

THE EVALUATION OF A SUSTAINABILITY INDEX FOR INTEGRATED URBAN WATER MANAGEMENT IN SOUTH AFRICA.

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ABSTRACT

Water is not only essential for maintaining life; it is a key component of social and economic development, having links to, inter alia, health, “sense of place”, food production and industrial growth. Although progress has been made with regard to the provision of water services in South Africa, there are still significant backlogs which need to be addressed. The failure in service provision can partly be attributed to a lack of an integrated approach with regard to the various aspects of urban water management. A systems approach has been used by researchers at the University of Cape Town to develop a composite Sustainability Index (SI) which, by addressing five components of sustainability (environmental, social, economic, political and institutional), attempts to give a measure of the potential for sustainability in the context of integrated urban water management. This paper describes an evaluation and modification of this SI. It makes recommendations for its further improvement and ongoing development; in particular making the index less data intensive. In the evaluation of the SI, data accessibility and usefulness of results were used to determine its effectiveness. The original and revised indices were tested on two South African cities, East London and Port Elizabeth. Results of the analysis demonstrated that the sustainability index can highlight areas for improvement and ultimately guide more appropriate action and policy-making for better service delivery and improved resource management.

INTRODUCTION

Basic human needs for water were first articulated in 1977 by the United Nations, in declaring that: “...all peoples, whether their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs” (1). The reality is such however, that in many countries water availability is falling to crisis levels, partly due to rapid population growth. The combination of safe drinking water and hygienic sanitation facilities is a precondition for sustainable development as well as being central to human rights and the personal dignity of every person on earth (2). This realization has prompted countries around the world to commit to achieving the Millennium Development Goals (MDGs) as set by the United Nations (3).

The South African Government has made some progress in reducing the water and sanitation backlogs in this country. Nonetheless, there are major problems with service delivery; it is estimated that there are still over 2 million people in South Africa without access to any form of water supply infrastructure, and 12 million without a sanitation facility (4). Population

growth, urbanization, inadequate maintenance of infrastructure and low institutional capacity all contribute to these backlogs. One of the key issues contributing to the Government not being able to meet service provision needs appears to be its apparent inability to consider the problem as a whole. The long-term sustainability of the urban water cycle (water supply, sanitation, drainage, wastewater treatment, groundwater and urban rivers) depends on a clear understanding of the links between each of the various elements. This research suggests that if decision-makers had a better understanding of the linkages, they would be better able to provide solutions to the service delivery crisis.

Internationally, the apparent lack of clear-cut solutions in areas such as service delivery has highlighted a need for tools that could help in monitoring the progress achieved by governments towards sustainable development (5). The development of such a tool is one of the projects being undertaken by the Urban Water Management (UWM) group at the University of Cape Town (UCT). A sustainability index for integrated urban water management (SI) has been developed with the objective of identifying the key components that need to be addressed by appropriate authorities with regard to urban water management. The aim of this research is to evaluate and improve the SI by optimising various aspects such as the selection of indicators and the weighting system in the hope that it will be able to aid decision-makers in their assessment of the best possible solutions for the provision of sustainable water services. The robustness of the SI was assessed with the aid of data from two case study areas. This paper reviews the results from the evaluation and modification of the SI.

BACKGROUND TO RESEARCH

A commonly cited definition of sustainable development is “*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*” (6). Sustainability explores the relationship between economic development, environmental quality and social equity (7). Sustainability assessment reports of cities are an attempt to understand and quantify the problems associated with unprecedented population growth and finite resources, and are an example of how international debates on sustainability are influencing local policy decisions (8). These reports are aimed at bringing about informed responses from all sectors of society.

The research summarised in this paper focuses on how cities manage their water, taking into account the various aspects of sustainability; social development, economic growth and environmental protection. Of all three, environmental protection is often the least acknowledged and at times the most limiting factor to the growth of cities. When trying to achieve sustainable development it is important to know how current development approaches support people. These impacts include both the physical consequences for the environment, and the associated economic and social consequences. It is therefore useful to assess sustainable development through the use of simple and reliable indicators which highlight areas where improvement is needed (7). In South Africa, urban water management has water supply, wastewater, stormwater and groundwater as largely separate elements, with the planning and operating of these having little reference to one another. In reality, these systems have significant interactions; for example, as an urban area grows the carrying capacity of water infrastructure such as a sewer system can be exceeded, leading to problems such as uncontrolled overflows of poor quality water into rivers.

Integrated Urban Water Management (IUWM) addresses the imposition of society on the natural water cycle in the urban context as well as the exploration of avenues for improved service delivery through appropriate management and concerted action. It has been described by UNEP (9) 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 reconciles social equity with economic efficiency as well as environmental sustainability, and recognizes that robust systems are needed to encourage structured decision-making in this regard. De Carvalho (10) breaks IUWM into three components: physical aspects mainly consisting of physical infrastructure and development; institutional and management aspects dealing with the programmes in place to ensure efficient use of available resources; and the policy background which supports development through legislative corridors. The SI expounded upon in this paper attempts to address all three components of this complex research area with the aim of highlighting issues in management.

Sustainability indicators at the national, regional and local level have become common assessment tools. There is a growing need to establish appropriate indicators to allow decision makers to make informed judgements regarding policies, programs, plans and projects (11). Indicators can provide crucial guidance for decision-making; they can translate physical and social science knowledge into manageable units of information to facilitate the decision-making process; and they can help to measure and calibrate progress towards sustainable development goals by providing early warning systems to prevent economic, social and environmental damage (4).

Sustainability Index for integrated urban water management (SI)

The SI was designed to assess the capacity of a city to be sustainable with respect to water management. In constructing the index, De Carvalho (10) drew considerably on existing methodologies and approaches. In particular, the work of Nardo *et al.* (12) provided guidance on the development of the composite index by way of a step-wise methodology. The SI (now referred to as SI 2007) consisted of five components, which disaggregated into 20 indicators and ultimately into 64 variables. Although the index cannot measure sustainability directly, it reflects the state of the overall components of IUWM which are thought to bring about a more sustainable society. De Carvalho (10) expanded the index from the traditional three components of the triple bottom line to a set of five components: environmental, social, economic, institutional and political. The addition of institutional and political performance indicators resulted in a more balanced foundation upon which the sustainability assessment could take place. Figure 1 gives an indication of the structure of the SI.

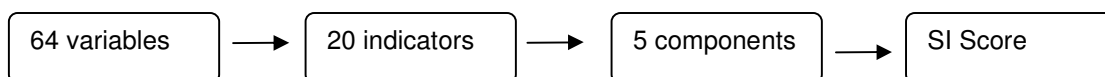


Figure 1: The SI structure

The SI undertakes the aggregation of multiple and diverse variables, often measured and represented in different units and having widely different scales. There was a need therefore, to standardise the data according to a set and comparable frame of reference. The indicator conversion employed a categorical scale normalisation approach, where all indicators were scored on a 0 – 5 scale. Depending on the variable, this was either quantitative, with a score

from 0 - 5, or qualitative, for example on the basis of excellent, effective, satisfactory, poor, very poor and none. Various weighting systems were developed in order to emphasise issues of particular concern. When applying the SI to a selected study area, a Microsoft Excel Workbook is used to analyse the gathered data and calculate sustainability performance scores for each component. Ultimately one final SI performance result is given as a percentage (%) calculated by averaging the five component results. The spreadsheet was designed in such a way that the higher the score for an individual variable, indicator and component the better the study area performs towards sustainability. The single final SI result only presents a 'snapshot' of the potential sustainability of the IUWM system in the study area and further exploration of the contributing component and indicator scores is required for a more detailed understanding of the system.

MODIFICATION OF THE SUSTAINABILITY INDEX

The formulation of the method for evaluating and improving SI 2007 was guided by the following broad research questions:

- Can the SI be improved to make it a more effective tool for measuring the sustainability of IUWM in a South African context?
- Can an index such as the SI reliably measure the sustainability of urban water management in South African cities?
- Is the index practical and easily understandable in its application for municipality officials and other target audiences?

In order to address these key questions, SI 2007 was applied to two study areas namely, East London and Port Elizabeth, in order to gain a better understanding of its practicality and effectiveness. Following this, an in-depth assessment and modification of the SI was done. The revised SI (SI 2009) was then applied to the study areas and the results obtained were assessed with reference to information gathered from visits to the study areas. Changes to SI 2007 were guided by 'recommendations for future research' given by De Carvalho (10) and the literature reviewed on developing effective sustainability indicators. In particular, the International Institute for Sustainable Development (IISD), one of the world's leading NGOs supporting the development of indicators of sustainable development, informed the modification process (13). The IISD offers the following guidelines to developing effective indicators:

- Availability of data: the indicator should use good quality, affordable and readily available data.
- Simplicity: the information gathered for the indicator must be presented in an easily understandable and appealing way. Complex issues and calculations should yield clearly presentable and understandable information.
- Policy relevance: the indicator should be associated with one or several issues around which key policies are formulated. This is because sustainability indicators are intended for audiences to improve the outcome of decision-making on levels ranging from individuals to the entire biosphere. Unless the indicator can be linked to critical decisions and policies, it is unlikely to motivate action.

- Validity: the data used in the index should be collected using scientifically defensible measurement techniques. Methodological rigor is needed to make the data credible for both experts and the general public.
- Time-series data: the indicator should use data which reflect trends over time.
- Reliability: the same information should be provided by multiple applications of an indicator using the same data. Ideally two different researchers should arrive at the same conclusions using the same indicator.

One problem identified by previous users of the index was that SI 2007 comprised too many indicators and variables. The first objective in modifying the SI was to reduce the number of these variables thereby making it more user-friendly and less time-consuming to apply, and improve its accuracy and robustness. It was important that the results obtained from the revised index accurately predict what was observed during the case study visits. The overarching guideline was that variables relating to sustainability principles were selected for the revised SI. Where the data were difficult to find, the indicator or variable was removed or replaced with a similar one with more readily available data. SI 2007 consisted of five main components and this structure was retained for the revised SI (SI 2009) because all five were considered to be important aspects in terms of sustainable urban water management.

In the context of indicator development, weightings often serve to emphasize issues of particular concern. The SI results are presented for two weighting systems as adopted by De Carvalho (10), namely; neutral weighting and subjective weighing. For the neutral weighting system a method of equal and balanced weighting was employed, where all variables within indicators were equally weighted and all indicators within component categories as well as components making up the index were equally weighted. For the subjective weighting system five sets of weightings were developed in line with the five dimensions of sustainability represented in the index. The sustainability index for a particular city (SI_i) is the sum of all the weighted components (Equation 1). Variables and indicators are aggregated in the same manner as components. The standardised value of the respective component X_i , is multiplied by the attributed weight, w_{x_i} , to give a value on a scale of 0 – 5. This figure is then expressed as a percentage by dividing it by 5 and multiplying by 100. To account for all 5 dimensions (components) of sustainability the formula is as shown in Equation 2

$$SI_i = \frac{\sum_{i=1}^N w_{x,i} X_i}{\sum_{i=1}^N w_{x,i}} \quad (1)$$

$$SI_i = \frac{w_s S + w_e E + w_{ev} EV + w_p P + w_i I}{w_s, w_e, w_{ev}, w_p, w_i} \quad (2)$$

(S- Social; E- Economic; EV- Environmental; P- Political; I- Institutional. The symbols: w_s , w_e , w_{ev} , w_p , w_i ; represent the weights for the 5 components)

It is important that the weight allocations are set to a specific scheme to ensure that case studies are comparable. In the preliminary SI 2007 assessment, data from East London and Port Elizabeth were used to compute the index score utilising the different weighting systems. It was found that the overall SI score did not vary significantly with a maximum variation of only 3%. In the SI 2009 calculation therefore, the neutral weighting scheme of 'equal and balanced' was selected and used in the study area comparisons.

In order to assist in the evaluation and modification of the individual indicators and variables used in SI 2007, a number of sustainability principles were drawn up for each of the five components, adapted from the framework for sustainable construction developed by Hill & Bowmen (14). For the SI to be effective, these sustainability principles should be reflected in the choice of indicators and variables, as follows:

1. The overarching principle of social sustainability is to ensure the continual improvement of the quality of human lives. For example, the 'level of service' in a city is a good indicator of the social sustainability principle.
2. Sustainable economic systems are seen as being rooted within social and environmental systems. In the context of urban water management, economic sustainability relies on financial resources being managed in such a way as to drive the principles of environmental and social sustainability.
3. Environmental sustainability implies that the earth's natural systems are able to continually restore and maintain themselves.
4. In order to achieve sustainability, political systems need to set a foundation upon which environmental, social and economic sustainability can be effectively accomplished.
5. Without good institutional structures with sufficient technical capacity, progress towards sustainability cannot be achieved in urban areas.

Ultimately the final structure for the revised SI (SI 2009) was determined through knowledge gained from these principles and recommendations from previous researchers. The structure of SI 2009 is shown in Table 1. This index structure has a reduced number of indicators (14) and variables (38). SI 2009 is thus less data intensive and therefore takes less time to apply than SI 2007.

APPLICATION OF THE SUSTAINABILITY INDEX

In order to test the SI, two case study areas, East London and Port Elizabeth, were selected. Both cities are located in the Eastern Cape Province of SA and are centres of urban growth.

East London

East London is located within the Buffalo City Municipality (BCM) which has an estimated population of 1.4 million extending over an area of 1100km² (15). The population of the city of East London itself is approximately 205 000 (1). Water supply in East London is the responsibility of BCM who as the Water Services Authority (WSA) and Water Services Provider (WSP), have various obligations and responsibilities in terms of achieving efficient and adequate water services for the city and other areas in the municipality. East London is faced with growing challenges relating to water, sanitation and wastewater management due to increased population. As part of the process for addressing this situation, BCM has recently embarked on a process of preparing a Sanitation Policy and Strategy (15).

Table 1: Structure of modified Sustainability Index (SI 2009)

| Components | Indicators | Variables |
|---|---|--|
| 1. Social security | 1. Levels of Service (LOS) | 1.1 Water supply |
| | | 1.2 Sanitation |
| | | 1.3 Drainage |
| | | 1.4 Waste collection |
| | 2. Vulnerability to disasters | 2.1 Susceptibility to natural disasters |
| | | 2.2 Risk Management & disaster mitigation |
| | 3. Health | 3.1 Under 5 mortality rate |
| | | 3.2 HIV/AIDS prevalence |
| | 4. Education and awareness | 4.1 % of people with secondary education |
| | | 4.2 Level of stakeholders consultation |
| 4.3 Level of dissemination | | |
| 2. Economic | 5. Capacity (to pay or access services) | 5.1 Unemployment rate |
| | | 5.2 Income levels |
| | 6. Cost Recovery | 6.1 % users paying for water |
| | | 6.2 % of unaccounted for water (UFW) |
| | 7. Investment levels | 7.1 % budget increase for water supply |
| | | 7.2 % budget increase for sanitation |
| | | 7.3 Sources of investment |
| 3. Environmental performance | 8. Fresh water Resources | 8.1 Per capita water availability |
| | | 8.2 Water quality at source |
| | 9. Sustainability/ Feasibility of water sources | 9.1 Sustainability of source |
| | | 9.2 River Health Index |
| | 10. Use (resource distribution per sector) | 10.1 Domestic |
| | | 10.2 Industrial |
| | | 10.3 Agricultural and livestock |
| | | 10.4 Maintenance of ecosystems |
| 11. Wastewater management | 11.1 Effluent quantity | |
| 4. Political support and international stewardship | 12. Governance | 12.1 Democracy and representation |
| | | 12.2 Measure of corruption |
| | | 12.3 Defined roles and responsibilities |
| | 13. Progress with meeting the MDGs targets | 13.1 % with access to protected water |
| | | 13.2 % with access to adequate sanitation |
| 5. Institutional capacity and technological progress | 14. Institutional capacity and technological progress | 14.1 Adoption of IUWM approach |
| | | 14.2 Adoption of alternative water supply technologies |
| | | 14.3 Adoption of 'sustainable' sanitation |
| | | 14.4 Monitoring capability |
| | | 14.5 Reliability of service provision |

Port Elizabeth

Port Elizabeth is the largest city in the Nelson Mandela Metropolitan Municipality (NMMM). The Metro comprises three main urban centres; Port Elizabeth, Uitenhage and Despatch, and covers an area of 1 951km². Port Elizabeth is considered the economic capital of the Metro and the Eastern Cape Province, and has a population of some 1.5 million (16). It is an important centre for the automobile industry and a major transport hub with its well equipped airport, harbour and port. The unemployment rate among the economically active sector of the community is however still high at approximately 35% (17). Although this has shown a steady decline since 1994, it remains much higher than the national average for South Africa which is 24.3% (1). A key challenge for the city of Port Elizabeth is balancing short-term job creation with long-term opportunities which will provide economic sustainability. The Municipality continues to provide relief to impoverished households through its 'Assistance to the Poor Scheme' under the Indigent Policy, and has increased its monthly free water supply from 6 kl to 8 kl and free basic electricity from 50 kWh to 75 kWh per household respectively. Approximately 93 000 households receive free basic water, sanitation and refuse removal services, while almost 95 000 households receive free electricity every month (17). NMMM acts as the Water Services Authority (WSA) for Port Elizabeth.

RESULTS AND DISCUSSION

Comparing the results of SI 2007 with those of SI 2009

A comparative assessment was made of SI 2007 and SI 2009 for both case study cities. The performance results for East London and Port Elizabeth are shown in Table 2. Overall, the final SI scores obtained in SI 2009 were lower than those of SI 2007 in both cities. Ultimately, SI 2009 appears to reflect a closer representation of sustainability in urban water management in the study areas as was confirmed by the information gathered during the city visits. This may be a result of unnecessary indicators and variables being removed.

Table 2: Comparative assessment of study areas performance for SI 2007 and SI 2009

| SI Component | SI 2007 | SI 2009 |
|---------------------|-----------------------|---------|
| | East London | |
| Overall performance | 67% | 56% |
| Social | 76% | 49% |
| Economic | 66% | 50% |
| Environmental | 63% | 45% |
| Political | 81% | 83% |
| Institutional | 48% | 52% |
| | Port Elizabeth | |
| Overall performance | 68% | 60% |
| Social | 72% | 53% |
| Economic | 68% | 50% |
| Environmental | 67% | 50% |
| Political | 86% | 93% |
| Institutional | 48% | 52% |

Comparing the results of the two cities

Physical similarities between the cities of East London and Port Elizabeth help to explain the similar performance in the SI 2009 assessment (see Figure 2). Both cities are located in the Eastern Cape Province of South Africa; this means that the same provincial authorities govern them. Similarly, geographical profile and social structure of these two coastal cities result in related environmental and social component scores. Both cities face the problem of informal settlements and housing backlogs caused by high population growth. East London and Port Elizabeth are both the main urban centres of their respective municipalities and tourist destinations to some extent.

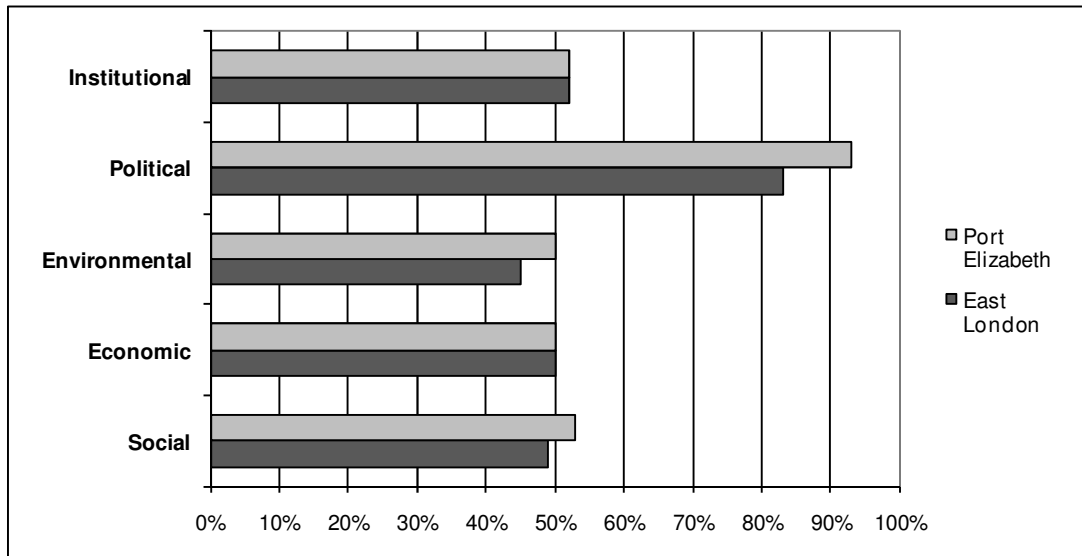


Figure 2: Comparative performances of East London and Port Elizabeth using SI 2009

East London and Port Elizabeth's multi-dimensional sustainability performance

Considering all factors, East London displays a relatively low performance in the sustainability continuum. The city attained an overall score of 56% with the highest score being in the political component (83%) and the lowest in the environmental component (45%). There is great variation in the results of the individual components, which indicates inequalities in the spheres of water management. The overall SI 2009 score for Port Elizabeth was 60%. Although this represents a slightly higher sustainability score compared to East London, there is still a lot of progress to be made in certain areas. The political component received the highest score of 93%, while the environmental and economic components were poor performers.

Sustainability index evaluation

An 'evaluation criteria matrix' was used to assess the effectiveness of the SI when applied at the city scale. The matrix was developed by Graymore *et al.* (18) to compare and contrast the effectiveness of five different sustainability assessment methodologies at a regional scale. The criteria matrix used in this research has been changed slightly to conform to the focus of the SI. The criteria matrix was selected as the evaluation technique for this research because it describes and evaluates the attributes of an effective indicator, as well as the characteristics that make the index useful for promoting sustainable management and capacity building (18). The evaluation criteria matrix showed that SI 2007 is a useful tool in simplifying the

complexity of sustainability and facilitating communication to a range of audiences by presenting overall results that are easy to understand and visually well represented. The main weakness of SI 2007 relates to the data collection and data input process as it is data intensive and time consuming to process and for this reason it was revised. The criteria matrix showed that SI 2009 was also a useful tool in assessing sustainability in an urban water management environment. The strength of SI 2009 lies in its reporting of performance at all levels of aggregation. However, the usefulness of the assessment results should be addressed in terms of the problems of scale and applicability for municipality officials.

In addition to the matrix described, a more in-depth evaluation of the two variations of the SI was conducted by responding to questions on sustainability assessment methodologies posed by Singh *et al.* (19) and the United Nations (20) that could not necessarily be translated into a matrix 'point' system, as follows:

- a) **Flexibility:** How flexible is the index for allowing change, purpose, method and comparative application?

SI 2009 is designed for use in a South African context. The SI is flexible and can be applied at different levels, i.e. city, local municipality and provincial level although in this research only the city level was applied. The index can be used in a comparative application as done with East London and Port Elizabeth.

- b) **Relevance to MDGs and other global initiatives:** To what extent does the index reflect progress made towards the achievement of the MDGs?

SI 2009 does take into account the MDG targets in its political component. Progress made toward achieving the MDG goals of water supply and adequate sanitation are accounted for in SI 2009.

- c) **Weaknesses:** What are the main weaknesses in and constraints to using the index?

The main weakness of SI 2009 lies in the reporting of the political and institutional components of the index. In applying the index it was found that the political component results were always the highest obtained and were often outliers. This was ascribed to the indicators dealing with governance whose data relied on interview information from municipality officials. The measure of corruption, for example, was often reported as 'low' during interviews, yet other sources of information would provide a different picture. One solution in dealing with this weakness would be to use different indicators for 'democracy' such as the Corruption Perception Index that is used globally. Another major constraint with the index was the process of getting data relevant to the same time period for all indicators. This was due to inconsistencies in reporting at city scale for the selected case study areas.

- d) **Strengths:** What are the main positive qualities of the index?

The main strength of SI 2009 is that it requires less time to input the data. This is as a result of a well explained instruction page for the Excel workbook which guides the user in applying the index and the fact that it is less data intensive.

- e) To what extent does the index reflect the **socio-economic situation** in the city?
SI 2009 takes into account various levels of service, health, education, vulnerability to disasters and income in the city. The results obtained for the study areas are therefore a good reflection of the socio-economic status in the cities.
- f) What use is made of the **index at different levels** (community, municipality, national, regional and global)?
The SI for IUWM is still in its development stage and has only been tested at a city level thus far.
- g) Is the **index able to predict** whether IUWM in a specific city is being practiced, and whether the urban water system can sustain itself?
The assumption has been made in this research that an integrated approach to urban water management is required in order for the water system in a city to be sustainable. Based on this, the index is able to use empirical data to show the level to which sustainable urban management is being achieved, and highlights areas where improvement in management is needed.

CONCLUSIONS

The main aim of this research was to evaluate and improve the SI developed by De Carvalho (10) and to test the updated index on two case study areas. Through knowledge gained from a review of literature and recommendations given by previous users of the index, an improved and modified SI (SI 2009) was developed. In terms of furthering the research and upgrading the SI, it is proposed that a wider application of the index and broader testing in a variety of settings is undertaken to determine the applicability and use of index. This is important because different study areas highlight various issues with regard to the effectiveness of the SI. The success of IUWM requires an interdisciplinary approach with strong political and institutional backing. It is important therefore that further engagement with relevant stakeholders and experts takes place in order to identify pertinent issues and formulate appropriate indicators. This will help in getting expert knowledge on the issues regarding IUWM that should be addressed in the SI.

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