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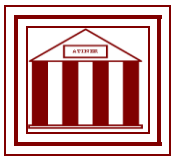

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# The Future of Sustainable Water Resource Development and Management in South Africa

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# The Future of Sustainable Water Resource Development and Management in South Africa

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## Abstract

There are a wide range of issues that stem from the inadequate access to, and the unsustainable management of water resources, which can lead to ecological and human crises. With the increasing demand for clean water for drinking and sanitation, coupled with population growth, aging infrastructure, and climate change, many of the regions within South Africa face a complex set of threats when dealing with their water resources and the management thereof. If current trends in water management continue and government does not intervene with what has been an unequal society, even in terms of the division of water, it will continue to lose ground in its development and sustaining of water resources. "The objective of managing the quantity, quality and reliability of the nation's water resources is to achieve optimum, long-term, environmentally sustainable social and economic benefit for society from their use" - Principle 7 of the National Water Policy. The aim of the research was to determine water availability and usage in South Africa, based on data on water consumption and availability in a number of regions across the country, an extensive literature review was utilised to categorise the regions with specific characteristics from a hydrogeological point of view, and place these into distinct water 'zones'. The Causal Layered Analysis (CLA) future studies technique was utilized in investigating the way water has been managed and developed, and the strategies and worldviews that have had an influential role on the relationship between water and its use in South Africa. The 'Seven Outlying Socio-Economic and Hydrogeological Sustainable Development Zones' defined within the study, were then used to derive strategies for a positive outcome in water resource development and management in South Africa.

**Keywords:** Causal Layered Analysis, Socio-Economic and Hydrogeological Sustainable Development Zones, Sustainable Development, Water Development, Water Resource Management.

## Introduction

The study aimed to develop strategies that can be adopted in a number of areas across the water sector with the objective of improving both socio-economic and hydrological sustainability in South Africa. It takes into consideration the possible future outcomes for freshwater availability, and quality in South Africa, and identifies factors that determine the way in which water is utilised, managed and developed in the country. The concern regarding water within South African borders is that freshwater is predicted to become the largest constraint on development (Von Bormann & Gulati, 2014: 21). However, the issue is not only of water availability; but according to Von Bormann and Gulati (2014: 21), the primary water issues stem from a declining quality of water.

There is little to indicate that the water sector will arrive at a sustainable, cost-effective solution to meet the growing water requirements, pressurised by economic and population growth in South Africa (2030 Water Resources Group, 2009: 4). South Africa, according to many studies, is a semi-arid, water-stressed country, with an average annual rainfall of approximately 495mm up to the year 2013, which is way below the average of 860mm per year of the rest of the world (Food and Agricultural Organisation, 2013: 1; Department of Water Affairs [DWA], 2004: 3; Hedden & Cilliers, 2014: 2)

According to the DWA (2004: 3), there are a number of challenges across South Africa with regards to water availability. These include: the uneven distribution and seasonality of rainfall, due to high levels of evaporation, as climate change worsens, with as much as 43% of rainfall occurring over 13% of the land in South Africa; low stream flows in rivers, which limits the stream flow potential, and the supply which can be relied upon for use; the location of major urban and industrial developments which are remotely situated from South Africa's larger watercourses, which means a higher necessity of water transfer infrastructure; and lastly, the impact of pollution on water resources. (DWA, 2004: 3; Department of Water Affairs and Forestry [DWAF]. 2012: 13).

Approximately 70% of South Africa's GDP is supported by water supplies in the Limpopo, Inkamati, Pongola and Orange River areas, which collectively make up two thirds of all the drainage areas in the country (DWA, 2004: 3). The frugal management of these water sources is integral not only to South Africa, but also to neighbouring countries (DWA, 2004: 3). Although the National Government is responsible as the trustee of South Africa's water resources, since ministers are responsible for implementing appropriate policies, ultimately the adequate management of water resources falls to the regional municipals, with 19 water management areas across the country (DWA, 2004: 3).

South Africa is ranked as the 30$^{th}$ driest country in the world. Because of the high displacement of water resources, it has less water per person, than countries considered to be much drier, such as Namibia and Botswana (DWAF, 2012: 13). The effective management and development of water therefore is

important for South Africa to achieve optimal social and economic performance in a sustainable manner. Water is centralised in the heart of economic growth and sustainable development of a nation (Muller, Schreiner, Smith, van Koppen, Sally, Aliber, Cousins, Tapela, van der Merwe-Botha, Karar & Pietersen, 2009: 6). According to the WWF, the focus should not be on scare tactics and forceful approaches when dealing with water crises, but rather to accept that there should be urgency to act, and focus on the nature of the risks currently faced by South Africa and its water resources and quality, and ultimately, how to respond to these changes (WWF, 2012: 1).

## The South African Water Map – Seven Outlying Socio-Economic and Hydrogeological Sustainable Development Zones

The following section introduces the seven zones, which will describe the outlying socio-economic and hydrological basis of analysis for the study. The basis, through which the framework for sustainable development of water quality in South Africa for this study was developed, is divided into three basic elements: the geographical location of water in South Africa; the amount of naturally-occurring freshwater; and the management of water resources in the country.

The methodology used in studying the possible future of water in South Africa is a new area of research for water in this country, and aims to provide strategies to help deal with the major water challenges faced by South Africa, and how these zones can approach the use of water. However, the zones will not only cover water availability; as emphasised by (Von Bormann & Gulati, 2014: 21), the challenge is also of declining water quality. The districts across South Africa that experience similar natural water distribution and strategies in the use of water are clumped together in a specific zone. The zones in this study are as follows:

- Zone 1, Urban and Industrial Districts (Wealthy demographic);
- Zone 2, Water Stressed Regions;
- Zone 3, Water development;
- Zone 4, Economic Water Scarcity;
- Zone 5, Shared Demand Driven;
- Zone 6, Potential Endangerment, and
- Zone 7, Decreasing Water Quality.

Each zone then has its own specific socio-economic and hydrological impact, with many experiencing similar water challenges, such as degrading quality of water, extreme conditions, sharing in demand or environmental risks. Some regions within South Africa will have overlapping challenges and therefore fall under more than one zone, in which case some strategies may be more adaptable than others. Therefore each zone and their characteristics will

be highlighted and analysed below. From the zones, the CLA will be applied, and strategies will be designed to manage water more effectively.

*Zone 1: Urban and Industrial Districts (Wealthy Demographic)*

This zone includes the wealthy urbanised and industrial areas across South Africa. Gross Domestic Product (GDP) is used in this study to measure the wealthiest areas in South Africa. The largest contributors to the South African GDP are first the Western Cape, second the Gauteng Province, and third Kwa-Zulu Natal, since they have out-performed South Africa's average GDP of 3.9% over the period 2002-2012 (Statistics South Africa, 2013: 10). However, the provincial contribution to the South African economy, over the measurement periods 1997, 2007 and 2012, sees the Gauteng Province as the largest contributor, then the Kwa-Zulu Natal, and finally the Western Cape (Statistics South Africa, 2013: 10).

*Zone 2: Water Stressed Regions*

This zone includes areas that experience low freshwater access, low levels of GDP, and seasonal variability due mainly to climate change and unpredictable precipitation (Absar, 2013: 4). These circumstances are predominant in North West Province, Northern Cape, and the North Eastern parts of South Africa; this includes the limited economic activity and drinking water quality of the Mpumalanga, Transkei or Southern coastal KZN areas and the Free State (le Roux & van Huyssteen, 2010 in Akoon *et al.*, 2010: 1; DWAF, 2012: 7; DWAF, 2011: 9; Statistics South Africa, 2011: 3).

*Zone 3: Water Development*

This zone includes areas that have a high access to freshwater, are rich in biodiversity, yet experience low to medium GDP. Three places which experience this are the Eastern Cape, Western Cape and KZN, based on an above-average access to freshwater of 80% or more, and a GDP below the top performing region of Gauteng (DWAF, 2012: 7; DWAF, 2011: 9; Statistics South Africa, 2011: 3). In this zone, some social and environmental issues still exist in river basins, much of which would be caused by population growth, non-point source pollution, degradation of water resource quality, and possible damage to environment. Even though regions such as the Northern Cape and Mpumalanga have significant amounts of natural water resources, their actual freshwater access systems are significantly lower than the average (DWAF, 2012: 11).

*Zone 4: Economic Water Scarcity*

This zone includes areas within South African borders that are experiencing economic water scarcity, which means they may have the water resources, but lack the infrastructure and appropriate investment to provide access to, and adequate basic water services, to meet human demands in these regions. Since 2009 the financial and economic challenges in South Africa have continued to constrain development in South Africa, but even since the

start of the democratic era, South Africa has enjoyed sustained growth, and allowed government to spend / invest on local infrastructure (World Bank, 2009: 4). The principle constraint to growth in South Africa's economy however, was the capacity to spend, rather than limited resources (World Bank, 2009: 4). The areas highlighted in this zone, said to be experiencing 'economic water scarcity' are KZN, Eastern Cape, and the Limpopo Province.

*Zone 5: Shared Demand Driven*

South Africa shares four major river systems with six neighbouring countries, with more than 60% of South Africa's river run-off being shared with other countries (DWAF, 2012: 17; Colvin *et al.,* 2013: 45). This stresses the need for South Africa to be a good water neighbour along with the countries on her borders which include; Zimbabwe, Botswana, Mozambique, Swaziland, Lesotho and Namibia (DWAF, 2012: 17; Colvin *et al.*, 2013: 45). International water-sharing agreements have been put in place in South Africa to ensure that all river basins are in line with the Revised SADC Protocol on Shared Watercourses (DWAF: 2012: 17). The shared river basins raise the importance of water in the regional integration agendas in the Southern African regions or SADC countries (DWAF: 2012: 17). The most substantial transfers, according to Statistics South Africa (2010: 20), take place from the Upper Orange to the Lower Orange, from the Upper Vaal to Middle Vaal, and from Lesotho into the Upper Vaal.

*Zone 6: Potential Endangerment*

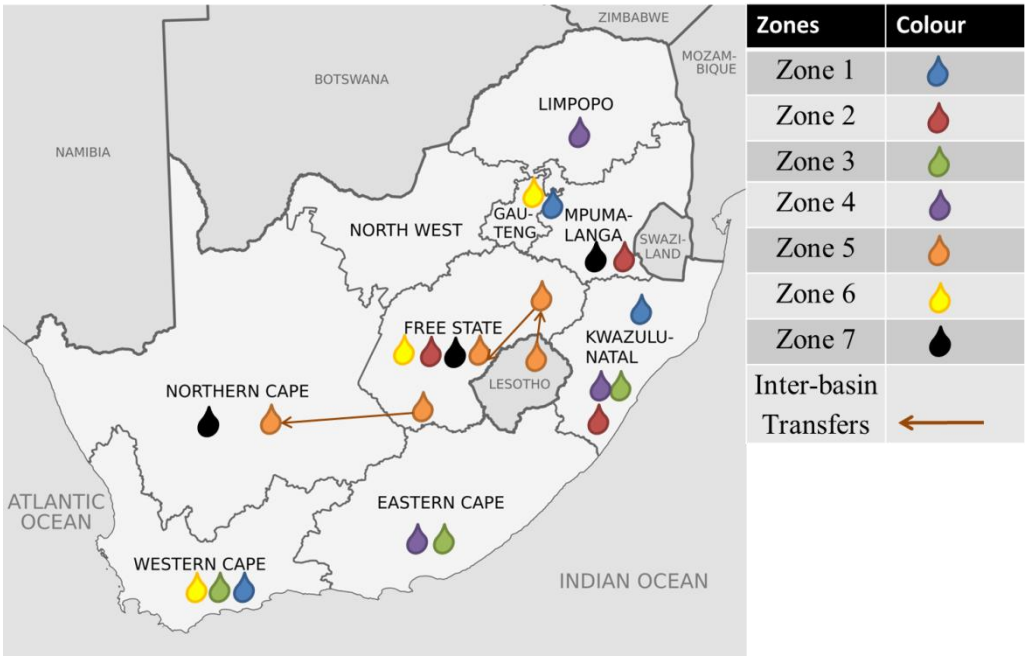
In this zone, environmental and climate-related risks exist, in which many areas are facing some form of natural, or man-made disasters or ecosystem degradation found predominantly in wetlands, much of which is brought about by climate change or pollution. The effect of the degradation is felt more severely in low income areas, areas which do not have a large bearing on South Africa's economy. The areas across South Africa where environmental systems are under threat are found predominantly around large city or urban centres, particularly in the Gauteng Province, Western Cape and Free State areas (South African National Biodiversity Institute, 2013: 17; DWAF, 2012: 74).

*Zone 7: Decreasing Water Quality*

In Zone 7, the areas worst affected by poor and decreasing levels of water quality across South Africa are analysed. These areas are either currently dealing with inadequate levels of water quality, or have experienced decreasing levels of water quality in the past. The areas with the poorest water quality were selected based on their 'Blue Drop' scores, the lowest of which were Mpumalanga, Northern Cape and the Free State. The rivers that drain from the northern and eastern parts of South Africa, according to STATSSA (2005: 10), generally carry good-quality water, unless it has been otherwise contaminated by human activity.

Below is figure 1, which depicts the various socio-economic and Hydrogeological sustainable development zones across South Africa.

**Figure 1.** *The South African Water Map – Depicting the Seven Socio-economic and Hydrogeological Sustainable Development Zones*




*Source: Author's own construction*

## Research Methodology

The researcher will undertake CLA as the preferred futures research method to analyse the past and present and establish plausible futures. Futures studies are well positioned to utilise CLA, as CLA allows for systematic problem-analysing at deeper levels (Kotze, 2009: 34-35). CLA was created by Sohail Inayatullah. This future-orientated methodology seeks to emphasise the issue of the existing future-orientated thinking, exploring the assumptions, ideologies, worldviews, statements or even policy-orientated futures (Ramos, 2002: 1).

According to Inayatullah, CLA method consists of four main levels: the litany, social causes, discourse or worldview, and myth or metaphor (Inayatullah, 2005: 6-7). The first level 'litany' is characterised by quantitative trends, problems, and is often exaggerated, and used for political purposes, by stating or leveraging off worst-case scenarios in order to influence the actions of the population (Inayatullah, 2005: 6-7). The next level focuses on social causes, which include economic, cultural, political and historical factors (Inayatullah, 2005: 7). This technique excels at technical explanations, as well as academic analysis (Inayatullah, 2005: 6-7). The third level is characterised by a deeper understanding of worldviews, which support legitimate causes, possibly due to the lack of proficient management in the studies case; management of water (Inayatullah, 2005: 6-7). The final layer of analysis, called the metaphor or myth, focuses on deeply-rooted stories or dimensions of

the problem or paradox; they are often emotive and unconscious stories about the discovery of the worldview under inquiry (Inayatullah, 2005: 7; Kotze, 2009: 29-30).

The CLA will allow the author to deconstruct the selected 'zones', societal and alternative approaches, revolving around the management of water into four levels, or layers, of analysis. Although water mismanagement is a common factor in each of the zones, the goal is to distinguish the value systems, cultures, and lifestyle impacting on the ways in which water is managed. Understanding these cultures and perhaps historical underpinnings will allow the researcher to construct alternative futures and solutions for future water management that are specific to the zones.

## Applying Causal Layered Analysis to Water Management Zones in Various South African Provinces

The CLA applied in this section aims to unravel the different zones, based on the literature review of water circumstances, and ultimately to interpret how water is managed or mismanaged, and what can be done or changed in the future.

**Table 1.** *CLA - Urban and Industrial Districts (Wealthy demographic)*

| CLA Level | Societal Approach |
|---|---|
| Litany | Water is a limited resource; however, the higher-earning regions are able to afford the assurance of this commodity. |
| Social Causes | Society acknowledges water as a limited resource. Water can be pumped to where it is need through inter-basin transfer schemes and other infrastructure developments, to meet domestic and industrial demands. |
| World View | There is a need to ensure water reserves are not depleted, while ensuring an adequate level of drinking water that does not allow standard of living to drop. Points of use water filter systems ensure standard of water in urban and industrial areas remains high. |
| Myth and Metaphor | 'Power from minerals and industry'. Wealth was accumulated which means power was gained. As long as economic development stays strong, solutions to water challenges will be found |

Source: Author's own construction.

**Table 2.** *Water Stressed Regions*

| CLA Level | Societal Approach |
|---|---|
| Litany | Climate change and low levels of economic development, as well as limited supplies of naturally-occurring freshwater, have led to restricted access to freshwater sources. |
| Social Causes | Access to water is secured through groundwater sourcing and transfer of water from more water-rich areas. |
| World View | South Africa is regarded as a water-scarce country, because water is unevenly distributed, rainfall often occurring distances from highest demanding and water scarce areas. Water restrictions are inevitable. |

| | |
|---|---|
| Myth and Metaphor | 'Environmental destruction'. South Africa has priority ecosystems areas, where water is protected because of the entitlement to water which South Africans feel. Many wetlands have been deleted, damaged or are now critically-endangered as a result of human entitlement, or heightened demand. |

Source: Author's own construction.

**Table 3.** *Water Development*

| CLA Level | Societal Approach |
|---|---|
| Litany | Water is naturally occurring and biodiversity flourishes. There is above average access to water, which in most cases supports the economy. |
| Social Causes | Population growth, non-point source pollution, and other forms of water quality degradation, put water resources at risk. Many of the risk factors, however, are avoidable through adequate management of water. |
| World View | Access to the water resources could be improved with better access systems and infrastructure, particularly in areas where water is naturally-occurring, but settlements are unable to fully-utilise the potential. |
| Myth and Metaphor | 'The values exchange'. The value added or achieved from water is felt in a number of industries, some of which include: agriculture, forestry and fishing industries. Predominant amounts of produce are exported, which allows for economies to achieve more from water sources. |

Source: Author's own construction.

**Table 4.** *Economic Water Scarcity*

| CLA Level | Societal Approach |
|---|---|
| Litany | Since the financial crisis in 2009, economic challenges in South Africa have continued to constrain development. Many years of growth catered for local infrastructure spending and investment. |
| Social Causes | Unsustainable short-term spending is not enough to maintain infrastructure systems in the long term. Rebalance of investment in water services has seen growth particularly in the social sphere; focus has therefore seen priorities being placed on poorer areas to ensure basic rights to water are achieved. |
| World View | South African government has shown commitment to reducing backlog of water service delivery. Almost the entire population has access to safe drinking water. Larger investments are now needed, to ensure core infrastructure is able to handle essential services, without intervention. |
| Myth and Metaphor | 'Monitoring and review'. Inability to implement adequate management, reviewing, monitoring and infrastructure repair systems for water, has led to a number of municipals unable to meet water demands adequately, or at risk when having to deal with more extreme conditions. |

Source: Author's own construction.

**Table 5.** *Shared Demand Driven*

| CLA Level | Societal Approach |
|---|---|
| Litany | South Africa has four major river systems shared with six neighbouring countries. Locally shared water also allows trans-boundary water exchange, to assist in areas short of naturally-occurring water in particular. |
| Social Causes | International sharing agreements have been implemented, to assist in the provision of water, and to ensure adequate levels of water in basins are kept at an adequate level. Inter-basin transfer locally is utilised to ensure areas abundant in water sources, allow neighbouring provinces, and areas with water shortages, have adequate resources. |
| World View | Areas such as the Gauteng Province, which is the largest contributor to South Africa's GDP, have high levels of demand for water, and therefore, if it were not for inter basin transfer, there would not be enough naturally- occurring water to supply this area. Water therefore needs to be transported long distances, particularly to higher-earning or more powerful regions of South Africa. |
| Myth and Metaphor | 'Centralised control'. There is a larger entity that determines the outcome of water management; Government delegates this task to National Water Resource managers, who then decide how water resources are allocated. Power therefore lies in a centralised position, and is managed according to demand. |

Source: Author's own construction.

**Table 6.** *Potential Endangerment*

| CLA Level | Societal Approach |
|---|---|
| Litany | South Africa is an arid to semi-arid country, often having to deal with droughts, water restrictions and desertification; however, flooding also occurs. Challenges are brought about either by climate change, or by other man-made (pollution) or natural disasters, leading to ecosystem degradation. |
| Social Causes | Many wetlands have been permanently lost to domestic and industrialised regions, and if the existing wetlands are not managed adequately, serious damage may be caused to ecosystems and nature's natural ability to filter water. |
| World View | Responsibilities for water are believed to be in the Government's hands; however, even government branches (municipals) inadequately manage water. It is naïve to think that there is no issue. It is becoming progressively more important to consider environmental impacts, before planning and implementing water schemes. |
| Myth and Metaphor | 'The man on the street'. The average South African cannot have an impact on the environment. Because issues have moved past the stage of turning off the tap, or watering the garden, government needs to ensure that the water management systems are executed adequately at infrastructure level. |

Source: Author's own construction.

**Table 7.** *Decreasing Water Quality*

| CLA Level | Societal Approach |
|---|---|
| Litany | Most regions across South Africa experience some form of decreasing water quality, whether as a result of human pollution, or treatment and control of effluent discharges, as well as urban and agricultural runoff. |
| Social Causes | Treatment of water sources has allowed for many polluted and damaged water sources to be utilised for either drinking water, or lesser-quality purposes, such as crop irrigating and hydroelectric or nuclear power cooling. Many treatment techniques, however, are considerably financial resource intensive. |
| World View | Drinking water is a right for all South Africans. Standards have been set by Government based on international drinking water standards, where municipals are obliged to meet these requirements. |
| Myth and Metaphor | 'Drinking water is easy'. People can generally turn on a tap, and clean water will be available instantly. Water travels from long distances, is extensively treated, and required to be tested at certain points. Many households, particularly in wealthier areas, make use of water filters. Poorer regions are worst-affected by water quality, and suffer as a result of poor water quality. |

Source: Author's own construction.

In the next section the author utilises the CLA to derive strategies for developing strategies for sustainable water quality development in South Africa towards 2050.

## Derived Strategies

The CLA, in table 5.4.1-5.4.7, is a breakdown of water practices and principles, highlighted earlier in this chapter, and in the literature study, into four levels of analysis: Litany, Social Causes, World View, and Myth or Metaphor. The objective is to distinguish what aspects of South African water management systems can change, and how sustainability, on different levels, can be improved when analysing each of the zones described. The desired outcome would focus on strategies for each zone, and how to take the South African Water map into the future. The strategies derived from the CLA designed by the author include:

- Appropriate management of water;
- Water rebates for households;
- Priority-based recycling and water treatment system;
- Bottom-up approach to localised water management, and
- Adequate water-quality monitoring at output points.

*Appropriate Management of Water*

There are a number of factors that contribute to the misappropriation or misuse of water resources in South Africa. According to Msibi and Dlamini

(2011: iii), these include: water scarcity resulting from unevenly-distributed rainfall in space and time, particularly in more arid regions of the country; higher temperatures as a result of climate change; inter-basin and trans-boundary transfer schemes; over-allocation of water resources with ten of the 19 water management areas (WMA) already experiencing over-allocation; skewed water-allocation to wealthier areas combined with irrigation levels at their maximum. A common theme amongst all the listed factors is that management could allow for more appropriate use, and allocation of water resources. There are currently a number of acts and legislation frameworks supporting the 'water allocation' cause, with the National Water Act (NWA) prioritising this issue as well as Water Allocation Reform (WAR), set up by the NWA in order to deal with water-allocation challenges (Msibi & Dlamini, 2011: iii).

Water was declared a human right for all South Africans, and therefore the appropriate allocation of water hinges on a number of factors. These factors include: infrastructure, and can include expansion of water catchments, addition of water pipes, creating more efficient and widespread access, repair of existing infrastructure or greater infrastructure output; adequate supply, which could mean water is transferred or transported long distances to supply areas in shortage; and finally, centralised monitoring systems, which would include a number of critical point source tests executed automatically with the help of technology. Water management, although a topic in itself, is too broad a strategy to improve; therefore the remaining strategies, all involve some form of water management scheme, or improvement to existing water management schemes.

*Water Rebates for Households*

Rebates for houses with tanks and recycling systems could allow for more efficient handling and use of water at domestic level. Households situated in urbanised areas in South Africa are perfectly-positioned to utilise this sort of strategy. In areas which lack adequate access to basic water services, which is the case in many informal settlements or rural areas in South Africa, this is not a strategy that would be suitable, as most of these areas do not pay for their water services. The National Water Act (NWA) as stated in (DWA, 2004: 85), does already allow for pricing rebates when water is returned to a natural resource; this, however, is only one-dimensional.

Rebates can include a number of different elements that can benefit water users and managers. This can be achieved by way of incentivising the efficient use of water. The current water pricing model utilised by the NWA and DWAF, needs to be improved in a way that all users are incentivised, and can benefit from a rebate strategy in some way or another. As already set out in the NWA this can be achieved through a pricing rebate when water is returned to a natural resource, other rebates could include coupons for households employing water catchment strategies such as storage tanks, or water efficiency strategies, for households' efficient use of water such as solar geysers, circular heat pumps and even grey water alternative usage.

The coupon strategy can be executed by municipal involvement, where 'water efficiency personnel', is a person hired to assess a home and calculate on a points basis. This would indicate how much water is stored on the property, how many water-efficiency strategies are being employed, and how much water can be saved through this strategy. According to their score, the individual would receive a coupon to, for example, a hardware store which stocks water efficiency tools and technology. This would benefit the following: the consumer, as water will be saved through their own methods, therefore lowering water usage costs, as well as receiving coupons / incentives to purchase additional water saving products; communities, as jobs will be created through the 'water assessment personnel'; the business that is issuing coupons, stocking water-efficiency and saving products; the environment at large, which can be spared the increasing demand particularly from domestic and urban usage; and lastly the municipal, because it is responsible for providing a service, if demand were lowered as a result of water efficiency tools and technology, infrastructure would then also be spared, as less pressure would be placed on these systems.

If no water saving techniques or systems is employed, 'water assessment personnel' have the ability to advise the consumer on ways in which it can be improved, and the business providing the tools and technologies can assist them. There can also be on the more extreme side where 'penalties' are applied to those households who do not employ any water-saving or efficiency techniques; consequently municipals can use this system to justify increases in the cost of water. This technique would be difficult to apply in lower income areas, or in communities which do not pay for their water services. An opportunity could exist for municipals, businesses, and ultimately the community as a whole.

Incentives for the business could mean they are supplied materials from the municipals at a lower cost, therefore improving their margin, and if personnel from communities are trained and employed, this could benefit the social cause of the country. Municipals can improve efficiency in urbanised areas, as well as improving the standard of living in poorer communities, by providing these personnel with services. Lastly, communities will benefit from additional jobs, service delivery, and opportunities for building a career. Although this strategy considers households only, it could even be adopted in industries and in organisations where the organisation would benefit from having a 'green business' or 'green buildings'.

*Priority-Based Recycling and Water Treatment System*

A priority-based recycling method will allow for more efficient recycling and filtration techniques to be applied. From the research it was found that various avenues should be sought after, before constructing large water-treatment and capturing facilities. These avenues include desalination plants or other large-scale water treatment facilities. The demand for improved and more cost-effective water treatment, or filtration, is constantly increasing, with many wealthy and developed nations, particularly in the Middle-Eastern and North American regions of the world lacking easy access to drinkable-quality water.

It is for this reason that other methods as well as existing methods are being researched, in order to provide more cost-effective and efficient methods in filtering water, and providing fresh drinkable water.

To achieve efficiency in both cost, and future water implications, one should first prioritise the methods into value based systems, and then understand the environmental impact of each method. Desalination of sea water, for example, may be a cost-effective method all factors considered; however, the environmental impact may be too great where marine life is damaged as a result of the treatment facilities sucking large amounts of water into the water treatment plant, as well as the bi-product of this technique, known as 'sludge', and how this is disposed of, that poses environmental risks. Therefore, below are a number of strategies in a prioritised order, for dealing with high demand for drinking water:

- Recycling of water from run-off (urban, agricultural, and mining effluent): by cleaning this water first, whether partially or completely, the resulting flows will have a lesser effect on environment, infrastructure, and ultimate cost. One could then decide if it would be more appropriate to reuse immediately or return it to a natural resource;
- Inter-basin transfer: this is an extremely useful system particularly in a country such as South Africa, where naturally-occurring water is normally found long distances from where the highest demand is experienced. For this reason WMA work together, in providing the country with water; the cost, however, of laying pipes to all the areas in greatest amount of need is to be considered, as well as the challenge of avoiding over-allocation of water from the relative basins;
- Treatment of existing naturally-occurring water resources, or first restoring these areas to its original wetland status: before looking to the sea, land-based surface water resources need to be assessed for the best possible level of use;
- Sustainable techniques should then be considered, with energy now being a continuously growing concern, along with degrading level of water quality as well as supply: There are a number of new techniques already being adopted across the globe, which include: solar thermal desalination systems; water from air-where windmills use the power generated from the wind to condense the moisture from the air and filter that to drinking water quality; and even new developments in membrane technology, increasing energy-efficiency and decreasing environmental impacts, and
- Lastly large scale techniques, such as desalination of sea water, treatment of human waste, and other heavy chemically-induced water treatment systems all have potentially disastrous effects for the environment, but also experience a particularly high cost and drain on energy.

These strategies do not take into consideration new techniques to filter water on a micro and macro level, such as Nano-tube technology, household

rainwater catchments and filtration, solar water desalination, and other recent technologies and developments in water treatment and management. Many of the new water treatment techniques being developed are often not implemented, either because of the cost of the technology, or because of lack of research and manufacturing difficulties.

*Bottom up Approach to Localised Water Management*

This strategy focuses developing local water improvement strategies in the least-developed areas of South Africa. A system which benefits both the people living in these areas, and the environment should be considered; however, this system would be more complicated to implement, as these areas often do not pay for their water services. It is difficult to design a strategy that would benefit all parties involved in other words a 'one size fits all solution', as well as one there being very few 'silver bullets' / 'quick fixes' in solving many of the growing issues.

Some of the challenges which would need to be tackled include:

- Pollution, particularly human faecal pollution, which poses one of the greatest health risks to communities living near polluted water sources; other effluent waste washed into water sources;
- Infrastructure, or lack thereof, in other words, the undelivered water services including sewerage systems such toilets and wash basins, laying of pipes or taps, bringing water to homes, repair of leaking water pipes, and other services such as clean water and even hot water, and
- Finally, quality of water often fails to meet the level set by SANS 241 and is barely legal for communities to use, this is because of a combination of reasons, whether its failing infrastructure or inadequate treatment services, some poor areas are receiving degrading levels of water quality.

The 'bottom up table', in table 8 below can therefore be applied in this circumstance, which means the poorest areas, with the least number of services, and pollution exceeding other areas, can be ranked into appropriate 'tiers'. The region in question may experience any one of the factors defined, which would then add to their score, with the Service Multiplier worked out to a percentage of 30%. Tiers will be broken up into percentages. The ranking would work as follows: Pollution (20%), Infrastructure (30%), Water Quality (20%), and Services Multiplier (30%). The Services Multiplier to be applied should be calculated as follows: first the total capital cost of providing services to that area (T) is multiplied by the area's population (P), in relation to the highest multiplier area (highest T x P). This percentage is then multiplied by 30% to arrive at the Service Multiplier (therefore the worst ranked area will always be 30%, and the rest a smaller percentage that that). Taking all factors into account, these regions can then be placed into 'tiers' of priority, 'Tier 1' being the highest priority or the absolute bottom ranked region and area in greatest need.

**Table 8.** *Bottom up Table (Example)*

| **Issues** | **Pollution** | | **Infrastructure** | | **Water Quality** | **Services Multiplier** | | **Total** | **Tier** |
|---|---|---|---|---|---|---|---|---|---|
| **Factors** | Human | Other | Sanitation | Water | | Total Cost (T) | Population (P) | *100%* | |
| **District** | *15%* | *5%* | *15%* | *15%* | *20%* | **30%* | | | |
| Walmer township | Y | N | Y | Y | N | R2 000 000 | 500 000 | 48% | **3** |
| | | | | | | 3%** | | | |
| Motherwell | Y | Y | Y | Y | N | R10 000 000 | 1 000 000 | 80% | **1** |
| | | | | | | 30% | | | |
| Mill Park | N | Y | N | N | N | R500 000 | 10 000 | 5.015% | **5** |
| | | | | | | 0.015% | | | |

Source: Author's own construction..
* = [(T x P) / Highest (T x P)] x 30%
** = [(2 000 000 x 500 000) / 10 000 000 000 000] x 30% = 3%

- Tier 1: 80 – 100%
- Tier 2: 60 – 79%
- Tier 3: 40 – 59%
- Tier 4: 20 – 39%
- Tier 5: 0 – 19%

*Adequate Water Quality Monitoring at Output Points*

The final strategy derived from the analysis would be a system monitoring the quality of water output at points across the country. Although this may be a best case scenario, implementing a monitoring system that assesses the quality of water, when it reaches certain points across the country, could allow for more accurate management of water. The issues of water quality that plague South Africans can be established and narrowed down into problem areas, and a system can then be utilised where the output could potentially be failing. The SANS 241 has specific guidelines, as to the adequate output for water in the country; therefore, maintaining this quality should be of upmost importance.

The system would work as follows: live tests can be done periodically in specific areas or regions within a province, for example in urban or semi-urban areas, as well as in industrial and agricultural areas. The tests would be rated against the SANS 241 standards, and on levels of pollution. Municipals can then assess, prioritise, and narrow down the areas which need attention and which can be managed in that manner. All measurements would be 'live', with data sent to a central point via the internet or wireless network, and to regional Water Affairs offices for them to deal with or assess the issue.

It would be easier for regions to justify the need for capital expenditure, as well as continuous service delivery of water at adequate quality, as the outcome of investments made would be tangible. This would mean that government would be able to witness from the systems in place that the various municipal budget allocations are adequately allocated. The system could highlight the areas with greatest level of need, from a quality and quantity point of view. Strategies can then be planned around this, and priority-based investments can be made. Therefore, this system should in theory eradicate unevenly-spread services, as these areas will fall under priority, and not only wealthy areas would benefit from adequate water quality output.

## Conclusion and Recommendations for Future Research

South Africa faces a challenging time ahead with specific regard to sustainable water resource development and management. The country is not only limited by dwindling supplies, increasing demand, and over allocation, infrastructure failure, and mismanagement, but issues of corruption, crime, uneducated population, and even the lack of access to technology, which will continue to inhibit sustainable growth in water development and water resource

management. More emphasis, therefore, needs to be placed on the health and economic development of the nation, which will be held back if water issues and challenges persist and even worsen. If South Africa focuses on sustainable development, management, and particularly the monitoring of water schemes and sources, a positive outcome may yet still be on the cards.

The strategies contained within the study were constructed by the author in an attempt to provide ideas for a positive change for the future. With the growing number of water-related issues in South Africa, a strategy to achieve the sustainable future of water is an important objective. This, as stated, means that strategies and approaches need to be considered beyond the litany level and changing the worldview and metaphor with regards to water management and sustainable water development, by incorporating the listed water management strategies or public beneficiary campaigns. The bottom up approach in particular, provides a future-orientated approach to water conservation, water equality, and water protection for the future, which would help the developing areas of South Africa.

The effective management of water is important, if South Africa wishes to achieve optimal social and economic performance in a sustainable manner. Water is centralised at the heart of economic growth and sustainable development of a nation (Muller *et al.*, 2009: 6). South Africa, because of its geographical makeup, faces unique challenges, such as general aridity and high variability of rainfall in space and time, which means it is especially vulnerable to changes in water availability (UN Water, 2011: 8). According to the WWF, the focus should not be on scare tactics and forceful approaches when dealing with water challenges, but rather to accept that there should be urgency to act, and focus on the nature of the risks currently faced by South Africa, and the country's water resources and quality, and how to respond to these changes (WWF, 2012: 1).

CLA was the methodology applied in this scientific report, to design strategies for possible futures for water in South Africa, and to use it as a new area of research for water in South Africa. The strategies were designed to help deal with the major water challenges faced by South Africa, and how the defined zones can approach the use and management of water. The zones will not only cover water availability and supply but as emphasised by (Von Bormann & Gulati, 2014: 21) the challenge is also of declining water quality, which is also considered within the zones. The districts across South Africa that experience similar natural water distribution and strategies in the use of water are clumped together in a specific zone. Each zone had its own specific socio-economic and hydrological impact, strategy for management of water, and each experienced similar water challenges, such as degrading quality of water, extreme conditions, sharing in demand, or environmental risks.

The challenge of improving water circumstances in South Africa is not one that can be solved overnight. This study aimed to take small steps towards change in South Africa's water resource development and management mind-set. Through the levels of analysis applied to the different 'zones' across South Africa, clarity over issues stemming from infrastructure to environmental

degradation was highlighted in an attempt to change the attitude towards water, and establish new strategies to aid in the betterment of the water industry. It is hoped that from the results found from the research performed, water users will begin to understand the complexities and vulnerability of water, and water management agencies will find structure and other future possibilities to benefit water in the long term.

Through the course of the research a number of areas in need of further research were identified. The issues suggested for the continuation of the research include:

1. Rural water awareness campaign: this will dig more deeply into areas where water services are limited, understand the cultural implications of how water is managed and establish to what extent water service delivery is skewed towards higher demanding urban and industrial areas. What type of investment will be required to provide basic water and sanitation services? Would it be more viable to provide homes with these systems, installed in the low cost buildings on some sort of condition? Therefore, understand the different components of rural life, and the cultural links between water and the management thereof.
2. Water manager's contribution to conservation: the impact that water management makes is hard to quantify; however, it could provide much-needed value to what water managers do. If a person could put to value the contribution water managers make and have made from one year to next it could provide reasons for continual investment in the specific WMA. Measurements could be based on water quality and water supply / percentage of areas with adequate or inadequate water supply.

The areas that were not covered in the contribution of the research, which includes knowledge gaps and even region-specific challenges particularly in data-scarce areas, include research topics such as:

3. The impact of climate change and global warming on sustainable development of water; there is an opportunity to illustrate region specific challenges to climate change. The multiple areas or regions across South Africa are impacted by climate change in one way or another, often the largest impact being extreme conditions or weather events such as droughts or floods both of which have large impacts on water sources. Other smaller issues occurring in different areas are challenges such as change in water temperature and climate pressures, which negatively affect ecosystems and water resources and often make filtering or managing water more challenging.
4. Desertification and fracking - defined as the mining of shale gas, impact on water in the Karoo; the two topics mentioned here and previously are considerably relevant to current and future conditions of water in South Africa. The topic of shale gas mining could benefit South Africa's economy and provide a supply of fuel for a considerable amount of time. The issue remains the study of the impact that shale gas mining may have on the condition of water, particularly the water in the

Karoo, and the surrounding areas reliant on these groundwater sources. The other issue the northern areas need to contend with is desertification; this could perhaps be split into a separate study, however, much of the same area would be under the scope.

5. Central water agency; this would mean that water is monitored and managed from a central water intelligence centre, which means it could also fall into the previous area of research mentioned. There has already been talk from the DWA in moving towards a centralised unit; however, no movement or much material of this change shows evidence of this happening in the near future. A study therefore of the benefits of having a central water management agency may display the benefit of this change, and how it could positively impact the control of water in South Africa. This should not take away from the existing (WMA), but would absorb them into a larger, more-efficient, centralised unit.

The above-mentioned further research undertakings all have a common theme. All the topics focus on the betterment of water conditions, or managing the consequences of water decisions and challenges. The topics could provide an opportunity to apply the methodologies to a number of studies, with viable and potential outcomes such as strategic planning, sustainable development, clarification of roles, review and monitoring, and ultimately foresight, and present possible futures for each area under scrutiny. Mechanisms and calibration of stakeholder, public and private participation could mean a move towards a 'win-win' situation being achieved; however, it will take the sustained commitment of all stakeholders, and active involvement from all provinces and corporate stakeholders, to create the platform for improvement.

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