is set up during the first few years after a town has been established, which is then updated on a regular basis. In the master plan, areas are classified as being either urban, urban-edge or rural. The urban-edge is usually the area where a town expands. Therefore, the urban-edge of a town shifts continuously. The water poverty map itself can be used to keep track of the town boundaries as well as the areas that have been classified according to the three different classifications. The master plan serves two main purposes. It provides a detailed description of what is currently available (in terms of infrastructure, etc.), and what the current demand is and what will be needed to ensure that the demand can be sustainably met. An analysis of the current processes of the local municipality highlighted that the resource component of the water poverty map can be used as part of the master plan to guide development. The Resource component will give a very clear indication of how much development is viable given the current maximum carrying capacity, in other words, when will the maximum level be reached. The main limiting factor on development (suggested planned development) is resource availability because water is and will always remain a finite resource.

Recommendation to Water Service Provider

The water service provider needs to consider all the predictions from the municipalities they serve when preparing their prediction for government. Although they annually predict the demand for the next year, every five years they have to predict the demand for the next five years when they apply for their permit from DWAF. The permit they obtain from DWAF gives them permission to extract water from the system and states how much water they are allowed to extract. The advantages of the use of water poverty maps by the water service provider are similar to those that will be experienced by local municipalities. The only difference will be the scale on which the water poverty map is constructed.

Recommendation to Government

The advantages of more accurate predictions are tenfold for government and DWAF. Government has to ensure that it can meet the water demand of its inhabitants, and to enable these accurate predictions of future demand to be needed so that they can have a clear idea of when the demand is going to overtake the supply. The sooner they know when this is likely to happen, the more time they have to prepare for alternatives.

On a provincial government level, the results obtained from water poverty maps on a municipal level can be used to identify the municipalities or districts most in need of an intervention. This information can then be used when assigning resources to ensure that the water poverty is addressed efficiently. On a national level, the benefits of water poverty mapping are similar. The maps can be constructed on a provincial level to identify the province with the highest water poverty. Once the province has been identified, a map on a smaller scale can be used to identify the worst district in that province, and from there a map on an even smaller scale can be used to identify the worst municipality in that district.

Conclusion

A water poverty map that has been constructed on a sufficient scale and with the correct sub-components can be very helpful for the management of our scarce water resources. They not only act as a quick reference point for various water related information, but can also assist the various management levels to obtain more accurate water demand predictions, and to do better town planning through the master plan. The fact that they can be constructed on any scale and with any components, means that they are not limited in terms of their scope and usefulness.

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References

Ahmad, Q. K. (2003). “Towards Poverty Alleviation: The Water Sector Perspectives,” *Water Resources Development*, Vol. 19(2), pp. 263-277.

Asheesh, M. (2004). Allocating the Gaps of Shared Water Resources (the scarcity index) case study Palestine Israel. Finnish Institute of Technology, Kotkantie 1, 90100, Oulu, Finland. http://www.ipcri.org/watconf/papers/mohamed.pdf. [11 February 2010]

Clarke, R. & King, J. (2004). The Atlas of Water, Mapping the world’s most critical resource. Earthscan, 8 – 12 Camden High Street, London, NW1 0JH, United Kingdom.

Cullis, J. D. S. (2002). 'Targeting the Water Poor through Water Poverty Mapping: A Case study using Census Data and the Water Poverty Index for the Estcourt Municipal District, South Africa,' Unpublished M.Sc. Thesis, Environmental Change Institute, Oxford University.

Cullis, J. D. S. (2005). 'Water Poverty Mapping: Development and Introduction Using a Case Study at the Local Municipal Scale for the Eastern Cape,' Water Research Commission, TT 250/05.

Department of Provincial and Local Government (DPLG). (2005). 'Framework for a Municipal Indigent Policy,' Executive summary. http://fbs.dplg.gov.za/fbs/site/docs/DocumentLibrary/IP/Executive.pdf?PHPSESSID=ba2fc5b7d282940898dab7f61abdde5e. [15 February 2010]

Gleick, P. (2002). The World’S Water, The Biennial Report on Freshwater resources, 2002 – 2003. Island Press, 1718 Connecticut Avenue, N.W., Suite 300, Washington, DC 20009.

Hemson, D, Kulindwa, K, Lein, H & Mascarenhas, A. (2008). 'Poverty and Water. Explorations of the Reciprocal Relationship,' Zed Books Ltd, 7 Cynthia Street, London, N1 9JF, United Kingdom.

Holland, A. S. (2005). 'The Water Business. Corporations Versus People,' Zed Books Ltd, 7 Cynthia Street, London, NI 9JF, United Kingdom.

Lawrence, P., Meigh, J. & Sullivan, C. (2002). “The Water Poverty Index: An International Comparison,” *Keel Economics Research Papers*, KERP 2002/19.

Meyer, W. N. (2007). 'The Economics of Water, Water for Life; Sanitation for Dignity,' *Van Schaik Publishers*, 1064 Arcadia Street, Hatfield Pretoria.

Newson, M. (2009). Land, Water and Development. Sustainable and Adaptive Management of Rivers, 3rd Edition. Routledge, 2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN.

Pallett, J. (1997). Sharing Water in Southern Africa, Desert Research Foundation of Namibia, PO Box 20232, Windhoek, Namibia.

Rand Water. (2008). http://www.wisa.org.za/patrons/randwater/index2.html [2 October 2008].

Sullivan, C. A, Meigh, J. R. & Fediw, T. S. (2002). Derivation and Testing of the Water Poverty Index Phase 1: Final Report. DFID.

Sullivan, C. A. (2002). Calculating a Water Poverty Index, *World Development*, Vol. 30(7), pp. 1195 – 1210.

Sullivan, C. A, Meigh, J. R. & Lawrence, P. (2006). Application of the Water Poverty Index at Different Scales: A Cautionary Tale, *Water International*, Vol. 31(3), pp. 412 – 426.

Sullivan, C. A., Meigh, J. R., Giacomello, A. M., Fediw, T., Lawrence, P., Samad, M., Mlote, S., Hutton, C., Allan, J. A., Schulze, R. E., Dlamini, D. J. M., Cosgrove, W., Delli Priscoli, J., Gleick, P., Smout, I., Cobbing, J., Calow, R., Hunt, C., Hussain, A., Acreman, M. C., King, J., Malomo, S., Tate, E. L., O"Regan, D. P., Milner, S. & Steyl, I. (2003). The Water Poverty Index: Development and Application at the Community Scale, *Natural Resources Forum*, 27, pp. 189 – 199.