

34th WEDC International Conference, Addis Ababa, Ethiopia, 2009

**WATER, SANITATION AND HYGIENE:
SUSTAINABLE DEVELOPMENT AND MULTISECTORAL APPROACHES**

**Sustainable urban water management in
Cape Town, South Africa: Is it a pipe dream?**

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The City of Cape Town (South Africa) faces numerous challenges in respect of water supply, drainage and sanitation services. It is hypothesised that the potential for long-term sustainability in urban water systems can be established through the application of a five-component sustainability index. This paper describes the development of such an index, the "Sustainability Index for Integrated Urban Water Management" (SIUWM), for specific application to southern African cities. It reviews the results from initial testing of the index on Cape Town, discusses its usefulness in terms of sustainability assessment, and provides a way forward for continuation of the research. It concludes that, by drawing on the numerous connections that link the different aspects of urban water management, the SIUWM is able to highlight several critical areas of "unsustainability" in the City and shows that sustainability will remain a pipe dream if these challenges are not addressed systematically and urgently.

Introduction

In 2008, for the first time more than half of the world's population lives in cities. Sub-Saharan Africa is the least urbanised region, but is expected to have the highest rates of growth for decades to come, including massive growth in urban slums (ACC, 2008). Cape Town, South Africa is an example of the types of pressures being experienced by cities in Africa. From 1996 to 2006 the city grew by almost 1 million people from 2.56 to 3.5 million, and since 1985 its spatial footprint has grown by 40%, with significant growth of informal settlements and related social and environmental problems (City of Cape Town, 2008).

The adequate provision of urban services, and in particular, the three water-related services – water supply, sanitation provision and drainage – are vital in the quest to eradicate poverty and ultimately provide the environment for sustainable development (de Carvalho, 2007). The challenge of service delivery in Cape Town is exacerbated by ongoing migration to the city together with considerable backlogs in housing. Whilst almost all formal housing in the city has access to the full suite of urban services, a large percentage of Cape Town's inhabitants reside in informal settlements. The current influx is approximately 7,700 households per annum (City of Cape Town, 2007), and latest estimates suggest that the backlog in housing is between 300,000 and 400,000 units. In an effort to meet service targets, the City has provided either emergency or basic levels of service to informal settlements until such time as people can be accommodated in state housing schemes where full services are provided. Thus, every person in the City should now have access to basic water provision (defined as 25ℓ of potable water per capita per day (ℓ/c·d) within 200m cartage distance). The provision of sanitation facilities has lagged behind however – it is estimated that at least 30,000 households have no access to even basic sanitation (defined as a minimum of one ventilated improved pit (VIP) latrine per household). Limited availability and suitability of land, the high unit cost of facilities and the current housing policy are constraints to progress.

Aside from the difficulties in eradicating the backlog of sanitation services, the city faces numerous other challenges with respect to water and sanitation services, including that of meeting increasing water demand, complying with wastewater standards, reliability of power supply, managing ageing infrastructure and deteriorating assets, extending infrastructure to meet developmental needs, ensuring financial sustainability, and building human capacity capable of addressing these pressing challenges (City of Cape Town, 2008).

Whilst these may seem overwhelming, a failure to address them and at the same time put the City on a sustainable trajectory could have dire social and environmental consequences.

The latest Integrated Development Plan (IDP) of the City of Cape Town addresses five strategic focus areas, one of which is “Sustainable urban infrastructure and services”. The report states that the City faces a number of challenges in achieving sustainability particularly in respect of environmental concerns, which are generally being addressed in a reactive manner as they arise, while the core of the city’s assets slowly erode. Cape Town has thus been described as being on a path of weak sustainability, implying an inherently inefficient method of crisis management which is unlikely to create long-term environmental sustainability (City of Cape Town, 2008). To protect the City’s critical assets, a strong model of sustainability is required, as is the realisation that change is urgently needed. This implies a central focus on people and their well-being as a direct outcome of well-managed natural resources – key interventions are required to improve the City’s ability to manage the environment according to this strong model of sustainability. The City has committed itself to various programmes in this regard, including an annual State of the Environment report, integrated with the bi-annual State of the City report, as well as a Sustainability report that is published every three years. Whilst these reports may provide comprehensive analyses of the state of urban water services however, they fail to provide a clear statement as to whether the City is moving toward a sustainable position or not. In providing a way forward, it is suggested that innovative approaches be employed, including methods of assessment and comparative analysis, in order to highlight areas of “unsustainability” and thus prompt alternative management strategies.

It is assumed that shortcomings in service provision and the management of water resources can partly be attributed to a failure in addressing the interrelatedness and the need for integration in the management of same. Integrated Urban Water Management (IUWM) is described by UNEP (2003) as, “*the practice of managing freshwater, wastewater and stormwater as links within the resource management structure, using an urban area as the unit of management*”. IUWM is increasingly being considered in the water and sanitation policies of Cape Town, but its philosophy and practice has still not been fully adopted by the city. To illustrate this point, the Catchment, Stormwater and River Management (CSRSM) department are only responsible for the management of the stormwater system (including surface water bodies) in the metropolitan area. Although water and sanitation services are the largest impactors on the stormwater system (increased flows, greywater run-off, sewer overflows etc) their planning and operational systems are carried out in a separate Department housed in another Directorate and do not adequately integrate with those of CSRSM. The implementation of IUWM could ensure that all water-related processes are planned and managed with a view toward their collective social, economic and environmental impact.

This paper firstly develops a conceptual understanding of sustainability in terms of water and sanitation services, and seeks to address the question, “Is sustainable urban water management in Cape Town a pipe dream?”, i.e. can the City provide water supply, sanitation and drainage services while conserving resources, and minimising pollution of the natural environment? It then goes on to describe a first attempt to develop a structured framework for a multi-dimensional assessment of urban water systems in order to define how the objective of sustainability can be achieved. It is hypothesised that the potential for long-term sustainability in urban water systems can be established through the application of a five-component sustainability index, the “Sustainability Index for Integrated Urban Water Management” (SIUWM), which has been developed for specific application to southern African cities (de Carvalho, 2007). This paper reviews the results from initial testing of the index on the city of Cape Town, discusses its usefulness in terms of sustainability assessment, and provides a way forward for continuation of the research.

Sustainability in the context of integrated urban water management

Sustainability literally refers to the maintenance or sustenance of something over the long term. Sustainable development is the process through which specific targets are set, actions planned and strategies implemented in order to deliver on current needs in a manner that is responsive to the earth’s capacity to replace ‘used’ resources and absorb ‘generated’ wastes, being conscious of the needs of future generations (Goodland & Daly, 1996). Another view is offered by Gibson (2005): “*Sustainability is essentially about linkages, interconnections and interdependencies. The concept of sustainability is a challenge to conventional thinking and practice, and represents a need for positive alternatives to the present unsustainable path we are on*”. It is with this in mind that the SIUWM is being used in an attempt to identify current performance and to suggest how practices can be modified toward the ideals of sustainability. Various assessment tools are available for determining whether sustainability goals are being

achieved; sustainability indicators are often used to measure the state of the environment by considering variables and monitoring relative changes against given criteria. Sustainability assessment offers a principled approach to designing policies and strategies that integrate social and biophysical resources so as to influence policy, plans and practice in the long term.

The overarching institutional impediments to sustainable urban water management are the lack of coordination of governing policies and regulations, fragmented administrative frameworks and the limited attention to institutional learning. IUWM provides the framework within which development objectives may be aligned and integrated so as to foster more efficient and sustainable use of water resources. It should be noted that a fundamental prerequisite for IUWM is the availability of appropriate data in order to be able to examine individual components and the interactions between them (Fletcher & Deletić, 2008). It is also worth noting that many of the barriers inhibiting the adoption of sustainable practices in the city are social and institutional rather than technical. While a range of technologies are available, human behaviour and matters of governance remain major challenges in Cape Town for a variety of complex historical and socio-political reasons. Legislative blockages in particular may result in alternative technologies not being trialled or implemented, e.g. the Water and Sanitation department may want to investigate dual reticulation options in a specific setting, but Building Regulations appear to outlaw them. The SIUWM has therefore also focused on social and institutional indicators of sustainability rather than exclusively on technology.

Development of the Sustainability Index

Various existing indices were investigated during the course of this research with a view to identifying an appropriate methodology and a core set of indicators / variables to provide input into the SIUWM. The system model was adapted from the life cycle assessment approach used by Lundin & Morrison (2002) for the development of environmental sustainability indicators for urban water systems. Together with this, a structured framework based on the composite index approach by Nardo *et al.* (2005) was used to define the system and identify the indicators for the SIUWM, as follows:

- Developing the theoretical framework
- Selecting indicators and showing links to others
- Conducting multivariate analysis
- Identifying data inputs
- Normalising and standardising data where necessary
- Applying weights and aggregating indicators
- Conducting robustness and sensitivity analysis
- Computing the index and interpreting / disseminating results

The index itself was designed in a similar manner to the Environmental Sustainability Index (ESI) developed by the Yale Centre for Environmental Law and Policy (2005). The scale of implementation between the ESI and SIUWM differs considerably – the ESI targets national-level policy whilst the SIUWM aims to improve management of water at sector level. Nevertheless, there is a commonality of purpose in the two indices with respect to informing on progress towards sustainability, aligning with existing policy and highlighting gaps in legislation. In order to account for the dimensions of sustainability, above, the SIUWM was thus designed using the similar five broad components of the ESI:

1. Social / cultural – social fairness and equitable resource distribution.
2. Economic – economically sound principles, economic growth and cost returns.
3. Environmental – environmental protection and preservation of ecological systems.
4. Political - support and international stewardship.
5. Institutional – including technical capacity and progress

A review of the relevant literature as well as an analysis of the urban water cycle in a southern African context resulted in the preliminary selection of 64 variables that were aggregated into 20 indicators as will be shown later in Table 3. The chosen indicators and variables are both qualitative and quantitative over widely differing ranges; standardisation was therefore required to place them within comparable scales. This was achieved by expressing each indicator on a categorical scale from zero to five where the values were either based on pre-established standards (e.g. WHO guidelines for access to water supply – see Howard & Bartram, 2003), or subjectively, using literature or expert opinion. Table 1 provides an example of the sort of normalisation that was applied to the various indicators for health status.

Under 5 mortality rate	Malaria-related mortality rate	Reported cases of water-related infectious diseases/1000	HIV/AIDS prevalence	Score
0%	0%	0	0%	5
1%-5%	1%-10%	1-20	1%-5%	4
6%-10%	11%-20%	21-100	6%-10%	3
11%-20%	21%-30%	101-300	11%-20%	2
21%-30%	31%-40%	301-500	21%-30%	1
> 30%	> 40%	>500	> 30%	0

The development of the SIUWM as an interactive spreadsheet-based program allowed for aggregation into a single figure result, as well as the attribution of different weights to variables. In the context of indicator development, weights often serve to emphasise issues of particular concern; however the allocation of weights is also an issue of conflict, which has given rise to debates regarding the validity of composite indices. As a first step in the testing of the SIUWM, an equal balanced weighting system was applied to all components, indicators and variables to establish an initial base situation. Additional weighting sets were then developed to emphasise specific component issues. A composite index approach was employed to compute the overall sustainability index score for a particular urban area as the sum of all the weighted components. In this approach, the standardised value for each variable is multiplied by the attributed weight to give a value on a scale of 0 – 5. The score for each indicator is then determined from the sum of the variable values multiplied by their respective weightings, expressed as a percentage by multiplying by 100. The scores for the five components – and ultimately the SIUWM – are determined in a similar manner.

Application of the index to the City of Cape Town

Cape Town is a major city on the southern-most coast of South Africa, with a population of about 3.5 million (City of Cape Town, 2007). It is an important driver of regional, provincial and national development, generating 76% of the Western Cape region's Gross Domestic Product (GDP) and 11% of the national GDP (City of Cape Town, 2008). It is home to some beautiful and unique natural environments, and possesses a diverse cultural heritage. In contrast to its natural beauty however, it faces several developmental challenges, one of the most important being that approximately 1 million of its residents (about 30%) live in informal settlements. The lack of formal services to these areas means that the City's environmental quality remains under pressure and continues to decline. Resource use and consumption is increasing, while the ability to absorb urban-generated waste is decreasing.

Average water use per capita is currently approximately 230 $\ell/c\text{-d}$, indicating a slight decrease from the 270 $\ell/c\text{-d}$ recorded in 2000. Water restrictions in 2001 and again in 2004/5 led to moderate decreases in demand, illustrating a potentially useful demand management system for a water scarce city such as Cape Town, but consumption started climbing slowly again in both instances once restrictions were lifted. Surface water resources represent 440.5 Mm^3/year , or 97% of the total yield. The City currently obtains 70 to 75% of its raw water requirements from dams owned by the SA Department of Water Affairs and Forestry (DWAF) and the remainder from its own sources. Approximately 15% of the raw water requirements are obtained from sources within the Cape Metropolitan Area (CMA). Groundwater resources make up 6.64 Mm^3/year , representing only 1.5% of the total yield. With the implementation by DWAF of the Berg River scheme, the existing water resources supplying water to Cape Town will be sufficient until approximately 2013, as long as the low water demand projections are followed. To reduce over-exposure to climate change and the potential decrease in system yield due to environmental reserve requirements, the strategy is to diversify water resources to lessen the dependence on surface water. Schemes to be pursued under this strategy are the exploitation of the Table Mountain Group Aquifer, other groundwater schemes, desalination, and treated wastewater effluent re-use. The City's aim, as set out in the IDP, is to reduce the actual demand for water by 20% from the projected unconstrained demand scenario by the year 2010.

Cape Town scored an overall sustainability rating of 68% when the SIUWM was applied, and Figure 1 shows the breakdown of this result for the 5 different components, in the form of a "spider diagram". Various weighting schemes were used in the application of the index but only the results using equal balanced weighting are reported here. It was found that the use of different weighting sets resulted in slight

variances in the scores at indicator and component levels, but that there was little variance in the overall scores at aggregate index level. As an example of the composite indicator approach in reaching the final score, Table 2 provides the results obtained for the Political component, as determined from its composite indicators and variables.

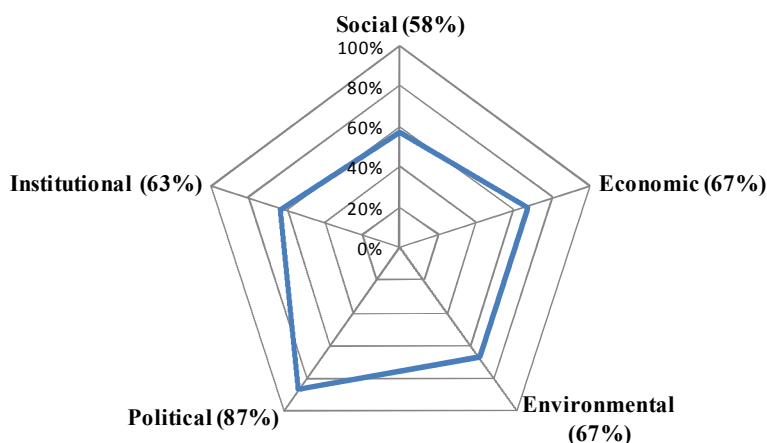


Figure 1. “Spider diagram” representation of SIUWM component results for Cape Town

Weight	Value	Indicator	Weight	Value	Variable	Weight	Value
0.20	4.33	Governance	0.5	4.00	Democracy and representation	0.33	3.00
					Measure of corruption	0.33	4.00
					Defined roles / responsibilities	0.33	5.00
		Compliance with policy	0.5	4.66	Government policies	0.5	4.66
					MDGs	0.5	4.66

The SIUWM scores highlight the inherent strengths and weaknesses in the general management of urban water in the City, and consequently in the performance across each dimension of sustainability. Single component analysis for Cape Town indicates that only one dimension of sustainability appears to be well-established, namely political. This is mainly as a result of the fact that the City has a well-defined set of policies in place, and has managed to comply with most of the relevant targets (such as the MDGs) even though it has experienced some political instability over the past few years. All other components receive moderate scores, with the social component receiving the lowest score. Further scrutiny of the individual scores in an attempt to highlight specific problem areas, shows particularly poor performances for indicators such as: wastewater management, environmental stresses, water use and sustainability of water resources.

Discussion

The current Water Services Development Plan (City of Cape Town, 2007) highlights the following critical challenges to the provision of equitable and sustainable urban water services in the City:

- Eradication of sanitation services backlog and expansion of basic services for influx of residents
- Intensification of Water Demand Management Strategy
- Meeting wastewater effluent standards to reduce impact on receiving waters
- Greywater runoff quality in informal settlements
- Timely provision and maintenance of infrastructure to meet development growth needs
- Financial sustainability of service and cost recovery; affordability of service; reduce bad debt
- Increasing performance and efficiency; establishing new, more effective institutional arrangements

The above challenges are reflected in the list of evidence of “unsustainable” water and sanitation services shown in Table 3. These have been linked, where possible, to the twenty indicators chosen for the SIUWM (referred to under “Development of the sustainability index”), in an attempt to highlight areas of key concern and identify interactions between the various aspects of urban water management.

Table 3. Links between SIUWM indicators and evidence of “unsustainable” urban water services		
Component	SIUWM indicator	Evidence of “unsustainable” water and sanitation services
Social	Access to water supply	<ul style="list-style-type: none"> • Overflows / blockages at communal standpipes
	Access to sanitation facilities	<ul style="list-style-type: none"> • Basic sanitation services backlog
	Levels of service	<ul style="list-style-type: none"> • 300 000 to 400 000 households limited to basic and/or emergency access to water and sanitation services
	Vulnerability to disasters	<ul style="list-style-type: none"> • Flooding and fire hazards
	Health (morbidity and mortality)	<ul style="list-style-type: none"> • Infant mortality rate and incidence of gastro-intestinal infections unacceptable high
	Education / awareness	<ul style="list-style-type: none"> • Residents in formal areas ‘over’ satisfied with water services, those in informal settlements dissatisfied.
Economic	Capacity to pay / access services	<ul style="list-style-type: none"> • Unemployment levels over 20%
	Cost Recovery	<ul style="list-style-type: none"> • Excessive water loss as unaccounted for water (UFW) – 19.3% in 2007 represented loss of 47 million m³ pa • Full cost recovery not being achieved - non-revenue demand is 62 million m³ pa or 23%. • Outstanding debt of R1.77b places a constraint on infrastructure and development
	Investment levels	<ul style="list-style-type: none"> • Ageing reticulation systems – number of bursts/100km deteriorated from 6 to 14 in last 20 years due to reduction in number of kilometres of pipeline replaced per annum • Further investment in bulk water supply schemes inevitable - new large schemes will need to be implemented between 2011 (no WC/WDM) and 2019 (comprehensive WC/WDM). • Unaffordable rising costs caused by diffusion of the city - urban sprawl increases unit costs of services.
Environmental	Fresh water Resources	<ul style="list-style-type: none"> • Water demand exceeds surface yields; surface water 97% of total yield. Demand likely to be exceeded by 2019 even at low water trajectory. Daily usage unsustainably high.
	Sustainability of water source	<ul style="list-style-type: none"> • Major uncertainties in the future - available supply depends on effects of climate change, and implementation of ecological reserves for existing schemes
	Use (resource distribution/sector)	<ul style="list-style-type: none"> • Domestic demand unacceptably high (52% of total in 06/07)
	Wastewater management	<ul style="list-style-type: none"> • Effluent from wastewater treatment works (WWTW) fails to comply to DWAF water quality standards - mean compliance for discharge into freshwater bodies was 81% in 2007, with 83% being the target for 2008/09 • Increase in volume of wastewater sent to WWTWs - 470ml/day in 2000 to 565ml/day in 2007
	Stormwater management	<ul style="list-style-type: none"> • Blue Flag beach status threatened along with coastal marine ecology - 24% of sample points exceed 80th percentile water quality guideline in 2004/2005.
	Compatibility of water system with surrounding environment	<i>Incomplete understanding at present</i>
	Compatibility of sanitation system with surrounding environment	<i>Incomplete understanding at present</i>
	Environmental stresses	<ul style="list-style-type: none"> • DWAF water quality standards too lax for effluent discharged into freshwater resources - given deterioration of freshwater resources within the city, current 1984 Water Quality standards/targets should be re-evaluated
Political	Governance	<i>Good scoring on current indicators</i>
	Compliance with policy	<i>Good scoring on current indicators</i>
Institutional	Institutional and technical capacity	<ul style="list-style-type: none"> • Limitations of current WDM strategy wrt conservation of water resources. Targeted savings for 2008 are 18.7 Ml/day or 6.84 million m³ per annum, approximately 2% of demand. • Limited critical personnel to manage key technical services

The problems highlighted in Table 3 are not usually the result of intention, but much rather *inattention*, that is the failure to see and respond adequately and timely to factors such as increased population, migration to

the city, climate change and uncertainties of meeting ecological requirements. There is an urgent need to change current thinking, behaviour and practices to prevent the continued risk to human and environmental health, and to avoid a threatening water crisis. The linking of the SIUWM indicators to the evidence of current “unsustainable” services in the City is thus an attempt to show where most effort should be directed. In this way, it is suggested that the application of the SIUWM and the careful consideration of the overall index score, as well as the individual component and indicator scores, could be used to identify and prioritise problem areas and guide decision-makers towards more sustainable practices.

Conclusions

This initiative set out to explore possibilities for improved management and integration of activities in urban water systems so as to ensure the efficient delivery of services and appropriate accounting of human impacts on the environment. Poor access to efficient water, sanitation and drainage systems, and the socio-economic and environmental effects of this, demand the attention of policy makers, governments, academics, practitioners, businesses and civil society at large. The SIUWM attempts to assess the possibility of cities becoming more sustainable by drawing on numerous connections that link the different aspects of Urban Water Management. This assessment has been undertaken with the aim of shaping cities of the future by highlighting current unsustainable practices and thus prompting alternative strategies.

The research team is still divided regarding the merits of reporting a simple composite index versus the five components, or even the twenty indicator scores. Currently the view is that reporting a final composite figure does not detract from the component analysis and that the simplicity and desirability for a single number could ultimately generate greater awareness of the underlying issues with key decision makers. This is particularly the case in targeted benchmarking exercises where, for example, the assessment of urban water management in cities around South Africa could be compared with one another. Similar existing initiatives such as the development of processes for best practices in the municipal water sector (Africon, 2007), and the assessment of drinking water quality management in Water Service authorities throughout South Africa (Delpert, 2007) could also be used to complement / inform the outputs from the SIUWM.

In terms of furthering the research and upgrading the index, it is proposed that variations in indicator selection / composition and methods of aggregation be employed to determine whether they have an effect on the overall index scores. Wider application and testing of the index on a variety of settings and scales, both in Cape Town as well as other cities around South Africa, will be used to determine its applicability and robustness. Continued engagement with relevant stakeholders will be used to emphasise the need for greater data collection and the development of regularly updated data banks. This will enable the appropriate use of the SIUWM as an advocacy and management tool at both national and local government level.

Applying the index to the City of Cape Town has served two purposes to date – 1) the obtaining of a “snapshot” of sustainability performance with respect to urban water services in the City, and 2) the assessment of the sustainability index itself, to try and gauge whether the results obtained match up to the existing conditions on the “ground”, and see whether the tool can be used as an effective measure of sustainability in the context of integrated urban water management. The City is already using a range of useful indicators to report on its progress. The SIUWM could be a valuable addition to these by virtue of the fact that it further emphasises the integration of all water aspects in the urban water system; an approach that emphasizes health, well-being and productivity; a continuous reduction in the quantity of polluted water entering the environment; and efforts to rehabilitate degraded water bodies and rivers within the City. The index is able to show that the provision of sanitation and water services also needs greater co-ordination. For instance plans for sanitation and water services must take livelihood, cultural and gender issues into account and must recognize that appropriate sanitation which meets the needs of residents goes beyond the provision of toilet facilities. Proposed service delivery options will need to demonstrate alternatives to conventional water supply and wastewater treatment technologies, such as rainwater harvesting, greywater recycling, urine diversion toilets, methane gas digesters, etc.

By providing some detail on the performance of urban water services in Cape Town, the SIUWM can also respond to the question: “Is sustainable urban water management in Cape Town achievable?” It does this by suggesting that, whilst the political component of sustainability has strength, there is insufficient attention being given to environmental, social, institutional and economic components. It is argued that sustainability will remain a pipe dream if the challenges besetting the City of Cape Town are not addressed systematically and urgently.

Acknowledgements

The authors would like to acknowledge the National Research Foundation of South Africa (NRF) for partly funding the research.

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Keywords

Integrated urban water management, sustainability indicators, sustainability assessment

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