MSc: Research Report

Climate Risk Management Options in the Water Sector

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Faculty of Science,
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DECLARATION

I, Kavita Pema (student number 8701724/M) am a student registered for an MSc by coursework. I hereby declare that this research report is my own unaided work. It is being submitted in partial fulfilment of the requirements for the Degree of Master of Science in the School of Geography, Archaeology and Environmental Studies, Faculty of Science, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University

Kavita Pema

Signed: 29 July 2011

"The least developed countries, notably in Africa, are among those likely to be worst affected by water scarcity over the coming century."

United Nations Secretary-General, Ban Ki-moon, speaking at the Water Tribune in Zaragoza, Spain, SG/SM/11770 Sept 2008

ABSTRACT

Existing water management initiatives, strategies and policies in South Africa, ranging from the overarching water management legislative framework to the local-level practical operational aspects, were examined as a component of this project. The integration between National Strategies pertaining to water resource management and local implementation was addressed in terms of examining Water Conservation and Demand Management approaches and assessing the effectiveness of these approaches in addressing climate change risk factors in the water sector.

Current South African regulatory instruments in the water sector allow adaptation and flexibility in order to address climate change impacts on the water resources in South Africa. The greatest obstacle in the implementation of effective Integrated Water Resource Management (IWRM) for climate change adaptation strategies is the lack of institutional support required from national levels of government to local municipalities. There is also a lack of strategic guidance and support in the form of policies specific to climate risk in the water sector in South Africa. Another important aspect of the IWRM, namely social learning, also suffers in the process due to lack of participation from key stakeholders and limited integration amongst interdependent sectors.

DEDICATIONS

I would like to extend my gratitude to the following:

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- My parents and sister for their constant support and encouragement;
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AWM	Adaptive Water Management
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CMA	Catchment Management Agency
CoJ	City of Johannesburg
CSD	Commission on Sustainable Development
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DST	Department of Science and Technology
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
GECHS	Global Environmental Change and Human Security
GEF	Global Environmental Facility
GEO	Global Environmental Outlook
GWP	Global Water Partnership
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organisation
IWRM	Integrated Water Resource Management
NAS	National Academy of Science (Washington)
NCCC	National Climate Change Committee
NCCRS	National Climate Change Response Strategy
NWA	National Water Act, 1998 (Act 36 of 1998)
NWRS	National Water Resource Strategy
PRI	Policy Research Initiative
RSA	Republic of South Africa
SA	South Africa
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
WC/WDM	Water Conservation and Water Demand Management
WMA	Water Management Area
WSA	Water Services Authority
WSP	Water Services Provider
WUA	Water User Association

CHAPTER 1 INTRODUCTION

Climate change is expected to have a major impact on water resources (IPCC, 2007). Melting glaciers, for example, may increase flood risk during the rainy season, and could strongly reduce dry-season water supplies to one-sixth of the world's population (Venton, 2007). Rising global temperatures may lead to an intensification of the hydrological cycle (Bates *et al.*, 2008), causing possible changes in the South African water regime such as wetter conditions in the eastern regions and drier conditions in the western regions of the country resulting in drier dry seasons and wetter rainy seasons (Stuart-Hill and Schulze 2010). Changing climate will therefore have possible significant impacts on the availability of water, as well as on the quality and quantity of water that is available and accessible (Bates *et al.*, 2008).

Among some of the more "iconic" impacts resulting from a changing climate there may also be important additional consequences for water (IPCC, 2007), including:

- A change in the seasonality of water flow;
- Increased evapo-transpiration resulting from higher temperatures, which may be responsible for lower total annual flows;
- More-frequent, high-intensity precipitation events that can change drainage patterns and produce flash floods that could have safety implications, not only in terms of physical hazards, but also for water quality (PRI, 2008); and
- Water resources will also be affected by factors such as land use change, management and construction of dams, pollution sources and water and wastewater treatment. Vulnerability of freshwater systems is dependent largely on water management (IPCC, 2007).

Kabat *et al.* (2003) maintain that, in some regions, increases in the magnitude and frequency of extreme events are already being observed with the root cause being largely attributed to a changing climate. In essence, the indications are that global increases in temperature will have profound effects on evaporation, which in turn affects atmospheric water storage with consequent impacts on the magnitudes, frequencies and intensities of rainfall events as well as on the seasonal and geographical distribution of rainfall and its inter-annual variability. An undeniable fact is that there is a high degree of uncertainty in the anticipated changes in rainfall characteristics with climate change (Kabat *et al.*, 2003). Water resource managers, in particular, face the challenge of incorporating the added uncertainty of the impacts of climate variability and climate change on hydrological responses into their already very complex decision-making process.

Against this backdrop, international water policy is also increasingly emphasizing the need to improve governance policies and structures related to water resources management. A global consensus has also emerged on the need to implement ecosystem-based management approaches to address sustainable water resource need (UNEP, 2007). During the last four decades, many assessments have been conducted to address global environmental change issues such as stratospheric ozone depletion, climate change, and the loss of biodiversity (Watson and Gitay, 2006). Due to the nature and extent of these issues, most of the assessments have been conducted at the international level, providing the scientific basis for the creation and elaboration of international and national agreements (NAS, 2007).

In terms of addressing the anticipated impacts of climate change on water availability, Integrated Water Resources Management (IWRM) has increasingly been emerging as a viable and suitable vehicle, which can be used to address the evolving water resources management aspects, specifically those linked to climate change (Pahl-Wostl, 2007; Muller, 2007; Sadoff and Muller, 2009). Through responses such as IWRM, social and economic development goals can be achieved in a manner that offers the world sustainable aquatic ecosystems to potentially meet the water resource needs of future generations. An increasing realization of the limits of traditional regulation in local management structures has also led to the introduction of more participatory regulatory approaches, such as demand management and voluntary agreements and these approaches are largely characterised by an increased need for capacity building, public participation and co-operative governance (Sadoff and Muller, 2009b).

1.1 South African Context

With this global- and macro-context as background, attention turns to focus in on what such concerns and issues may mean for the water sector in South Africa. Climate-related impacts on the hydrological cycle can have serious implications for water availability, because they can often pose serious challenges (Schulze, 2008) to storage of water, whether natural (lakes, ponds, aquifers etc.) or artificial (dams and reservoirs). There is increasing evidence that global climate variability and change is affecting the quality and availability of water supplies (Kashyap, 2004). Climate change is expected to possibly alter the present hydrological resources in Southern Africa based on the projections that the eastern part of the country will be wetter with heavier rainfall and the western part will be drier (Lumsden *et al*, 2009). The anticipated impacts of wetter conditions in the eastern parts of the country include negative effects on sediment yields and siltation rates (Stuart-Hill and Schulze, 2010)

while the drier condition impacts could largely be linked to increased flow variability (Lumsden *et al*, 2009), resulting in reduced availability and accessibility of water (Stuart-Hill and Schulze, 2010). Within the South African context, climate change will have an impact on the quantity as well as quality of water available for use (Turton, 2003). Poor distribution of water resources in southern Africa coupled with climate variability, in the form of frequent droughts and floods, has in the past led to direct hardship for many people, particularly the poor (Mukheibir, 2005) in terms of loss of housing, displacement of communities due to apartheid legacies and the consequent lack of water and sanitation facilities.

Available downscaled climate model projections for the City of Johannesburg (CoJ), for example, do however; indicate that the local climate is likely to become both significantly hotter and more humid in future. In addition projections also point to the possibility of more intense storm events, potentially impacting severely – both directly and indirectly – on built environment management functions such as storm water management and attenuation, wastewater treatment, road and storm water design standards, floodline determination, water conservation and retention, pollution control, etc. (CoJ, 2009).

According to the CoJ Climate Change Adaptation Plan (2009), there is a risk that the CoJ will experience an increase in annual rainfall characterised by a higher frequency of storm events and a longer rainy season (finishing later in the autumn and possibly starting earlier in the spring). While these predictions may seem vague there are a number of challenges in the immediate future, which need to be addressed to combat future impacts (CoJ, 2009).

Although our current scientific understanding can provide us with some fundamental sense of the types of impacts we can expect, there is still uncertainty associated with climate change. It is critical that this uncertainty is incorporated into modeling tools and decision-making processes (PRI, 2008). Notwithstanding the uncertainty that persists, it is clear that climate change is going to add additional pressures to water availability and distribution. This change will require effective and adaptive management in order to ensure that the impacts are addressed. South Africa has, as is the case with most countries in the world, participated in various international initiatives to address the local, as well international causes and implications, of climate change. The main political drivers include addressing the fact that policies need to be developed for the protection of the environment with the long-term goal of also addressing climate change (Taylor, 2004; Mukheibir, 2005). Concerns are, however, being raised about

the fact that the policies designed to protect the environment sometimes suffer from deficiencies in research, information and in process e.g. in consultation and the accurate and efficient formulation and implementation of action plans at various levels (Taylor, 2004).

It is clear that at the higher levels of governance, both nationally and internationally, vast amounts of work have been done to understand climate change. The knowledge base that has been created in terms of science and policy at this level is incredible and widely acknowledged as being vital for future management of causes and implications (IPCC, 2007; Muller, 2007; Bates *et al.*, 2008; Carriger, 2009). In South Africa, for example, the National Committee on Climate Change (NCCC) was been established to advise the Minister of the former Department of Environmental Affairs and Tourism (DEAT) [1], through the Director General on matters relating to national responsibilities with respect to climate change – and in particular in relation to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (DEAT, 2008).

Climate change does not, however, occur in a vacuum. Water resource management in South Africa is guided by the National Water Resource Strategy (NWRS) that is formulated, implemented and reviewed by the Department of Water Affairs[2] based on the requirements of the National Water Act (NWA), 1998 (Act 36 of 1998). A vital element of the NWRS is the progressive decentralisation of the responsibility and authority for water resources management to catchment management agencies and, at a local-level, water user associations. These institutions, representative of water users and other stakeholders, are designed to facilitate effective participation in the management of water resources in their areas (DWAF, 2004).

Water management is also complicated by interacting spatial and temporal scales and issues. While water management in South Africa is based on management at

[1] During the cabinet re-shuffle in 2008, the Environment portfolio from the Department of Environmental Affairs and Tourism was re-deployed to the Water Affairs portfolio resulting in the formation of the Department of Water and Environmental Affairs. The Minister of this Department manages the portfolios as two separate Departments i.e. Department of Water Affairs (DWA) and Department of Environmental Affairs (DEA).

[2] The management of South Africa's water resources falls under jurisdiction of the Department of Water Affairs (DWA). This Department was formerly known as the Department of Water Affairs and Forestry (DWAF). The name of the Department was changed when the Ministry was changed and the Forestry portfolio was re-deployed to the Department of Agriculture in 2008.

catchment levels, challenges on an institutional level arise because catchment boundaries do not follow the same pattern as political boundaries in terms of provincial delineations (NWRS, 2004). As clearly highlighted by the NWRS (2004), water in South Africa is a national asset under the custodianship of the Minister of the DWAF but the *actual implementation of water resource management is intended to take place at a local-level*. In order to facilitate water resource management at the local-level the National Water Act (NWA), 1998 (Act 36 of 1998) introduced the concept of an environmental reserve, which will be managed by locally based Catchment Management Agencies (CMAs). The concept of the reserve essentially requires the DWA to make provision for meeting the requirements for basic human needs and for the aquatic environment before water is allocated to any other users. This approach, once fully implemented, can have a very strong positive impact on all river systems, by enhancing the control mechanisms, which are used to manage uncontrolled development. The greatest challenge, however, will be experienced in satisfying environmental needs where catchments are already fully developed. This will require reclaiming water from existing water users, who are increasingly urban and industrial users, by means of compulsory licensing, in order to improve environmental standards that have long been degraded (DWAF, 2009b).

As Kashyap (2004) mentions, it is critical that the principles underlying Integrated Water Resource Management (IWRM) are fully internalized into the socio-economic development policies and governance systems at national, regional and local-levels by bringing people to the center of the decision-making process through decentralized planning and management of water resources, particularly at the catchment level. South Africa has clearly already moved into this direction and is in the process of establishing the requisite supporting institutions (Turton, 2003, Schulze, 2008) such as CMAs. According to the NWA, each of the nineteen water management areas in the country must be managed by a CMA. Currently eight of the nineteen CMA's have been established namely, Inkomati; Crocodile; Marico; Mvoti; Thukela; Usuthu to Mhlathuze; Breede; Olifants and Gouritz (DWAF, 2009c). The area that will require concerted effort to ensure the successful operation of such institutions is that of planning tools, management strategies, and human, institutional and systemic capacities to meet local demand for sustainable water services under climate variability and climate change regimes (Kashyap, 2004).

King (2004) emphasises that understanding the response of our complex climate system to human interventions in greater detail will help countries and businesses adapt to the climate change that is inevitable and help target investment where it is

most needed (King, 2004). This can only be achieved, however, if the governance and institutional management structures are suitably established and the responsible role-players clearly understand and exercise their mandates (Pahl-Wostl, 2002, King, 2004). The actions taken by the relevant institutional management structures have to be guided by well founded and strong strategic guidance provided by national government.

In addressing the question of whether South Africa has sufficient water resources to sustain both its path of economic growth and its population growth and concomitant needs, the DWA maintains that it has taken a long-term perspective and is assessing and addressing, in a very detailed manner, the quantity of water available in relation to projected demand, and ways of addressing imbalances where they exist (DWAF, 2009). Reconciliation Strategies are being utilised to address this aspect and have been completed for some of the country's major water supply systems. It is anticipated that these strategies will be followed by reconciliation studies for every town in South Africa. By mid-2011, the Department aims to have an accurate picture of water demand and supply and consequently devise strategies to achieve the required balance at a micro level (DWAF, 2009b).

Within the South African context IWRM can be a useful tool to facilitate equitable and sustainable social and economic development, with the aspect of climate change merely adding another layer of complexity to an already complex management of water resources (Schulze, 2008; Stuart-Hill and Schulze, 2010). It has been argued that the adaptability of water management systems to climate change impacts can best be achieved by the application of IWRM (Muller, 2007; Sadoff and Mullller, 2009) and AWM (Pahl-Wostl, 2002 and 2007; Pahl-Wostl *et al* 2004; Pahl-Wostl and Sendzimir, 2005) principles. The critical aspects which will influence the flexibility of water management resources is thought to be:

(i) integration of interdependent sectors within the water sector (Stuart-Hill, 2010);
(ii) strong and reliable institutional support structures (Muller, 2007; Sadoff and Muller, 2009); and
(iii) active and participative stakeholder engagement facilitating social learning (Pahl-Wostl, 2002 and 2007; Pahl-Wostl *et al* 2004; Pahl-Wostl and Sendzimir, 2005) to capitalise on local knowledge.

Against this backdrop, the following section provides an overview of the aims and objectives of this project. The main intent of this work was to test the suitability of

implementation of IWRM and AWM processes in the South African water sector to facilitate adaptability of water resource management to climate risk factors.

1.2 Aims and Objectives

The hypothesis underpinning this research presented here is that effective institutional arrangements related to water resource management can enhance resilience and adaptation to changes *including* climate change challenges. Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker *et al*, 2004). Adaptation measures, it has been argued, will be strengthened by making progress in areas related to good governance, human resources, institutional structures, public finance and natural resources management (UNEP, 2009). Combining approaches at the government and institutional level with bottom up approaches rooted in regional, national and local knowledge will also strengthen adaptation measures (Kashyap, 2004). This notion of flexibility and interaction of governance structures and processes at various levels, thus provide an over-arching hypothesis for this research. It is against this backdrop that current efforts in water governance e.g. Integrated Water Resources Management (IWRM) and Adaptive Water Management (AWM) at a local city level (Johannesburg) are examined.

In terms of addressing the anticipated impacts of climate change on water availability, Integrated Water Resources Management (IWRM) and Adaptive Water Management (AWM) have increasingly emerged as viable and suitable vehicles that can be used to address the evolving water resources management aspects specifically, but not solely, linked to climate change (Pahl-Wostl, 2007; Muller, 2007; Sadoff and Muller, 2009). Through responses such as IWRM and AWM, social and economic development goals can be achieved in a manner that gives the world sustainable aquatic ecosystems to meet the water resource needs of future generations.

The research for this project focused on the following aspects:

- Preliminary investigation into whether the South African legal framework will support the development and implementation of adaptation measures for climate change impacts in the water sector;
- Obtaining a better understanding of some of the strategic management interactions and interventions in the water sector that have been designed to better ‘manage’ water; and

- Assessing whether the key principles of IWRM such as sectoral integration, supportive institutional structures and adaptive social learning can be effectively applied in the South African context.

The project also aimed to assess the degree of "fit" (Young, 2002) between the current water resource management strategies, as being configured by the City of Johannesburg, IWRM and AWM practice and planning for climate change.

The integration or correlation between National Strategies and local implementation was addressed in terms of examining Water Conservation and Demand Management approaches and assessing the effectiveness of these approaches in addressing climate change risk factors in the water sector. The applications of the concepts of Adaptive Water Management and Integrated Water Resource Management were tested in a real-time project, namely, the development of a Water Conservation and Water Demand Management (WC/WDM) Strategy for the City of Johannesburg.

1.3 Methodological Overview

It is within this setting of attempting to understand the institutional architectures of water governance with reference to climate change that this study is placed. There are many approaches to the management of water resources, which have evolved over time. From a practical point of view within the water management sector there has been a shift in water management from a pollution control approach to a more integrated water quality management approach. The need for integration of management practices related to water quality and quantity has become more and more pronounced (DWAF, 2000; Turton, 2003).

There have been increased instances, for example, of advocating the implementation and use of Integrated Water Resource Management (IWRM) and Adaptive Water Management (AWM) as effective tools for the development and implementation of adaptation strategies. The IWRM and AWM approaches have largely been promoted and piloted by institutions such as the Global Water Partnership (GWP) and affiliated specialists who have highlighted approaches such as AWM and Co-Adaptive Water Management (Pahl-Wostl, 2002 and 2007; Pahl-Wostl *et al* 2004; Pahl-Wostl and Sendzimir, 2005) and IWRM (Muller, 2007; Sadoff and Mulller, 2009). To date few such attempts, with respect to the water sector and relevant stakeholders (Schulze, 2008) have been applied in South Africa, particularly at more local scales.

The main elements of the IWRM process are comprised of a sequence of stages, which make up the IWRM cycle as depicted in Figure 1 below:

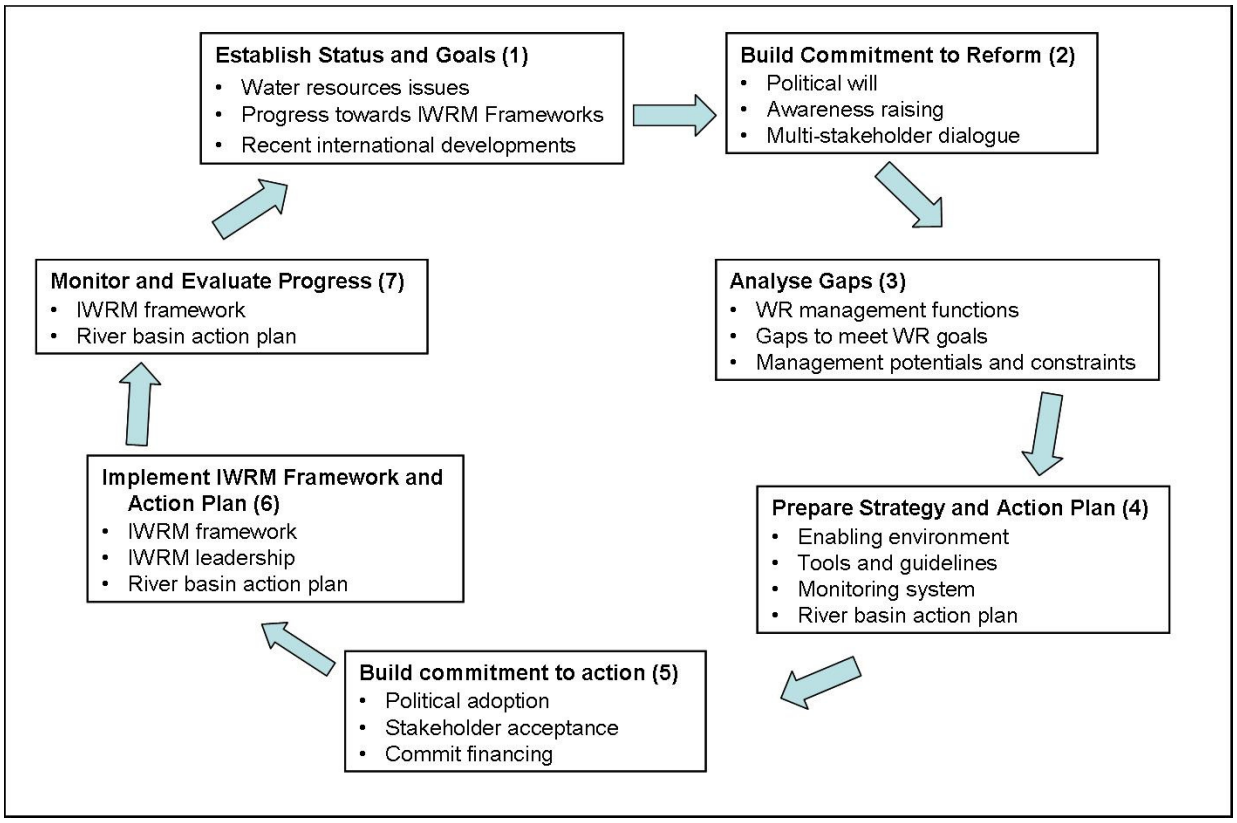

Figure 1: The IWRM Cycle (adapted from van der Keur et al. 2006)

In essence the principles of the IWRM cycle constitute a process aimed at creating an institutional framework through which policies, strategies and legislation can be implemented (Pahl-Wostl, 2007; Muller, 2009).

The cyclic IWRM process as described by van der Keur *et al.* (2006) is comprised of the following elements:

- The planning process, which continues into implementation of the framework and actions plans, and monitoring of progress, forms the initial stage of the process.
- During the analysis stage in the cycle, an assessment of whether reforms result in expected and desired effects is conducted.
- *Active stakeholder involvement is the key to providing feedback on any stage in the IWRM cycle and may result in adjustments and parts of the cycle being*

repeated [3]. Stakeholder platforms within the IWRM cycle are aimed at fostering joint ownership of the process by all participants (Pahl-Wostl, 2006).

- Prioritisation of the water resources and the status of the present water resource management system.
- Commitment to reform requires political will, awareness raising and an active stakeholder dialogue.

Based on evidence of increasing environmental degradation and lack of implementation of suitable regulatory and governance tools to combat environmental degradation the need to re-assess current practices and to devise new and improved methodologies for bridging the science-policy interface has been sharply highlighted. In the last century, science, research and technology have made important contributions to identifying serious environmental problems created by human actions, improved the understanding of the causes and effects of these problems, and developed ways to overcome them.

The basic intention of this work is to obtain an understanding of the theory behind the methodologies prescribed by the approaches of AWM and IWRM and further assess the suitability of these approaches and the potential of these to effect adaptation in the water sector to climate change. The framing of the contextual background therefore entailed an examination of existing literature in order to conceptualise the theory behind the approaches prior to assessing the practical application.

The research approach therefore progressed through the following stages:

a. A literature review provided the theoretical basis for the conceptualisation of the climate change debates, the implications on water resources, the concepts of IWRM and AWM as well as associated risk perceptions linked to climate change and its impact on the variability of water availability. The theory underpinning this research is captured in Chapter 2. The existing initiatives, strategies and policies in South Africa, ranging from the overarching water management legislative framework to the local-level practical operational aspects, were examined in order to understand the local approach to the management of water resources within the climate change regime. IWRM

[3] This stage was a key component of this research methodology based on the structural change cycle as described by Pahl-Wostl *et al,* (2007a) which places great emphasis on active stakeholder participation and social learning in order to ensure effective implementation of IWRM

approaches are considered to be a suitable vehicle to facilitate development and implementation of climate change adaptation strategies (Pahl-Wostl, 2007; Muller 2009, Stuart-Hill and Schulze, 2010). The applications of the concepts of IWRM and AWM were thus tested in a real-time project, which entailed the development of a Water Conservation and Water Demand Management (WC/WDM) Strategy for the City of Johannesburg, the need for which emerged due the realisation that water availability in the region could not be assured over the long term (DWAF, 2006).

b. The existing initiatives, strategies and policies in South Africa, ranging from the overarching water management legislative framework to the local-level practical operational aspects, also needed to be examined in order to understand the local approach to the management of water resources within the climate change regime. This was also critical in attempting to comprehend the correlation between national priorities and regional, local and sector initiatives. A further link to the science-policy interface was also examined in terms of regulatory instruments as well as institutional development.
c. Having obtained the conceptual background to the theory of AWM and IWRM as well as obtaining an overview of national and local regulatory approaches, the applications needed to be tested in an actual practical situation.
d. The applications of the concepts of AWM and IWRM were then tested in a real-time project, the development of a Water Conservation and Water Demand Management (WC/WDM) Strategy for the City of Johannesburg (CoJ). The assessment of these concepts within the CoJ WC/WDM strategy development process was considered to be a viable test for the theory since it was based on the development of a strategy that would address the global problem of the variability of water supply at a local-level based on an imperative from national government.
e. The approach adopted for gaining input from the relevant stakeholders within the CoJ, was based on an interactive workshop and discussion platform. This workshop methodology is discussed in more detail in Section 1.4.4 below. This approach was based on the observation made by Pah-Wostl (2006) that social learning, which is imperative for flexible water resource management, is strengthened by insights gained by individuals when they engage and observe other actors. Individual contributions are enhanced by their social interactions within a group (Pahl-Wostl, 2006).

The overall methodology for the project was informed by the structural change cycle as proposed Pahl-Wostl *et al* (2007a) which specifically emphasises the importance of

adaptive capacity and learning processes in understanding the complexities of water resource management. This approach essentially entails integration within a framework which focuses on the inclusion of local knowledge and active stakeholder participation and perspectives. Another critical aspect of this approach is that the actions must be realisable within a limited time period (Pahl-Wostl *et al*, 2007a). "Learning through participation" (Pahl-Wostl, 2006, pp3) influences structural change by providing a platform for interaction in the short to medium term between role-players and in the medium to long term facilitating structural change in governance structures (Pahl-Wostl, 2006; Pahl-Wostl *et al*, 2007a).

These aspects were the foundation of the CoJ WC/WDM project based on the short- to medium-term focusing on participation amongst role-players to facilitate integration. The need to develop a WC/WDM strategy for the City emerged from a national imperative in response to the realisation that the water availability in the Gauteng Region was seriously threatened (DWAF, 2006). The solution to address the water demand driven aspects was the development of strategy to address water consumption and development needs for the future. In order to develop the strategy it was important that the perspectives of the various departments responsible for development, resource management, environmental management, finance and planning were integrated into the strategy. The need for the inclusion of local knowledge and active stakeholder participation and perspectives (Pahl-Wostl *et al*, 2007a) thus was a central focus of the project.

Further to this, the imperative from the national DWA to the CoJ included a timeframe within which the strategy needed to be developed and implemented in order to achieve the required water savings. The aspect of IWRM, within the adaptation framework, calling for actions that must be realisable within a limited time period (Pahl-Wostl *et al*, 2007a) also was a critical component of the WC/WDM strategy development process.

In essence the methodology for this project focused on the following key attributes which are seen as the cornerstones required to build adaptive capacity thereby making the development of strategies capable of meeting climate change challenges:

1. **Sectoral Integration:** Various sectors within a country and within a specific region or catchment area are interdependent and affect each other in terms of water resource management. The integration of these sectors which impact on water resources (Stuart-Hill and Schulze, 2010) is critical in developing an effective strategy for adaptation to climate change challenges. The

convergence or divergence of stakeholder perspectives and views are critical factors (Pahl-Wostl, 2006) in determining the success or failure of a management process. The need for integration within an organisation such as the CoJ is deemed to be vital for successful implementation of IWRM for effective and flexible water resource management. Moreover such integration it is hypothesises is also critical for flexible adaptation to climate change and was used as a guiding theme for this research.

2. **Supportive Institutional Structures**: In order to ensure that there is effective integration, it is imperative that the requisite institutional structures required to facilitate the trade-offs (Muller, 2007; Sadoff and Muller 2009), encourage co-operation and ensure implementation are in place.
3. **Social Learning:** The very nature of IWRM is characterised by an ongoing process of learning and adapting (Pahl-Wostl, 2002 and 2007; Pahl-Wostl *et al* 2004; Pahl-Wostl and Sendzimir, 2005) and the constant engagement of stakeholders (Muller, 2007) and capitalisation of local knowledge are essential for effective IWRM.

The structural change process for effective IWRM (Pahl-Wostl *et al*, 2007) and its correlation with the process followed for the development of the CoJ WC/WDM Strategy is depicted in the Figure 2 below.

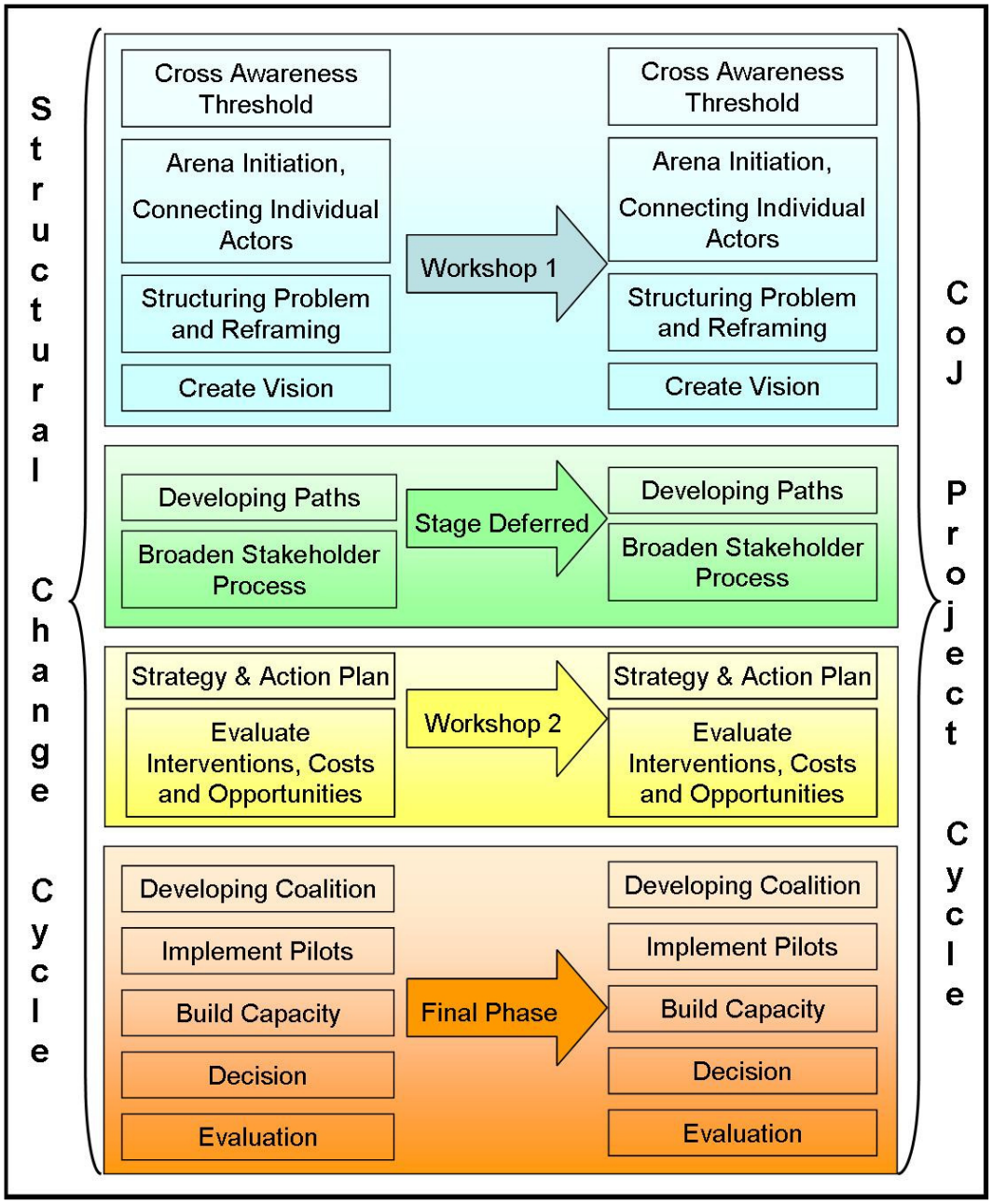

Figure 2: Structural Change Process applied to the CoJ WC/WDM process

The correlation between the two processes supports the methodological approach of focusing on integration of various stakeholders, in this case the relevant departments

within the CoJ. Further, the need for stakeholder participation and interactive debate and discussion in order to develop an effective strategy and action plan is clearly demonstrated.

A significant deviation from the structural process is that broader stakeholder involvement outside of the CoJ departments was not undertaken. The project manager from the CoJ preferred that the key components of the WC/WDM Strategy, the key focus areas and the following action plan were first developed through participation with the relevant departments within the City. Once the strategic framework was developed extended stakeholder participation would be undertaken. This stage of the process was therefore deferred to a later phase in the project cycle.

The following sections provide a detailed breakdown of the steps that were followed as part of the Development of the WC/WDM Strategic Framework for the CoJ, which provided the institutional case for this research. These frameworks also influenced the conceptualisation and implementation of this research.

1.3.1 WC/WDM Strategy Development Methodology

The CoJ has embarked on the development of a high level strategy for Water Conservation and Water Demand Management (WC/WDM). The methodology adopted in developing the WC/WDM strategy is illustrated in Figure 3.

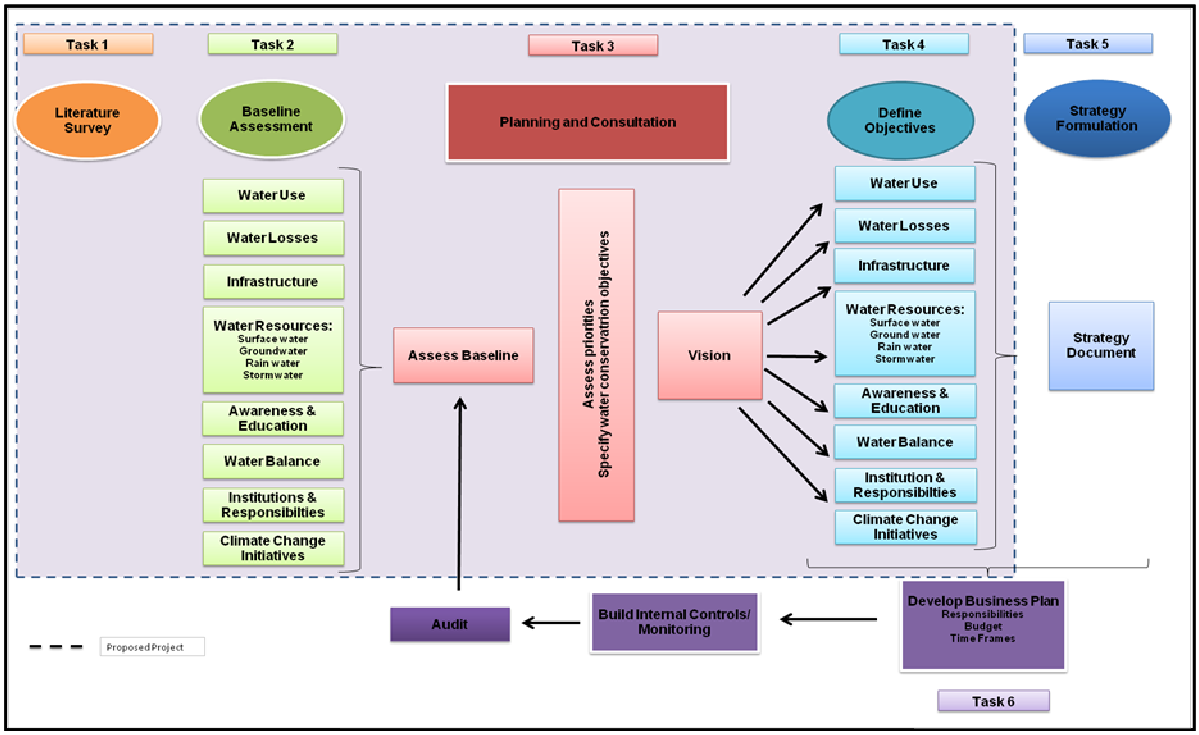

Figure 3: Proposed Project Methodology for the CoJ WC/WDM Strategy development

The key focus of this methodology is that the WC/WDM strategy needed to be developed is based on an assessment of existing work and initiatives already undertaken by the CoJ. This was important to support the learning cycle which is critical in IWRM process aimed at adaptive management (Pah-Wostl *et al*, 2007a).

Based on the assessment of existing information, a background document (see Appendix 1) was compiled which was used as a basis for the interactive stakeholder participation which was undertaken in the form of workshops. These discussions were used to formulate an integrated vision, identify key focus areas and devise and action plan. The details pertaining to the relevant tasks undertaken are discussed in the sections below.

1.3.2 Task 1: Literature Survey

All readily available information pertaining to the WC/WDM project was collated and reviewed. Since the project was focused on a local situation, in addition to the theoretical literature survey discussed in Chapter 2, a literature assessment of existing documentation within the CoJ was also undertaken. A critical barrier to successful integration and participation is that scientific and data gaps could block (Pahl-Wostl, 2006) strategic deliberation. An effective means for dealing with uncertainty is to provide an assessment of existing data and support innovative transition by gathering new knowledge (Pahl-Wostl, 2006).

The local-level literature survey focused on obtaining and examining available reports and studies pertaining to water resource management aspects in the CoJ. The main aim of the review of the available documentation was to assess whether the existing information would be suitable for the development of a strategy, which would address the following aspects:

- Reduction in water usage;
- A reduction in water losses;
- Optimisation of infrastructure and deferment of infrastructural investments due to more efficient water usage;
- Reduced operational costs of water provision and water resource management;
- Improved ability to ensure sustainable access to water supply and water services;

- Optimal use of available water resources including surface, groundwater and rainfall;
- Increased awareness of both the financial and environmental value of water resources ;
- Improved protection of water resources;
- Improved quality of surface water resources through improved management of the quality urban runoff; and
- Improvement management of water balances and water recycling optimising opportunities for attenuation and reuse.

The following are some of the critical initiatives and strategic documents obtained from the CoJ as part of the strategy development process:

- City of Johannesburg: Water Service Development Plan, June 2009
- City of Johannesburg - Infrastructure and Services Department: The Formulation of a Comprehensive Demand Side Management Strategy for the City of Johannesburg
- City of Johannesburg - Infrastructure and Services Department: Water consumption patterns in the City of Joburg, January 2007
- City of Johannesburg: Sanitation Policy for the City of Johannesburg, October 2002
- City of Johannesburg: Sanitation Policy Framework, 2002
- City of Johannesburg: Catchment Management Policy
- DWAF: Potential Savings through WC/WDM in the Upper Vaal and Middle Vaal Water Management Areas, South Africa, October 2006
- DWAF: Potential Savings through WC/WDM in the Upper Vaal and Middle Vaal Water Management Areas, South Africa, 2007
- DWAF: Water Conservation and Water Demand Strategy for the Water Service Sector, 2004
- Johannesburg Water: Water Conservation and Water Demand Management Strategy, January 2008
- Johannesburg Water: Public Awareness Campaign To Address Water Demand Management – Project Implementation Plan
- Johannesburg Water: Demand side management business plan 2009/10, Rev.1, 28 May 2009
- Mark van Ryneveld: Selected strategic issues – summary argument and evidence (2004), Draft #1, 30 November 2004

1.3.3 Task 2: Baseline Assessment Analysis

In developing a strategy, a baseline analysis that identified the constraints and opportunities in implementing WC/WDM, was carried out by conducting a desktop assessment of existing information which could be used to provide an understanding of the status quo in the CoJ related to water services and water provision. The baseline assessment, focused on a number of components at a strategic level in terms of water availability, resource management and conservation actions required to develop a framework strategy, and was based on information provided by the CoJ. The project team members[4] within their specific areas of expertise addressed the components listed below:

- The existing demand analysis that focuses on the reduction of distribution leaks, reduction in plumbing leaks within domestic consumers, retrofit of existing plumbing fittings, reduction in gardening water use, reduction in the demand by new consumers – reduction of natural growth rate
- Assessment of the extent of invasive alien plants in these resources and propose measures to remove this in order to increase catchment yield and availability of resources
- Overview of the water supply system
- Capital infrastructure situation
- Water Resource Management
- Source Directed Measures
- Resource Directed Measures
- Institutional and Financial Arrangement
- Climate Change Initiatives

The last three components have a direct bearing on this project and were specifically addressed by the author in order to obtain understanding of the IWRM and AWM approaches in current local practices.

This task resulted in the preparation of a consolidated Baseline Assessment report, which formed the basis for discussion at the key stakeholder / focus group workshop, which was an essential component of the planning and consultation task.

[4] The project team was comprised of a Strategic Specialist, 2 Water Services Experts and a Water Resource Manager. The role of the Water Resource Manager was undertaken by K. Pema (author of this project report). Relevant ethical concerns were addressed as explained in section 1.4.

1.3.4 Task 3: Planning and Consultation

The workshop component of the project required the interaction with key stakeholders and entailed the following activities:

Identification of relevant stakeholders for the workshop

i. Since the development of the WC/WDM strategy for the CoJ was in response to an imperative from the national DWA, representatives from the National Directorate: Water Use Efficiency and the Gauteng Regional office of the Department were included among the stakeholders for the workshop.
ii. The WC/WDM Strategy was being developed in response to the DWA imperative to reduce water consumption on the premise that the projections based on the Vaal WC/WDM Report (DWAF, 2006) indicated reduced water availability linked to variable climate conditions and rainfall patterns. Based on the fact that the WC/WDM strategy which would be developed would have an impact on the various Departments in the City, the workshop also comprised of the management representatives of the following Departments:
    - Central Strategic Unit;
    - Community Development;
    - Development Planning and Urban Management;
    - Economic Development;
    - Environmental Management;
    - Finance;
    - Health;
    - Housing;
    - Infrastructure and Service Dept (ISD);
    - Legal and Compliance;
    - Shareholder Unit; and
    - Transport.
iii. The CoJ is also comprised of a number of Municipal Owned Entities (MOEs) and the top level managers of the following MOEs were also included in the workshop
    - Johannesburg Water;
    - Johannesburg Roads Agency; and
    - Johannesburg City Parks.

1.3.5 Task 4: Define Objectives

Execution of the workshops

The two workshop sessions were not equally attended by representatives from the above mentioned stakeholder groups. The first workshop was comprised of 26 participants representing the various organisations and departments identified above while the second workshop was comprised of only 11 participants. Notable exceptions in terms of attendance were the National and Regional Offices of the DWA. Although representatives from the CoJ Department of Health were not present, comments on the background document and the identification of priority areas were received from representatives by email. These comments and inputs were also incorporated into the overall identification of key priority focus areas for the strategy.

A short background document was provided to the workshop participants as a brief introduction to the framework within which the water conservation and demand management strategy would be developed. The following were the key components included in the background document:

- Drivers for Action
    - Water;
    - Energy;
    - Climate change; and
    - Socio-economic factors.

- Key Issues and challenges
    - Attitudinal;
    - Institutional;
    - Cost Factors;
    - Management; and
    - Technical.

The content of the background document pertaining to the above aspects, as provided to the participants can be found in Appendix 1. The first workshop was aimed at providing the participants with a background presentation on the challenges and constraints of water resource management and water availability specifically within the urban-domestic water sector. As part of the discussions in the workshop, factors including climate change, water scarcity, energy demands and socio-economic factors were highlighted as key aspects which would influence the strategy (see Appendix 1 for more detail).

While a wide variety of questions was posed to the participants of the workshop, the following critical questions had a bearing on this project:

- Are the implications of climate change and the consequences on water availability clearly understood by the key role players and decision makers involved in water resource management at national and local-levels?
- Are adequate institutional arrangements in place to facilitate the management of the variability of water availability over the long-term due to climate risk? Has the significance of the lack of availability of water for future needs been accepted at the political level?
- Which areas would be considered as Key Focus Areas for achieving the Department of Water Affairs imperative to achieve a 15% water demand reduction by 2013?
- Is there effective communication between the CoJ and National Government, amongst directorates within the CoJ, with scientific specialists and with community representatives?

The participants were asked to list 5-10 key aspects which would be considered as priorities for the CoJ in terms of strategic management and provision of services.

The following were the key priority aspects identified by the various role-players in terms of focus areas for strategic interventions which will be required to facilitate sound water resource management while still making provision for growth and development:

- Economic stability in terms of job creation;
- Climate change as a long term strategic management aspect;
- Management and Institutional aspects such as human resources, capacitated staff, strategic and functional support from national government etc;
- Water in terms of both quality and quantity available for basic human needs as well as economic development
- Growth and development of the city as a whole.

The consequent discussions were aimed at identifying key focus areas or themes, which would correlate to the priorities in the execution of the mandates of the various functional areas within the CoJ and their influences on the water management in the City. The key focus areas around which the discussion evolved were listed as follows:

1. Resource Management
2. Distribution Management
3. Consumer Demand Management
4. Return Flow Management
5. Social Awareness and Education

6. Management and Institutional Aspects

Based on discussions and debates around the above topics as well as an assessment of the process, Chapter 4 provides an assessment of the possible role of IWRM and the practical application at the local-level using the CoJ WC/WDM Strategy as a case study. This assessment is then followed by Chapter 5, in which possible areas of further research are identified in order to further enhance understanding of practical applications of theoretical models.

1.4 Ethics Process

The University's ethics process was followed in order to ensure that the participation of respondents was transparent and fair. The methodology of this research did not require individual interviews but was rather focused on group discussions and debates through interactive workshops. Participants of the workshops were identified based on their functional roles within the CoJ, relevant affiliated Municipal Owned Entities (MOE), and National Government. The main intent of the workshops with the relevant participants was to obtain insight into the relevance of the strategy being developed to the execution of their functions while assessing the fit of current processes with the IWRM and AWM approaches.

As part of the ethics process of the School of Geography, Archaeology and Environmental Studies, a consent form, that introduced the author and emphasised that participation was voluntary, not binding on any participant, and will not result in references to specific participants in the final report, was also provided. A letter of consent from the CoJ as well as the author's employer was also obtained to ensure that there would be no conflict of interest.

1.5 Conclusion

Experts involved in water resource management have emphasised the need to implement effective IWRM as a response to the increasing challenges posed by various challenges including global environmental change. The ideal means for addressing a global problem will entail and require increased co-operation, institutional support, capacity, communication and availability of resources. However, while these ideals may seem to the answer to the problem, the actual application of the principles as described (Pahl-Wostl, 2007; Muller, 2007; Sadoff and Muller, 2009b) needs to be assessed in actual practise.

In order to gauge the applicability of the approach of IWRM and AWM as a tool to aid the development of adaptation strategies, the application of the principles were assessed in practice in the process of developing a Water Conservation and Water Demand Management Strategy for the City of Johannesburg. The main aim of the exercise was to assess the applicability of the principles and identification of key elements, which may pose a challenge to actual implementation.

CHAPTER 2 LITERATURE SURVEY

The primary purpose of this literature survey is to explore the evolution of environmental management paradigms as they pertain to the water sector and to gain an understanding of the global initiatives and the associated risk perceptions linked to climate change and water resource management. Policies are concurrently being developed within varying spheres of government to address the causes and implications of global environmental change with particular emphasis on climate change. There is a need therefore, to improve our understanding of how ideas are being 'framed' and 'taken up' around climate change and in particular in the water sector (Pielke Jnr, 2007).

A brief overview of the main themes that are used in the conceptualisation of the theory of IWRM and AWM combined with some consideration of the emerging concepts and the inherent barriers and inhibitors encountered in the practical water resource management is provided in the following sections. This will then be followed by an assessment of climate change linkages to water resources and consequently on the water services sector.

2.1 Introduction

Scientific paradigm shifts, like any other phenomenon, are largely determined by and dependent on the latest socio-political climate and the latest topical issues, which enjoy prominence in the media and political arenas. The issue of climate change and the social, political and related economic consequences are key items on many agendas today. The most obvious arena, where one can easily observe the responses to climate change drivers is in academic and/or scientific as well as political circles. Scientific and academic research is ongoing and constantly adding to the wealth of knowledge around the climate change debate.

The challenges already experienced in water resource management are further compounded by increasing uncertainties caused by climate and global change and by fast changing socio-economic boundary conditions. It is thus imperative that more attention is devoted to understanding and managing the transition from current management regimes in the water sector to more adaptive regimes that take into account environmental, technological, economic, institutional and cultural characteristics of catchments and the associated water users, stakeholders and ecological regimes. As emphasised by a growing number of experts (Muller, 2007; Pahl-Wostl, 2007) this implies a paradigm shift in water management from prediction

and control (Schulze, 2008) to management as a learning by doing approach (Pahl-Wostl *et al.*, 2007b).

The learning by doing approach is a key component of AWM, centred on the fact that our ability to predict the future key drivers of any given ecosystem, as well as system behaviour and responses, is inherently limited. As a result, water resource management systems must include the ability to change operational practices by incorporating the insights gained from experience (Pahl-Wostl and Sendzimir, 2005). Adaptive management includes at its core an assessment and learning cycle leading to adaptive co-management which emphasises the collaboration between agencies, researchers, and local government officials (Pahl-Wostl *et al.*, 2007b).

While it is evident that there are a vast number of initiatives addressing water resources and risk management within the academic and scientific as well as political communities, the greatest challenge will be in ensuring that there is a suitable, 'honest', interface between science and policy as well as between the higher levels of governance and actual local- level, implementing agents. One critical interface which needs to be addressed is arguably that of the link between the higher governance levels in countries (e.g. National Climate Change Committees) and the local implementing agencies (e.g. in this case Department of Water Affairs and local municipalities). Suitably constructed institutional frameworks are therefore need to be established to operate optimally within the private, as well as government sectors.

In order to effectively conceptualise goals, it is essential to obtain a good understanding of the background and evolution of environmental management. The following sections of this Chapter will therefore provide an overview of the evolution of environmental management. Links will be emphasised to the water sector and specifically to the perceptions of climate change and the associated risks to water availability. Risk perception in climate change linked to water resource management will be highlighted to gain an understanding of the current practices in operational areas of water management.

2.2 The Evolution of Environmental Awareness

Based on the Global Environmental Outlook (GEO) 3 as published by UNEP in 2002, paradigm breaking books such as Rachel Carson's *"Silent Spring"* and Garrett Hardin's *"The Tragedy of the Commons"* were the driving forces for the galvanization of the international community towards the conceptualization of the environmental

issues which needed to be addressed to manage the spiralling downward trend of resource availability. In essence, the "real" environmental awareness movement gained momentum in the 1960s with the year 1972 standing as a major watershed in modern environmentalism.

While each decade since the 1960s has been characterized by specific environmental paradigms, the most influential decade in terms of environmental knowledge and application of political initiatives on a global, national and local scale is arguably the 1990s. This decade was characterized by a vast array of international protocols, conventions and agreements, which were the products of deliberations at world conferences on various environmental issues. Table 1 below provides a summary of some of the more significant initiatives of the 1990s.

Table 1: Summary of Some Environmental Initiatives in the 1990s

Year	Environmental Initiatives
1990	International Panel on Climate Change (IPCC) established in 1989 convened and produced the first Assessment Report warning of impending global warming.
1991	Global Environmental Facility (GEF) created to deal with the financial aspects of grants and loans to developing countries
1992	UN Conference on Environment and Development – The Earth Summit – in Rio de Janeiro, Brazil took place and gave rise to the following: The Rio Declaration on Environment and Development Agenda 21 – a blueprint for environment and development The United Nations Framework Convention on Climate Change (UNFCCC) The Convention on Biological Diversity (CBD) The Commission on Sustainable Development (CSD) Agreement to negotiate a world desertification convention Principles for the sustainable development of forests.
1992	The Basel Convention aimed at the reduction of transboundary movement of hazardous waste entered into force
1993	The CBD came into force as a global agreement on the conservation and sustainable use of biodiversity
1993	The first meeting of the CSD took place and occurred annually thereafter
1994	The UNFCCC came into force and was supported by governments based on the assessment report provided by the IPCC on the looming

	global warming threat
1994	UN Convention to Combat Desertification was developed and became effective in 1996
1995	World Summit for Social Development in Copenhagen, Denmark
1996	ISO 14 001 create for environmental management systems in industry to facilitate self regulation
1997	The Kyoto Protocol which set limits fro emissions was signed
1997	Rio+5 which reviewed the implementation of Agenda 21 took place
The 1990's were generally characterized by the increasing need to balance the environment with development and economic growth and can essentially be seen as the decade that gave birth to the Sustainable Development Paradigm.	

Source: GEO3, UNEP-2002

The Intergovernmental Panel on Climate Change was established in 1988 to assess on an objective, open and transparent basis the scientific, technical and socio-economic information relevant to climate change (UNEP, 2007). The IPCC convened and produced the first Assessment Report warning of impending global warming in 1990 (UNEP, 2002).

The United Nations Framework Convention on Climate Change (UNFCCC) was opened for signature at the Earth Summit in Rio de Janeiro in June 1992 (King, 2004) with an overarching framework to address the challenges of climate change through intergovernmental efforts (Venton, 2007). The objectives of the UNFCCC are:

- To control or limit greenhouse gas concentrations to reduce the impact and interference if these gases with the global climate system; and
- To achieve these reductions within a time frame that allows ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.

The Kyoto Protocol was developed in 1997 to reinforce the emissions reduction commitments of the UNFCCC and came into legal force in 2005 when it was ratified by 30 industrialised nations, creating legally binding targets for a 5 percent reduction in emissions below 1990 levels by 2012. In 2007, the IPCC together with Al Gore, was

awarded the Nobel Peace Prize. It is against this broad environmental landscape that the changing perception of water as a key environmental sector is traced.

2.3 Global Water Initiatives

Water was given relatively little attention at Rio in 1992, but the preparations in Dublin at the *International Conference on Water and the Environment* in January 1992, resulted in the detailed Chapter 18 on freshwater, the longest in Agenda 21 (Allan, 2003). This gave rise to the following Dublin Principles, which have been used as the foundation for IWRM:

- freshwater is a finite and vulnerable esource, essential to sustain life, development and the environment;
- water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels;
- women play a central part in the provision, management and safeguarding of water;
- water has an economic value in all its competing uses and should be recognised as an economic good (Bates 2008).

Some of the most critical and influential global water initiatives are depicted in Figure 4. The vision process of 1998-2000, following the first World Water Forum in 1997, was the first major attempt to construct knowledge about global and local water since 1992, and was characterised by a concerted attempt to include all interested stakeholders in a worldwide consultation process. Its goal was to provide the social and political pressure to change attitudes and more importantly address the crucial aspect of funding mechanisms for water policy priorities. The heightened awareness achieved at The Hague in 2000 culminated two years later in 2002 at Johannesburg at the second Environment and Development Conference. Water and making it available to poor communities were the prime issues. Other concerns such as climate and biodiversity were argued to be subordinate (Allan, 2003).

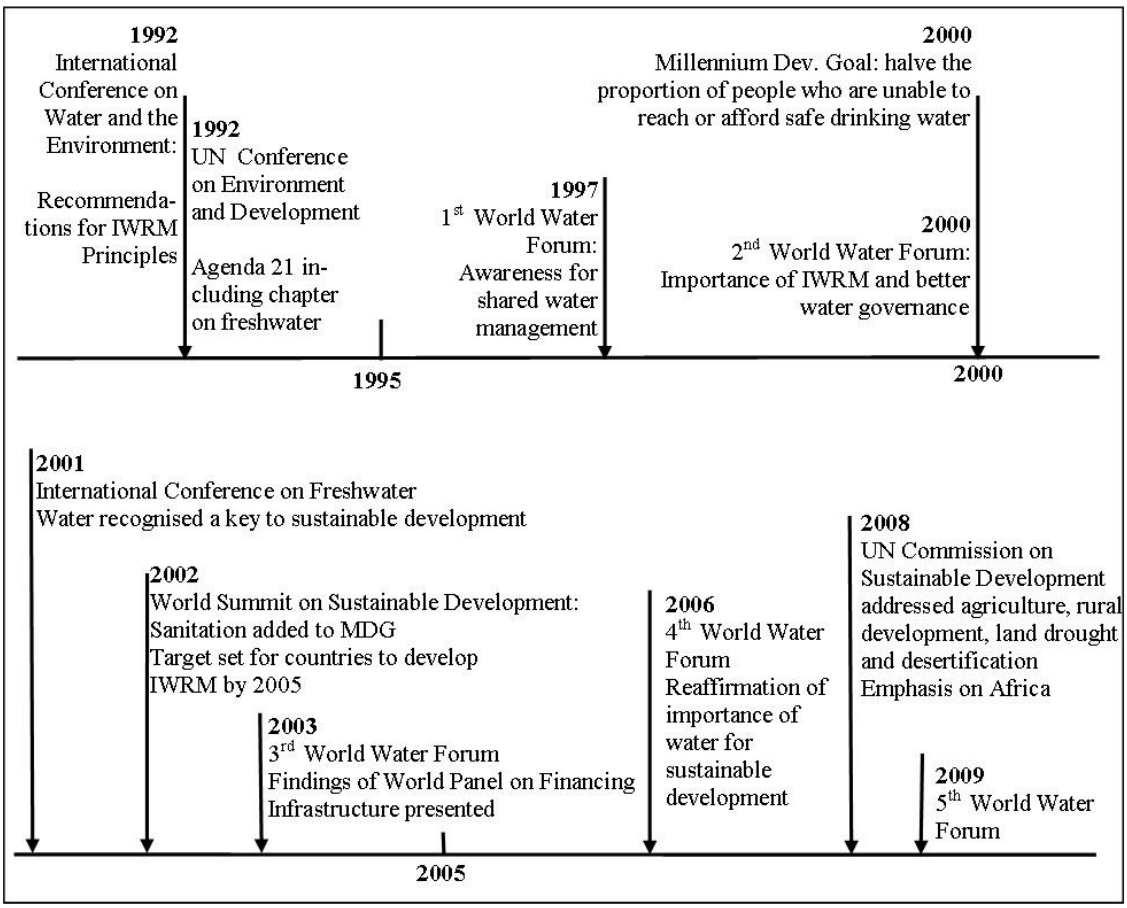

Figure 4: Influential Global Water Initiatives (adapted from GWP, 2008)

Having traced some of the broader international trends in water "thinking" attention now turns to an examination of water use and management in terms of risk governance approaches.

2.4 Risk Perception Factors

The advent of democracy in South Africa was characterised by the development of policies and guidelines aimed at economic development while at the same time acknowledging the constitutional right of all citizens to a clean and safe environment (Patel, 2005). Beck (1992) indicates that past social cultures accepted environmental risks as the price to be paid for technological advancement and general progress. This acceptance was further reinforced by the belief that the building of strong economies and the development of a welfare state founded on the guiding principle of the distribution of such "positives" as wealth, consumer goods, jobs, incomes, educational opportunities and property was necessary for the advancement of humanity (Beck, 1992).

According to the risk society thesis (Beck, 1992, 1998), Western societies presently find themselves in situations where they must urgently confront the unanticipated side effects and by-products of industrialization that take the form of large-scale environmental risks and technological disasters.

However, while the past generations accepted environmental risks, the risk profile of modern society has changed because the frequency and the magnitude of the impacts of environmental risks experienced today have dramatically increased, thus stimulating increased public interest in environmental issues in general and risk issues in particular (Giddens, 1990). Shifts in perception reflecting awareness of water resource scarcity have influenced the discourse on water management. Awareness of scarcity, has increased the prominence and intensity of water policy-making bringing the aspects of suitable and adaptive management to the forefront.

Allan (2003) describes the evolution of water management by identifying the five water management paradigms, which are discussed below. In Figure 5 below, he demonstrates the driving forces, which influenced water management policy since the late nineteenth century by using trends in levels of use of freshwater for agriculture as an indicator. The trajectories of the five paradigms clearly illustrate the way in which water for irrigation has been mobilised and managed over the past two centuries.

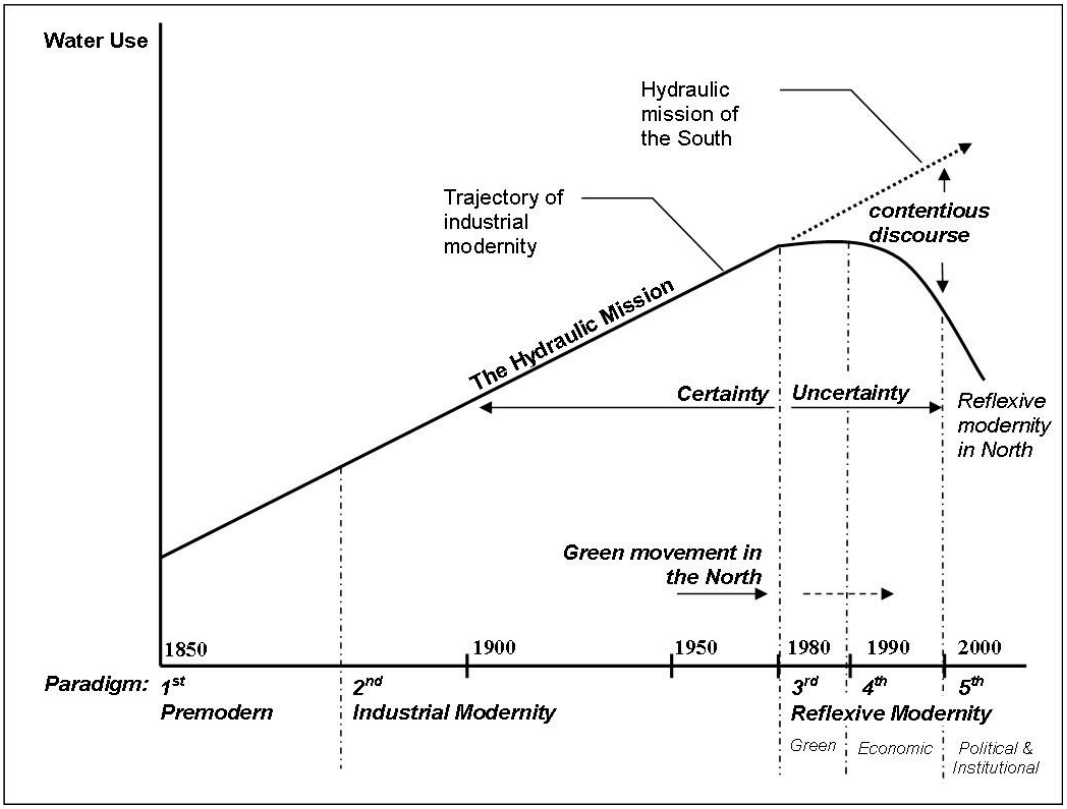

Figure 5: The Five Water Management Paradigms (adapted from Allan, 2003)

While all societies in human history have been challenged by threats and dangers, these have largely been the outcome of the natural world, such as infectious diseases, famine and natural disasters. The major difference in modern times is that based on increasing social and political awareness, the influence of human activity is now attached to risk (Giddens, 1990, Beck, 1998, Lupton, 2006) of reduced assurance of availability of resources such as water. The human factor now plays the dual role of being both the cause as well as the solution to wide-reaching risks such as environmental pollution, ionizing radiation, the contamination of foodstuffs and changing climate patterns amongst others (Lupton, 2006). Awareness of a 'new' risk is usually informed by science which captures data on environmental, technical, demographic as well as socio-political circumstances which influence water resource management (Allan, 1999).

Progressively the identification and quantification of such risks relies heavily, but not only, on technical expertise. The public is no longer so easily able to rely on factors such as traditions, local knowledge, religious beliefs or habits to shape their decisions about risks. Conversely, the "common man" has become more and more suspicious of expert judgments on risk due to the inability of experts to agree and the failure of governments to act. Therefore, the information or advice used to build trust and to effectively manage risk has become a contentious issue, often inspiring grassroots political action (Lupton, 2006).

A major obstacle in addressing risks in the environmental management field is the serious lack of *institutional mechanisms to facilitate the actual management of risks*. Risks constituted by the risk society do not conform to traditional boundaries and are not limited to time spans or particular groups in society. These risks are also incalculable in terms of occurrence and level of potential damage (Matten, 2004). Perceptions of risk and the acceptability thereof are based largely on personal and societal values. Certain types of risk such as voluntary, individual and distributed risks are more acceptable than those, which are involuntary, government, controlled or unfairly distributed (Wandersman and Hallman, 1993).

In the risk society context it is also vital that the relevant role-players, whether individual members of the public, organized environmental groups or regulators, accept the uncertainty related to the identification of risks and the associated mitigation factors. The need to derive a logical and pragmatic solution is fundamental and cannot be done by any one group in isolation or at the expense of exclusion of certain groups. How much people are willing to invest to protect themselves from damage depends on

their risk aversion and on the rate, they apply to discount the costs for future damage. The damage is not a natural given but depends on the ability of the current system to cope with extremes. The whole management approach is therefore caught in a positive feedback loop that potentially may increase the vulnerability of the water system to extreme events: given the fact that technical infrastructure is implemented to shield the water system from extremes, less precautions are taken elsewhere to cope with extremes (Pahl-Wostl, 2007).

2.5 Sensationalisation of Climate Change

Within this context, climate change has become a very topical as well as controversial topic, largely being used by celebrities and politicians to score political points. The mainstream publicity medium such a movies and documentaries are being used to highlight environmental issues such as global warming and climate change. The key aspect that needs to be borne in mind is that the medium is still very subjective and therefore, prone to inaccuracies. Hulme (2004) points out, that the various ways in which climate change issues have been portrayed and communicated in recent years, by science, by analysts and by the media, including the different forms of portrayals, largely influence public perceptions of dangerous climate change and the formation of public policy. The frequency and the magnitude of the impacts of environmental risks experienced today have dramatically increased, thus stimulating increased public interest in environmental issues in general and risk issues in particular (Giddens, 1990).

In recent times, many celebrities and politicians, such as Leonardo di Caprio and Al Gore, lent their names to the environmental movement through documentaries such as "*The Eleventh Hour*" and "*An Inconvenient Truth*". Other mainstream media foci have been through fictional movies such as "*The Core*", "*Deep Impact*" and "*The Day After Tomorrow*". All of these efforts have attempted to highlight the issue of global environmental change and climate change in particular to some extent.

While it can be accepted that the public who view the movies will accept them as works of fiction based on some scientific fact, movies achieve much in the arena of generating debate and discussion on the topic. The increased awareness in terms of causes and implications of climate change will prove to be beneficial if even a handful of people change their lifestyles as a response to the message in the movies, however misleading it may be. Nicol and Kaur (2009) maintain that while at present, the climate change debate is focused mostly on the extremes, risk and media-friendly scenarios of

change, the more mundane development of better planning that is more informed and inclusive, should also receive far more attention.

Despite the fact that mixed messages are being sent in terms of climate change and the long-term impacts on water resource management, the undeniable fact is that the changes in climate potentially may have a dramatic impact on water availability in the future (IPCC, 2008). It is in this context that the understanding of the hydrological cycle and the links with climate change will be explored.

2.6 Key Considerations: Climate Change and Water Resource Management

Nicol and Kaur (2009) stress that climate change will alter the hydrological cycle in many ways essentially triggered by the warming of the atmosphere and oceans, which may change major weather systems. Temporal and spatial patterns of rainfall may change with consequences for runoff, surface and groundwater storage, river flow regimes and, it is estimated, greater likelihood of extremes such as droughts and floods. These changes will, in turn, affect major human livelihood systems, particularly those dependent on direct access to natural assets. On the demand side, as populations grow and move compounded by increasing or decreasing income levels – their demand for water resources will change, both spatially and temporally (Nicol and Kaur, 2009).

Within the water resource management sector, the need to address water resource availability in terms of quality and quantity has become more and more critical. Many initiatives have been undertaken by the South African national government to understand the problem of climate change and its implications on water resource management. Some examples of such initiatives include:

- National Climate Change Response Strategy (DEAT, 2004);
- National Water Resources Strategy (DWAF, 2004);
- A Climate Change R&D Strategy for South Africa (DST, 2006);
- South Africa's Climate Change Technology Needs Assessment (DST, 2007);
- Water for Growth and Development – Strategic Framework (DWAF, 2009);
- Clean Development Mechanism (CDM) projects; etc.

Within this context, the convergence of science, empirical data and knowledge management, decision-making, socio-economic concerns and policy development is essential. The focus from institutional arrangements and the applications of only formal

legislation and policies has to shift to greater holistic problem solving and management plan implementation (Pielke, 2007; Rosenberg *et al*, 2007).

The planning of water resources requires the consideration of many uncertainties, including the extent and nature of future requirements for basic human needs and development, and knowledge of both rainfall and runoff; knowledge that slowly improves as the historical record grows. Climate change increases this uncertainty, with rainfall trends becoming one of the most important features to be distilled from historical records. An important challenge therefore, is to ensure that both water managers and climate professionals communicate with and understand each other, and also to relate these issues within the overall context of national development and other priorities for climate change management within the water sector (Kashyap, 2004).

2.7 Policy formulation, strategic planning and institutional approaches

Dovers (2001) asserts that ignoring the institutional settings of environmental resource management will prove to be fatal in actually achieving the goals of the responsible regulatory organizations. Institutions are both barriers to and opportunities for ecologically sustainable human development. Given the relative potential of institutional theories to increase the comprehension of the various dimensions of human–environmental interactions, it has become increasingly important to attempt to consolidate different interpretations of what institutions are, and how they mediate and constrain possibilities for more successful environmental outcomes (Hotimsky, *et al.*, 2006).

It is therefore quite critical that while intensive research centered on case studies is required, in terms of policy, a procedurally-rational approach that accommodates inevitable uncertainties, also integrates scientific and local knowledge into policies to advance the common interest, and relies on incremental learning from experience through policy appraisal and the termination of failed policies, is also vitally essential (Lynch and Brunner, 2007). Although the overall performance of water resource management institutions (referring specifically to organisations) may be difficult to conceive and measure, it may however, be possible to obtain an indication of the effectiveness of resource management, indirectly in terms of the progressiveness of water institutions. The progressiveness of water institutions will most likely be based on factors such as adaptive capacity, scope for innovation, openness for change, and ability to tackle emerging problems (Saleth and Dinar, 2000). King (2004) clearly highlights that understanding in greater detail the response of our complex climate

system to human interventions will help countries and businesses adapt to the climate change that is inevitable and help target investment where it is most needed (King, 2004). It is some of these elements that this work presented here begins to explore.

Within this context of the impact of climate change on water availability, the use of appropriate and effective management tools for mitigation and adaptation are vital. The following sections provide some insight into IWRM as a viable means for addressing climate change impacts in water resource management.

2.8 Integrated Water Resource Management

IWRM is about strengthening frameworks for water governance to foster good decision making in response to changing needs and situations. It includes amongst other issues:

- Avoiding the lives lost, the money wasted, and the natural capital depleted because of decision-making that did not take into account the larger ramifications of sectoral actions.
- Ensuring that water is developed and managed equitably and that the diverse water needs of women and the poor are addressed.
- Ensuring that water is used to advance a country's social and economic development goals in ways that do not compromise the sustainability of vital ecosystems or jeopardize the ability of future generations to meet their water needs (GWP, 2004).

Catchments are essentially the primary units of IWRM and are composed of many users, upstream and downstream of one another. The integrated approach considers the catchment as a whole and addresses the impacts that changes in the catchment or the distribution of water will have on the other users. Water resource managers no longer start with the assumption that certain structural measures (e.g. dams, levees) are the best solutions to address lack of water availability and focus instead on the management objectives, which need to be achieved. The objectives usually include factors such as social and community well being, women's roles in water user groups and environmental protection and conservation.

IWRM is now the encompassing paradigm for adaptation to contemporary climate variability, and it is the prerequisite for coping with the still uncertain consequences of global warming, climate changes associated with it and the resultant consequences on the water cycle. Effectual IWRM therefore requires the harmonisation of policies,

institutions, regulatory frameworks (e.g. permits, licences, monitoring), planning, operations, maintenance and design standards of numerous agencies and departments responsible for one or more aspects of water and related natural resources management (Kabat *et al.*, 2003). Thus, it can be said that IWRM comprises an integrated approach and a holistic perspective, in which a structure of inter-linked components is taken into account. In addition to hydrological or water resources components this structure also encompasses a number of other components, such as environmental, economic, demographic, socio-cultural and institutional subsystems.

Although many of the basic concepts and approaches encompassed by IWRM were already being practised before its formal adoption at the 1992 Earth Summit, Carriger (2009) maintains that the concept of IWRM arose as a response to the failure of traditional approaches to meet development goals without sacrificing environmental sustainability. Therefore it can be said that IWRM simply reflected evolving good practice, rather than any radical new innovations and essentially represents the best thinking available on good water resources management. According to Bates *et al.* (2008), despite the fact that IWRM can still be considered to be in its infancy, the formalised and institutional implementation of IWRM could be a key instrument to explore adaptation measures to climate change.

Successful integrated water management strategies would ideally include, among others:

- stakeholder engagement and participation;
- reviewing and adapting planning processes;
- coordinating land and water resources management;
- recognising water quantity and quality linkages;
- use of surface water and groundwater;
- conserving and protecting natural systems;
- remediation of contaminated land; and
- encompassing consideration of climate change (UNEP, 2007)

However, translating these principles and recommendations into practical actions at the international, national and local-levels has posed a major challenge due to a lack of experience in their application, and the predicament of overcoming institutional, scientific and other significant barriers to integration (UNEP, 2007). Thus the recognition that water management is a critical component, which needs to adapt in the face of both climate and socio-economic pressures in the coming decades, is vital for effective IWRM.

2.9 Adaptation

Climate change projections suggest that such change will superimpose itself on current drivers of scarcity and is likely to replace areas of economic scarcity (most of Africa) with physical scarcity (Nicol and Kaur, 2009). Changes in water use will be driven by the combined effects of: changes in water availability, changes in water demand from land, as well as from other competing sectors, and changes in water management (Bates *et al.*, 2008). Most water resource management experts agree (e.g. Pahl-Wostl, 2007; Muller, 2007; Bates *et al.*, 2008; Carriger, 2009), that the key to addressing the impact of climate change on water resources lies in the implementation of effective IWRM practices and policies to develop adequate mitigation and adaptation strategies to address climate change. Adaptation requires responses at multiple scales.

While the fact that climate change will affect water quality and availability is generally accepted, in order to adequately deal with this aspect it is vital that the governance structures and associated institutions dealing with climate change and water resource management lend themselves to adaptability. Adaptation, as indicated by Adger *et al.* (2005) is reactive since it is largely triggered by past or current events, but it is also anticipatory in the sense that it is based on some assessment of conditions in the future.

Climate change, as a subject, has been dominated by the natural science community and has thus been debated at a high level with an emphasis on national and international acceptance and, subsequently, mitigation (Venton, 2007). Evidence suggests that climate change is already occurring (IPCC, 2007) and even if mitigation efforts were immediately able to reduce root cause aspects, there will be certain ongoing impacts from climate change that need to be addressed (Venton, 2007). While many decision-makers think of mitigation and adaptation as two independent paths in responding to climate change, recent work shows that adaptation and mitigation are closely linked (UNEP, 2009).

Bates *et al.* (2008) describe two types of adaptation actions, which may be applicable to the management of the impact of climate on water resources:

- *Autonomous adaptation* actions are defined as responses that will be implemented by individual farmers, rural communities and/or farmers' organisations, depending on perceived or real climate change in the coming

decades, and without intervention and/or co-ordination by regional and national governments and international agreements.

- *Planned adaptation* is comprised of changes in policies, institutions and dedicated infrastructure aimed at facilitating and maximising long-term benefits of adaptation responses to climate change.

Autonomous and planned adaptation could, however, result in mal-adaptation, leading to increased land degradation and endangerment of the biodiversity of both wild and domestic species, possibly jeopardising future ability to respond to increasing climate risk later in the century. It is therefore apparent that in order to achieve effective adaptation, planning and implementation are vital.

Venton (2007) describes adaptation as a set of responses to the actual and potential impacts of climate change to moderate the harm or take advantage of the opportunities that climate change may bring. This is a new, critical and urgent challenge exemplified by a top-down technical consideration of climate change, which essentially needs to be met with a bottom-up community based approach. In fact, the community-based approach has to better inform policy and practice at the higher levels. Building local flexibility in designated sectors and with acceptable socio-economic constraints on possible options offers many opportunities for stakeholder involvement and other community benefits (Bates *et al.*, 2008). Long-term changes and increased variability in climate will require the development of strategies to adapt to the new conditions.

2.9.1 Adaptive Management

There is a widespread concern among conservation and development professionals that climate adaptation represents such a fundamentally new way of envisioning resource management, that a complete shift in worldview is necessary (Matthews and Le Quesne, 2009). It has become, even more difficult to quantify potential damages caused by weather extremes. As a consequence of taking into account the true complexity of water systems at different scales and an increase in uncertainty, radical changes are thus needed in water management.

This poses considerable challenges to the tradition of water management characterized by a prediction-and-control approach and an emphasis on technical solutions. To face those challenges adaptive water management under uncertainty is

advocated as a timely extension of water management and a requirement to really move towards IWRM (Pahl-Wostl and Sendzimir, 2005).

Pahl-Wostl (2007) explains that adaptive management is based on the recognition of the limited ability to predict future key drivers influencing an ecosystem and the resultant system behaviour and responses. Consequently, management must be flexible and sufficiently adaptive with the inherent ability to adjust practices based on new experience and insights. Adaptive management is therefore a systematic process for *continually* improving management policies and practices by learning from the outcomes of implemented management strategies. The most effective form of adaptive management employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed (Pahl-Wostl, 2007).

From the perspective of the water resources manager, the critical aspect to consider and understand is how climatic conditions will affect the strategy of sustainable water resource management (Kabat *et al.*, 2003). The consensus amongst leading experts (Pahl-Wost, 2007, Muller 2007) is that adaptation to climate change and water variability will have to be a critical component in the future management of water resources within the changing climate context.

2.9.2 Adaptation and Water Management

While climate change projections are generally broad-brush, they have major implications for water resource management and policymaking (Nicol and Kaur, 2009). The implications of climate variability and climate change, however, have not been fully considered in current water policy and decision-making frameworks. This is particularly true in developing countries, where the financial, human and ecological impacts are potentially greatest, and where water resources may be already highly stressed, but the capacity to cope and adapt is usually constrained at various levels (Kabat *et al.*, 2003). This lack of inclusion in water policy and decision–making frameworks at national levels can be attributed to the limits posed by the fact that most climate change projections are conducted at the continental-scale. Nicol and Kaur (2009) stress the fact that infrastructure development is, for example, largely engineered at national and regional levels through policy choices, budgeting priorities and other governmental and non-governmental instruments of social change and economic choice. This is where the decisions are made on most mitigation and adaptation measures and where those decisions will be implemented and reviewed for their effectiveness. Natural water supply, however, varies over time and across scales

and thus some variability can be compensated by the buffering capacity inherent in the water system such as natural storage or adaptation in water use patterns (Pahl-Wostl, 2007). In the absence of reliable projections of future changes in hydrological variables, adaptation processes and methods, which can be usefully implemented in the absence of accurate projections, such as improved water-use efficiency and water-demand management, offer no-regrets options to cope with climate change (Bates *et al.*, 2008). Social and political contexts will further determine the net impacts of climate change on social systems and on the effectiveness of adaptation interventions (Nicol and Kaur, 2009).

As briefly illustrated in various preceding sections above, adaptation strategies in the water sector will need to address a number of emerging trends driven by climate change. These include increased uncertainty, variability and extreme weather events. Climate adaptation is the process of adjusting to and anticipating emerging climate regimes — avoiding risk and facilitating change. This could include actions such as reducing water consumption to compensate for lower precipitation rates, re-location of an industry away from an increasingly drought-prone area to a wetter region, or altering urban stream morphology to compensate for larger and more frequent floods. Dealing with extremes, for example, has always been one of the major challenges for water management (Pahl-Wostl, 2007; Matthews and Le Quesne, 2009) largely due to the unpredictable nature of such events and the consequent impacts such as loss of lives, increase in water-borne diseases, destruction of food crops and arable land etc.

Technical facilities have been used to extend the capacity of the water system to cope with extremes. Large-scale technical infrastructure has been implemented to safeguard human activities from the variability of the resource. Artificial storage measures such as dams and reservoirs are used to enhance the resource base as contingency measures in the event of droughts. Such events have triggered an increasing awareness of water managers for the possible challenges posed by global and climate change. It becomes more and more difficult to predict probabilities for weather extremes, which are fundamental for the current strategy to deal with risks (Pahl-Wostl, 2007).

Based on the challenges posed by climate change, adaptation in the water sector will need to focus on responding to longer-term challenges that go beyond traditional short- and medium-term planning cycles. This involves building capacity to develop more sensitive analysis of climate-specific hydrological systems alterations and the balance between climate-induced change and other factors including demography

(Nicol and Kaur, 2009). Water resources management clearly impacts on many other policy areas (e.g., energy projections, land use, food security and nature conservation). Adequate tools are not available to facilitate the appraisal of adaptation and mitigation options across multiple water-dependent sectors, including the adoption of water-efficient technologies and practices (Bates *et al.*, 2008).

Nicol and Kaur (2009) suggest that this level of better information, understanding the context in which information is produced and shared and the beneficial use of this information is perhaps the starting point for improved sector responses to climate change. However, limitations will be experienced in the demand and supply-side in the social, physical and economic instruments and their capability in ensuring the availability and economic viability of water to meet those needs. Future planning must also be focused on the development of more comprehensive resource and drought mapping. Pahl-Wostl (2007) further emphasises the importance of increasing the adaptive capacity of water systems based on integrated system design which may range from the introduction of new socio-technical systems to increased socio-economic empowerment geared towards restoring a multi-functional landscape. The challenge lies in increasing the ability of the whole system to respond to change rather than reacting to undesirable impacts of change. A pro-active management style must be based on a sound understanding of what determines a basin's adaptive capacity and vulnerability.

Given this call for a holistic approach to adaptation, the IWRM framework can be the foundation for existing policy to become a major force in adapting to climate change contingent on the fact that such policies need to be sustained financially and institutionally by government at national level and below (Nicol and Kaur, 2009). However, as with any new concept or approach, there are certain challenges and barriers, which will need to be considered and addressed for effective implementation of IWRM.

2.10 Barriers and inhibitors

The issue of human security and vulnerability specifically linked to climate change and food security has become a very critical issue for discussion and attention at local as well as international levels. Governments of the world are continuously faced with challenges in this arena because the ability of individuals and communities to exercise options to avoid or adapt to risk to their basic needs or rights has been seriously compromised (GECHS, 2006). The human security sphere is characterised by spatial and temporal determinants, which also result in knock on effects on the production and

dependant sectors resulting in impacts such as migration to urban or prosperous areas, placing increased demand on urban services and therefore increased political pressure on the State. The State is then consequentially plagued by lack of revenue and a resultant lack of services (Barnett and Adger, 2005).

Environmental changes such as those most likely to occur as a result of climate change, in combination with socio-economic drivers, increasingly also threaten basic human interests and needs and should thus be considered high order threats to human well being (Maltais, Dow and Persson, 2003). This aspect will prove to be a major challenge and will have to be dealt with by the development of sound policies and strategies aimed at addressing the root cause of such problems. Although water agencies have the capacity to adapt to changing conditions, incremental innovation ultimately does not allow for the magnitude of change that may be necessary as conditions change. Something else is required as demands for service increase and social values change to require multiple (and sometimes conflicting) use of the resources. The pursuit of further sources of supply, for example, results in collision with and struggle for control over increasingly scarce supplies. Moreover, virtually all development of new water services for human use has negative consequences to the natural environment (Lach *et al.*, 2005).

Despite the logical appeal of, and belief in, whole catchment water management, initiatives in IWRM have often failed in the realisation of expected outcomes, largely based on weak execution. The current problems are likely to be aggravated further by anticipated impacts of climate change and the associated uncertainties (Schulze, 2008). The increase in water quality and wildlife protection regulations by regulatory authorities implies that routines and standard operating procedures of other agencies need to be continually examined, altered, and sometimes changed. The need to make real shifts in values and decision-making processes becomes a critical factor (Lach *et al.*, 2005). While good intentions and idealistic goals give rise to strategies for implementation, intrinsic barriers hamper actual realisation of objectives. Some of these are mentioned below.

Local Capacity: The most obvious factor affecting the viability of these strategies is the perceived lack of local capacity to ensure effective implementation. There is a severe shortage of qualified water managers resulting in non-compliance with quality standards. There is an urgent need for formal training in this sector. Deficiencies are evident in capacity with regard to effecting the integration between climate change and water resource management (Schulze, 2008).

Financial: The low financial resource base to cover the capital and running costs of most of the strategies hampers the implementation of strategies. Local government competes for nationally allocated funds for capital expenditure. Running costs are mostly covered from local revenues, which for the smaller and remote local municipalities are insufficient to ensure water security at this level (Mukheibir, 2005). Political buy-in for some of the strategies will need to be obtained through education programmes, but these also require human and financial resources. In order to address the impacts of climate change, policies and resources need to be focused on addressing the building of both financial and human resources at all governance scales e.g. local , regional and national government levels (Schulze, 2008).

Sectoralism and lack of integration: Adaptation to climate impacts for the most can only be addressed at the local-level as part of an integrated development plan (Mukheibir, 2005). Sectoralism often exists within and between government departments, manifested by the fragmented nature of institutional structures, often with different functions and political agendas concerning climate change responsibilities (Schulze, 2008). Contradictions among agencies are inevitable in a government structure that by design represents various stakeholder groups. However, in general, the various levels of government are in pursuit of common goals (Lach *et al.*, 2005).

Information: Deficiencies in research, and hence information, pertaining to climate change related impacts and vulnerabilities, frequently exist as a result of the application of outdated climate scenarios, inadequate downscaling and use of inappropriate models, insufficient spatial information, a lack of willingness among organisations to share data and information flows being inadequate (Schulze, 2008).

2.11 Climate Change Impacts on Water Resources

Renewable water resources are finite since they are limited by the flux of freshwater brought to, and withdrawn from, the continents by the processes of the hydrological cycle. Nevertheless, it is generally accepted that the *available* water resources are not equivalent to the sum of the annual river flows to the oceans. Floods compose a large proportion of the flows and when they occur as extreme events, they characterise a disaster rather than a beneficial resource. River flows are very unevenly distributed with time (Kabat *et al.*, 2003).

Most of the geochemical and biochemical characteristics of water are acquired during its travel from the clouds to the rivers, through the biosphere, the soils and the

geological layers. Changes in the amounts, or patterns, of precipitation will alter the route and the residence time of water within the hydrological cycle and in catchments specifically, and change its quality, in such ways that the resource might be lacking, not because of the quantity, but because its newly acquired quality may have render it unsuitable for the required use (Bates *et al.*, 2008). Consequently, there are real risks that an increase of the concentration of dissolved salts may occur because of an increase of evaporation under higher temperatures. The risk of increased salinity might also be associated with excesses of water. Under such conditions the water tables, which were previously kept at a given distance under the surface, may rise and reach horizons of soils, which may then become more saline or contain agrochemicals or industrial wastes. The water from these shallow aquifers may eventually be drained into the river network and reduce the quality of the water further downstream (Kabat *et al.*, 2003).

The IPCC 2007 Assessment Report warns that over the next two decades a global warming of about 0.2^{o}C per decade is projected for a range of emission scenarios. The report also states that even if all the concentrations of the Green House Gases and aerosols had been kept constant at levels from the year 2000, a further warming of 0.1^{o}C per decade would be expected (IPCC,2007). Impacts from future climate change will be felt on ecosystems, food production, industry, settlements, society, health and water.

The following are some of the possible impacts that can be expected to be felt in Africa:

- By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change.
- By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition.
- Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10% of GDP.
- By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios(IPCC, 2007)

Increased populations in Africa are expected to experience water stress before 2025 mainly due to increased water demand (Bates *et al.*, 2008). Although figures show that

at the global level the increase of water demands and uses appears as being the dominant catalyst in what is largely seen as a looming crisis, it must be pointed out that the relationship of humans with water is largely defined at the local-level, with water being considered either as a resource or as an ecosystem (Kabat *et al.*, 2003). Many aspects of the impact of climate change on water resource availability remain uncertain based on aspects such as system complexity (climate, hydrological and socio-economic); assumption constrained models and restrictive impact assessment methods; and the difficulty in weighing up relative cause and effect influenced by possible reinforcing or mitigating effects of climate and non-climatic factors at a local-level. This makes future projections of water stress at national and sub-national level – whether this stress relates to physical or economic scarcity – problematic (Nicol and Kaur, 2009).

2.12 Climate Change and the Water Sector

Individuals may find it difficult to directly perceive climate shifts in freshwater and precipitation. However, shifts in climate that alter freshwater ecosystems have profound socio-cultural, economic, and ecosystem implications. These impacts are likely to grow in strength in coming decades and will have important implications for the living things dependent on that water and for the economic activities that rely on freshwater resources (Matthews and Le Quesne, 2009). Climate change therefore poses a major conceptual challenge to water managers, water resource users as well as to policymakers in general, as it is no longer appropriate to assume that past climatic and hydrological conditions will continue into the future. Water resources management clearly affects many other policy areas and thus the appraisal of adaptation and mitigation options needs to be conducted across multiple water-dependent sectors (Bates *et al.*, 2008).

Since climate change impacts are amplified in the water environment, there are also dangers that go beyond the immediate water sector. If the interaction between climate change and the water environment is not understood, strategies in other sectors to address climate change may actually aggravate problems and increase the vulnerability of communities and their environments to both natural and manmade calamities. This has already been seen in the rush to increase bio-fuel production, which compounded water stress and hunger in many regions (Sadoff and Muller, 2009a).

Indicators of water resources stress include the amount of water available per person and the ratio of volume withdrawn to volume available. Projections show, for example,

that 0.5 billion people could experience increased water resources stress by 2020 as a result of climate change. Case studies show that the impacts of different demands and operational assumptions by 2050 are greater than, or of similar magnitude to, the potential impacts of climate change (IPCC, 2007). Estimates of the cost of climate change must take into account measures used to adapt to that change, and the economic costs of climate change will depend on the adaptation strategies adopted. It is difficult to quantitatively estimate impacts of climate change on water resources systems. In addition, the IPCC report urges the importance of assessing the effects of climate change in the context of the water management systems that would exist in future in the absence of climate change (Kabat *et al.*, 2003).

According to the "Water for Growth and Development Framework" formulated by the DWA in 2009, the department has identified the following critical factors and impacts related to the implications of climate change on water resource management:

- While it is accepted that the major implication of climate change will the reduction in the availability of water, the department anticipates that the effects will not be evenly distributed across the country. The general projected trend will be wetter periods in the eastern coastal regions with increased intensity and periods of drought in the interior and western parts of the country.
- Higher variability in weather conditions is also expected in terms of higher volumes of rainfall resulting in flooding. This undeniably has a high risk for the spread of water borne diseases specifically in areas, which do not have suitable urban drainage to deal with increased flows.
- The reliability of assurance of supply will be jeopardised and will lead to increased operational costs of water supply from national dams and related infrastructure.
- Based on projections of increased evaporation due to temperature increases, the need to weigh the options between the constructions of new dams versus the enhanced use of groundwater resources will have to become a focal point in water resource management.
- An obvious consequence of the reduced flow in rivers will be the loss of dilution factors and assimilative capacity. This will result in increased consequences of health risk due to pollution caused by wastewater and effluent discharges.

2.13 Water Resource supply demand and management

Since climate change could affect water quality and availability, in order to adequately deal with this aspect, it vital that the governance structures and associated institutions

dealing with climate change and water resource management lend themselves to adaptability. Adaptation, as indicated by Adger *et al*. (2005) is reactive since it is largely triggered by past or current events, but it is also anticipatory in the sense that it is based on some assessment of conditions in the future.

Within the water resource management sector, the need to address the integration between water resource availability in terms of quality and quantity has therefore become, and will arguably become, more and more critical. Many initiatives have been undertaken by the national government to understand the problem of climate change and its implications on water resource management, as illustrated in preceding sections. Within this context the convergence of science, empirical data and knowledge management with political agenda setting, decision-making, socio-economic concerns and policy development is essential. The focus from institutional arrangements and the applications of only formal legislation and policies has to shift to holistic problem solving and management plan implementation (Rosenberg, 2007). An important challenge therefore, is to ensure that both water managers and climate professionals communicate with and understand each other, and also to relate these issues within the overall context of national development and other priorities for climate change management within the water sector (Kashyap, 2004).

Water demand management, that aims to regulate water withdrawals at sustainable levels through such measures as the promotion of sustainable use, pricing mechanisms, and water saving crop production techniques, will become increasingly important in areas where relative scarcity and competition between sectors is increasing. Supply side management will become a priority where inter-annual resource availability is likely to change significantly and where populations are more vulnerable. Supply side management, in general, involves increasing or augmenting the supply of water resources through increased storage capacity, abstraction from watercourse, rainwater harvesting and recharge activities and introducing incentives for water conservation (Nicol and Kaur, 2009).

The IPCC Technical Paper on Climate Change and Water states that water resource issues have not been adequately addressed in climate change analysis and climate policy formulations. Likewise, in most cases climate change problems have not been dealt with in water resource analysis, management and policy formulation (Bates *et al*., 2008). Based on this observation it is clear that there is a clear need to enhance the understanding of the effects of climate change on human and natural systems with the

greatest imperative being the responses of policy makers to climate change aspects and impacts at local and international levels (Nicol and Kaur, 2009).

2.14 Conclusion

"Adapting to climate change involves cascading decisions across a landscape made up of agents from individuals, firms and civil society, to public bodies and governments at local, regional and national scales, and international agencies" (Adger, *et al*., 2005).

Increasingly among environmental practitioners there is growing recognition that the lack of progress in improving and enhancing water management practices and policies will result in a failure to achieve societies' broader development goals. In response to this challenge, over the last several decades numerous practitioners and policy makers around the world have been evolving practices for water resources management that have aimed to achieve a balance among economic efficiency, social equity and environmental sustainability. These practices have collectively come to be known as the IWRM approach. While IWRM is widely acknowledged as the way forward – particularly in the face of emerging challenges such as climate change – there are still questions about how to translate policy commitments to IWRM into practice (Carriger, 2009).

Worldwide acceptance of integrated water resource management has recently gained greater momentum. The notion is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good. As a general rule IWRM encompasses quantity and quality aspects, surface water and groundwater, and competing demands. It should enhance the efficiency of water use, sustainable water utilisation patterns, water conservation, and waste minimisation. Judicious land use and landscape planning should play an important role in controlling water distribution, and reducing pollution and eutrophication of freshwater bodies. In order to manage water in the age of scarcity, accurate assessment of the available resource is fundamental (Kundzewicz, 1997).

Based on the vast amount of literature available on the subject of IWRM and the use of this concept to address the matter of adaptation to climate change in the water sector, it is clear that if IWRM is properly implemented, it could provide a framework within which the challenges related to water management in a highly variable environment can be addressed (Sadoff and Muller, 2009b). This concept is largely dependent on the existence and functioning of effective institutions. Within this context the following chapter provides an overview of the South African legislative framework as it pertains to water resource management.

CHAPTER 3 THE SOUTH AFRICAN SITUATION

3.1 Introduction

The greatest advantage of having suitable policies and strategies in place for enhanced holistic water management would be the ability to facilitate and implement adaptive and flexible management practices (Kabat *et al*., 2003). Lack of resilient management structures will result in disjointed initiatives by a myriad of governmental and parastatal organisations rendering the effective implementation of IWRM unfeasible and unattainable. The greatest challenge in this aspect is based on the lack of focused and targeted initiatives for effective water resource management and this aspect will need to receive greater attention for the formulation and successful implementation of policies and strategies. As Koch *et al.* (2007) observe that since climate change and adaptation are relatively new fields in South Africa, the specific roles and responsibilities are still in the process of being established. The fragmented nature of institutional management related to addressing the issue of climate change needs to be addressed as a matter of priority with clearly defined roles and responsibilities aimed at achieving a common national goal.

In this chapter, a focused assessment of the current legislative framework in the water sector in South Africa will be undertaken to gain an understanding of the context within which water management and associated strategies are developed and implemented.

3.2 South African Legislative Framework

3.2.1 The Constitution of South Africa of 1996

The South African state's commitment to adaptation is already imbedded in its Constitution in which it is stated that every citizen has the right to access to "sufficient food and water" (Ch 2 Bill of Rights, Section 27b) and that every citizen be provided with the right to an "environment that is not harmful to their …well-being" and to have "the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures" (RSA, 1996).

3.2.2 The National Climate Change Response Strategy of 2004

The National Climate Change Response Strategy (NCCRS) was published in 2004 by the Department of Environmental Affairs and Tourism. The NCCRS has the mandate of providing a roadmap for national climate policy based on the obligations to the Kyoto Protocol as well as publishing a National Adaptation Plan which focuses on vulnerable societies and threatened ecosystems and their associated goods and

services that support many livelihoods and maintain South Africa's environmental health and integrity (DEAT, 2004).

3.2.3 The Climate Change Research and Development Strategy of 2008

A Climate Change Research and Development Strategy with a 10-year vision have been developed by the Department of Science and Technology. This strategy aims at fostering/enhancing South Africa's knowledge on climate change impacts, overall awareness and capacity as well as resilience in response to climate change.

3.2.4 The National Water Act of 1998

IWRM is firmly entrenched in the South African National Water Act, No 36 1998 (NWA), which clearly declares "the need for the integrated management of all aspects of water resources and, where appropriate, the delegation of management functions to a regional or catchment level so as to enable everyone to participate" (DWAF, 1998). Consequently, IWRM is the guiding principle of societal, environmental and economic needs and constraints, now and under conditions of climate change. The NWA introduced several new concepts, and regulates all water-related aspects in South Africa based on these. The most important of these are as follows:

- The Act recognises the scientific indivisibility of water as part of the full hydrological cycle, and the water resource is deemed to be all water found in the various phases of this hydrological cycle, including that portion of the water found underground. This ensures that water is treated in an integrated manner.
- National Government, through the Minister of Water Affairs, is the public trustee of the water resource, and must establish a national water resource strategy for the protection, use, development, conservation, management and control of water resources.
- It introduces the concept of "the Reserve" which comprises that quantity and quality of water required to satisfy basic human needs and to protect aquatic ecosystems in order to ensure ecologically sustainable water development and use. The Reserve is intended to cater for the constitutional guarantee to all South Africans of the right of access to sufficient water for basic human needs.
- It recognises that the management of water must take place at the catchment level, which is the basic management unit for the water resource. It therefore provides for the progressive establishment of catchment management agencies (CMAs) by the Minister within the framework of the NWRS. The basic intent of the establishment of CMAs is to facilitate the delegation of the

management of the water resource to the catchment level and ensure involvement of the local communities in the management of the water resource.

- In the NWA, use of water is no longer limited to abstraction of water. Water use is described as a range of activities in relation to water such as storing water, disposing waste, discharging water containing waste, altering river banks and beds, recreation, etc.
- It provides for public consultation processes in the establishment of strategies and the making of decisions, and guarantees access to information as well as the right to appeal against decisions.

3.2.5 The National Water Resource Strategy of 2004

The objective of the 2004 National Water Resource Strategy (NWRS) is to take the National Water Act from legislation to a more practical implementation phase via obligatory IWRM, which is to be effected through institutions such as Catchment Management Agencies and Water User Associations. Climate change features in the NWRS in the recognition that the interdependence of land use and climate change is seen as a critical factor with respect to resource availability (NWRS, 2004). Climate change is viewed in the NWRS as a cause of changing patterns of the water cycle by magnitudes and in variability as yet unknown. It is anticipated that the update of the NWRS will be more specific on issues of climate change in the water sector (Schulze, 2008).

There is a complex set of institutional relationships that govern the water sector, involving a myriad of organizations fulfilling different roles and functions. Problems and challenges experienced in the sector are in part a consequence of these multiple institutional layers and the associated risks of performance failure by any one party as depicted in Figure 6 (DWAF, 2009).

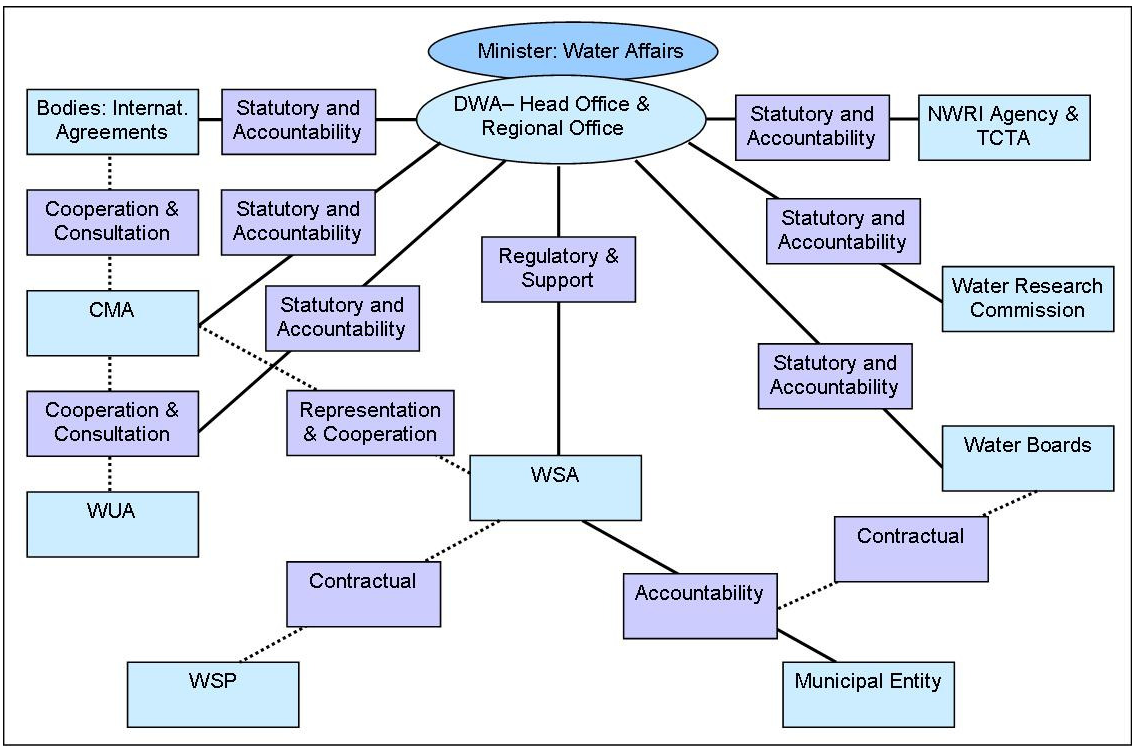

Figure 6: Institutional Arrangements in DWA (adapted from DWA, 2009a)

Figure 6 illustrates the institutions that are major role players in the water sector, and that are part of the transformation of the water sector. The respective roles and responsibilities are as set out in the various policies and legislation, including the following:

- CMAs are responsible for the management of water resources at catchment and water management area (WMA) level;
- Water User Associations (WUAs) consist of an association of water users that operate within a given allocation of water at a localised level;
- Water Services Authority (WSA) implies a municipality with powers to ensure delivery of water services;
- A municipal entity is a public entity at municipal level intended to carry out a municipal mandate; and
- Water Services Providers (WSPs) are organisations that provide water services on behalf of the WSA.

The NWA also recognises that, in order to implement international agreements, specialised institutions may need to be created for this purpose, as well as institutions of support to the DWAF's mandate. In this regard, the NWA gives the Minister power to establish bodies to implement international agreements when the need arises. To the extent that it may not compromise its primary objective, the NWA gives the Minister the power to direct such a body to carry out additional functions. Regional cooperation

is important because South Africa shares four major river basins (± 60% of land area, ± 40% of total runoff) with six neighbouring countries (DWAF, 2004).

In addition to the entities mentioned above, nine regional offices (one in each province of the country) are responsible for water resource management and water services provision. These regional offices also deal with forestry issues in the northern, eastern and southern parts of the country (DWAF, 2009a).

3.3 Climate Change and Policy Implications in SA

An initial framework for the development of planning strategies to facilitate adaptation to the impacts of anticipated climate change and the associated potential variability in water availability has been developed for South Africa following a series of workshops with water resource managers, water policy makers, consultants, agricultural experts, environmentalists, socio-economists and other scientists (Schulze, 2008). This framework is essentially comprised of the following aspects:

- Three time frames
    - Long-term – strategic level options
    - Medium-term – tactical
    - Short-term - operational
- Three sets of needs
    - legal and policy – based on the need to revise the NWRS to be more robust in terms of climate change and placing more emphasis on effective risk management policies;
    - institutional and management – largely related to the establishment and functioning of effective Catchment Management Agencies which are also more climate aware; and
    - information, research and monitoring – based on the availability of information, building capacity in climate science and the use of improved climate and hydrological models.

Kabat *et al.* (2003) stress that while most states and regulatory authorities acknowledge that climate change will impact on resources, most governments and associated policy and water management systems have not met the challenge of responding to the impacts based on the limited implementation of sustainable and adaptive management measures. This lack of pro-active and innovative measures is clearly evident in the South African situation based on the DWA's view that "the

Department's potential impact on mitigation of climate change is relatively small, and probably lies most in leveraging other government departments that have a greater impact on carbon emissions" (DWAF, 2009a; pp 21).

Climate change affects the function and operation of existing water infrastructure as well as water management practices. Extreme wetting and drying cycles could compromise the integrity of the water and sewage pipelines, resulting in cracks and failure and the stressing of water infrastructure. Higher rainfall and intense flood events could also result in excessive siltation in dams and estuaries (DWAF, 2009a). Current water management practices are very likely to be inadequate to reduce the negative impacts of climate change on water-supply reliability, flood risk, health, energy and aquatic ecosystems (Bates *et al.*, 2008). It is therefore critical that reliable information is available or sought through adequate research initiatives in order to inform policy and strategy which needs to be formulated to facilitate adaptation to climate change.

3.4 Demand Management and Adaptive Water Management in SA

In many countries around the world and in particular in South Africa, access to safe drinking water is a basic right that is enshrined in the constitution (RSA, 1996). Despite this, there are many challenges that are experienced in the provision of water services. The challenges experienced range from lack of availability, disproportionate demand due to skewed population growth, concentration of urbanisation in certain areas and governance issues related to water management. Generally, most of these challenges do not have any bearing on climate change which is another challenge placed on the already over-burdened shoulders of governance structures. Difficulty is also experienced in the actual identification of impact climate change impacts at local-levels and there is therefore a greater reliance on observations and projections to prepare and plan for future requirements (Bates *et al.*, 2008).

As a general trend, water quality and quantity data are collected in compliance to regulatory requirements and for purposes of strategic and operational management. Kabat el-al (2003) point out that in contrast, information related to climate is generally collected for scientific purposes. As a result there is a high degree of fragmentation in the collection, reporting and management of relevant data. This fragmentation is not only observed in different sectors but is also apparent in regions and countries.

Kabat *et al.* (2003) and Muller (2007) point out that substantial evidence exists to demonstrate the effectiveness of incentive based encouragements to assist with implementation of measures to facilitate substantial reduction in consumption.

Traditionally the most common practised for m or water management can be described as a “prediction and control” regime (Pahl-Wostl, 2002). This form of management is generally characterised by mechanical assessments in which system activities and reactions and responses can be envisaged or calculated and used for the design and development of the best possible control strategies. Therefore, the information needs are defined in terms of the requirements as specified by technical experts. The main data collection and regular monitoring focuses on the state of the environment in response to regulatory requirements and compliance criteria. Knowledge is not shared and communication with stakeholder and interest groups is mainly by passive channels (Pahl-Wostl, 2007).

In order to enable a system to adapt to change or to be prepared for future changes which are neither easily quantified nor understood, Pahl-Wostl (2007) stresses the importance of two key aspects as critical:

- The constant availability of new information and the ability to process, understand and address the interpretations of the information is essential in facilitating adaptation.
- The availability and understanding of new information is pointless if a system lacks the ability to adapt to the changing conditions prescribed by the new information.

By the very nature of the word, adaptive systems cannot be controlled by a central element, but rather need to be comprised of components of self-regulation with a fair measure of disseminated control. This kind of system proves itself more flexible and amenable to the efficient distribution of resources to many users (Pahl-Wostl, 2007). While persuading users to use the available resources more efficiently and wisely is a vital facet of demand management (Muller, 2007), Pahl-Wost (2007) warns that such strategies, if not managed adequately within the context of social impacts, can have severe implications in terms of responses to change and in particular for the development of management and mitigation strategies. In order to implement a system based on such incentives it is essential that the key factors of the water system as well as the integration of various elements are identified and clearly understood.

In essence, the proper development, implementation and enforcement of demand-side management measures will propel such initiatives in the desired direction. Possible demand-side measures could include initiatives such as:

- Beneficial land use methods;
- Integrated catchment management;

- Rainwater and grey water harvesting;
- Recycling;
- Water allocation strategies;
- Water conservation and water demand management strategies;
- Market-based incentives;
- Rebate schemes; etc

Gleick (2003) promotes the application of a “soft path” to facilitate improved flexibility and better understanding of information needs in terms of requirements for developing adaptation strategies. This approach will allow effective strategy formulation in water management regimes to address the mounting insecurity and challenges posed by global change. Based on the undeniable fact that the various components of a water management system are intrinsically linked, the fundamental point made by Gleick implies that an elementary paradigm shift from a “management as control” approach has to be replaced by “management as learning” (Pahl-Wostl, 2007) if any strides are to be made in effective integration of the various elements in the water regime.

3.5 Conclusion

Based on the assessment in this chapter it is clear that a sound policy framework does exist in South Africa to support water resource management and facilitate integration with other environmental aspects such as climate change. In order to test the actual applicability of the available regulatory resources in real-time situations, the development of the City of Johannesburg Water Conservation and Water Demand Management Strategy was assessed within the context of this legislative framework and the concepts of IWRM and AWM. The following chapter provides an indication of the fit between these concepts and the actual process, which was followed during the development of the CoJ WC/WDM Strategy.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Introduction

Within the context of climate, the convergence of science, empirical data and knowledge management together with political agenda setting, decision-making, socio-economic concerns and policy development is essential for effective water resource management and planning. The focus from institutional arrangements and the applications of only formal legislation and policies has to shift to holistic problem solving and management plan implementation (Rosenberg, 2007) in order to ensure that actual integration takes place between policy development and implementation of resource management measures such as conservation and development plans and strategies.

The hypothesis underpinning this research presented here is that the efficacy of South African institutional arrangements, most notably their flexibility related to water resource management, will be critical for adaptation to climate change challenges pertaining to the variability of water availability. The critical aspects that will influence this flexibility will be related to the effective integration of interdependent sectors as well as the need to ensure that there is active and meaningful stakeholder participation. To examine this call, the research for this project focused on the following aspects:

- Investigating whether the South African legal framework can support the development and implementation of adaptation measures for climate change impacts in the water sector;
- Obtaining a better understanding of the strategic management interactions and interventions in the water sector that have been designed to better 'manage' water; and
- Assessing whether the key principles of IWRM such as sectoral integration, supportive institutional structures and adaptive social learning can be effectively applied in the South African context.

The integration or correlation between National Strategies and local implementation was addressed in terms of examining Water Conservation and Demand Management approaches and assessing the effectiveness of these approaches in addressing climate change risk factors in the water sector ranging from national to regional levels. The applications of the concepts of IWRM and AWM as explained by Pahl-Wostl (2002, 2005, 2007), Pahl-Wostl *et al* (2007), Muller (2007) and Sadoff and Muller (2009), were thus tested in a real-time project, which entailed the development of a

Water Conservation and Water Demand Management (WC/WDM) Strategy for the City of Johannesburg.

This chapter will examine the key imperatives driving the development of the CoJ WC/WDM Framework Strategy and provide an indication of the fit of local processes with international design requirements emerging from WRM and AWM. The following overview summarises the findings of the study, and engages on some of the key IWRM elements, as identified in Chapter 2.

4.2 Results

The main intention of this research project was to assess whether the critical aspects of IWRM and AWM such as (i) sectoral integration, (ii) supportive institutional structures and (iii) effective and participative social learning can be effectively applied in the South African context particularly when considering climate change.

The steps which were followed in the execution of the project in terms of facilitation of active stakeholder participation to support social learning and institutional change were guided by the recommendations made by Pahl-Wostl (2006) as follows:

- Stakeholder analysis based on documentation and organisational structures within the CoJ was used to identify the relevant stakeholders for the participative component of the project.
- Using the workshop settings as discussion platforms, an emerging shared perception of the problem statement pertaining to variability of water availability was created by fostering communication among the various actors representing their specific sectors within the CoJ. While no attempts were made to seek consensus on identification of key focus areas and action plans and priorities for the WC/WDM Strategy, differing views were recognised.
- The workshops were also used to develop a priority list and identify specific actions to address the priorities.
- The action plan developed was linked to institutional responsibility with financial aspects also taken into account.

The tasks undertaken were part of a project that was conducted by ILISO consulting for the CoJ[5]. This project essentially entailed the development of a WC/WDM strategy

[5] At the time that this research project was undertaken, the author - K. Pema – was employed as an Environmental Manager at ILISO Consulting. The project team was comprised of a Strategic Specialist, 2 Water Services Experts and a Water Resource Manager. The role of the Water Resource Manager was undertaken by K. Pema

for the CoJ in order to comply with the national imperative issued by the DWA requiring a 15% reduction in water consumption. The major component of the WC/WDM strategy development project was centred on effective participation and stakeholder involvement using workshops as a medium for stakeholder engagement. The project methodology made provision for two stakeholder engagement workshops which would follow the baseline assessment phase in order to obtain insight from the participants on key focus areas and priority areas for action. The workshops were based on an open-discussion approach and were used to stimulate discussion and debate amongst the participants in order to obtain an understanding of the application of IWRM principles as well as the practicability of strategic interventions.

The work flow for this process although not a direct match to that suggested by Pahl-Wostl *et al*, (2007a), has similarities in design to flow design used by Pahl-Wostl and others. Tasks 1, 2, and 3 of the WC/WDM project (Figure 7), essentially the literature survey, baseline assessment and the planning and consultation components of this research, for example, correspond with the initial tasks of the structural change cycle.

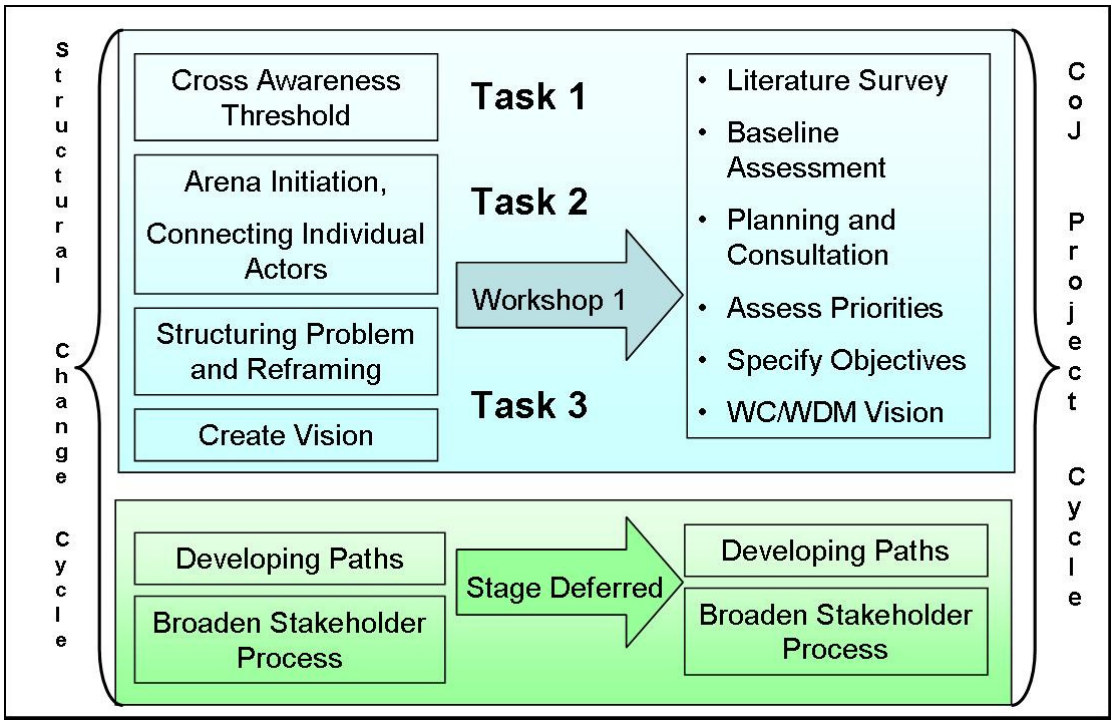

Figure 7: Project Tasks 1, 2, and 3 in the structural change process

The initial steps of the structural change cycle are focused on assessment of existing knowledge and using this knowledge to create a platform for integration amongst the different sectors involved (Pahl-Wostl *et al*, 2007).

Based on the stakeholder workshop and the discussions around the key focus areas as well as the identification of priorities, the main focus of Task 4 was to define the

objectives which would form the basis of the WC/WDM strategy which would be developed at the end of the process. Task 4 bears a close relationship to the strategy and action plan development phase of the structural change cycle (Pahl-Wostl *et al*, 2007a) as shown in Figure 8 below.

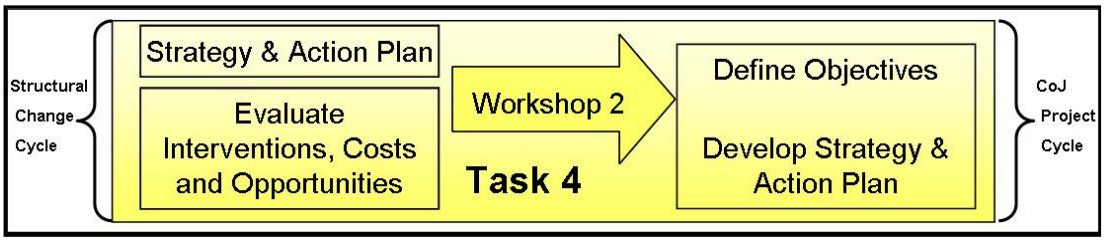

Figure 8: Project Task 4 in the structural change process

In essence, it can be said that the process followed in the CoJ WC/WDM strategy development conforms to the overarching structural change process used by others. A key consideration of this project however, was to assess the "fit" (Young, 2002) of South African process to the key aspects related to IWRM namely, integration, institutional support and social learning, each of which is discussed below.

1. Sectoral Integration

Various sectors within a country and within a specific region or catchment area are interdependent and affect each other in terms of water resource management. The integration of these sectors which impact on water resources (Stuart-Hill and Schulze, 2010) is critical in developing an effective strategy for adaptation to climate change challenges. The convergence or divergence of stakeholder perspectives and views are thus critical factors (Pahl-Wostl, 2006) in determining the success or failure of a management process. Thus the need for integration within an organisation such as the CoJ is deemed to be vital for successful implementation of IWRM for effective and flexible water resource management.

In order to ensure integration, a concerted effort was made to identify relevant departments within the CoJ that would be affected by the WC/WDM strategy. The participants who were invited to the workshops were identified through discussions with the project managers in the Environmental Management Department of the CoJ. The list of participants with an indication of the Department represented is provided in Table 2 below.

Table 2: List of participants[6] at both workshops

Participant	Department	Workshop 1	Workshop 2
Participant 1	CoJ - Environment	✓	✓
Participant 2	CoJ - Environment	✓	✓
Participant 3	CoJ - Environment	✓	✓
Participant 4	CoJ - Environment	✓	✓
Participant 5	CoJ - Environment	✓	✓
Participant 6	CoJ - Environment	✓	✓
Participant 7	CoJ: Climate Change	✓	X
Participant 8	CoJ : Share Holders Unit	✓	X
Participant 9	CoJ: Central Strategic Unit	✓	X
Participant 10	CoJ – Housing	✓	X
Participant 11	CoJ – Department of Economic Development	✓	✓
Participant 12	CoJ – Legal and Compliance	✓	X
Participant 13	CoJ – Budget Office	✓	X
Participant 14	CoJ: Regulatory Services	✓	✓
Participant 15	Joburg Water – Operations	✓	✓
Participant 16	Jhb – City Parks	✓	✓
Participant 17	Jhb – Roads Agency	✓	✓
Participant 18	Jhb – Roads Agency	✓	X
Participant 19	Jhb – Roads Agency	✓	X
Participant 20	DWA: Gauteng	✓	X
Participant 21	DWA: Gauteng	✓	X
Participant 22	Consultant	✓	✓
Participant 23	Consultant	✓	✓
Participant 24	Consultant	✓	✓
Participant 25	Consultant	✓	✓
Participant 26	Consultant	✓	✓

✓	Present
X	Absent

[6] As per the requirements of the ethical considerations, the names of the participants are withheld.

It is clear that the group of participants present at the workshops represented a range of interdependent Departments within the CoJ. In order to ensure continuity, the same participants were invited to both workshops. Some participants, however, failed to attend both workshops. In addition, the participants' distribution graph as depicted in Figure 9 below clearly indicates that the participant group was skewed in favour of the Environmental Department (this is perhaps not all that surprising given that this Department is the 'custodian' of climate change matters). This aspect together with the fact that all participants did not participate in both workshops indicates that there is still a long road to travel to ensure the holistic development and implementation of the WC/WDM strategy.

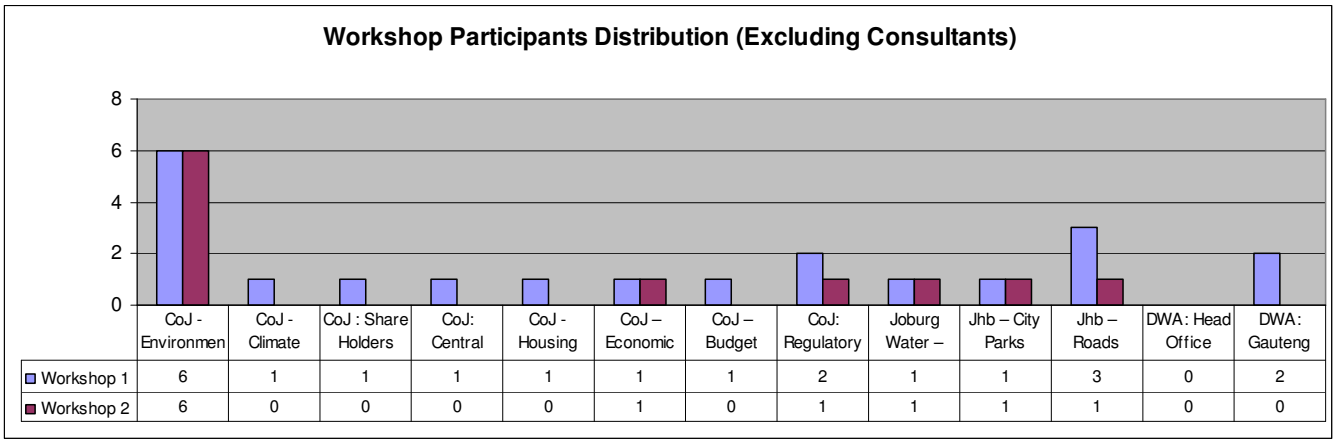

Figure 9: Distribution of workshop participants

This lack of integration can be attributed to the fact that the CoJ lacks the organisational structure which could provide a platform for addressing over-arching aspects such as climate change, water use, water demand management, water availability etc. The lack of an overall coordination and supportive component for over-arching aspects, which is critical for effective integration, is evident in the management structure of the CoJ: Environment Department at the time when the WC/WDM Strategy project was undertaken as depicted in Figure 10 below:

It must be stressed that although it is generally accepted that consultants can be very influential in debates and discussions, during this process specific emphasis was placed on the fact that the consultants were strictly present to facilitate the discussion amongst the officials present. Focus was therefore placed on the inputs received from the officials.

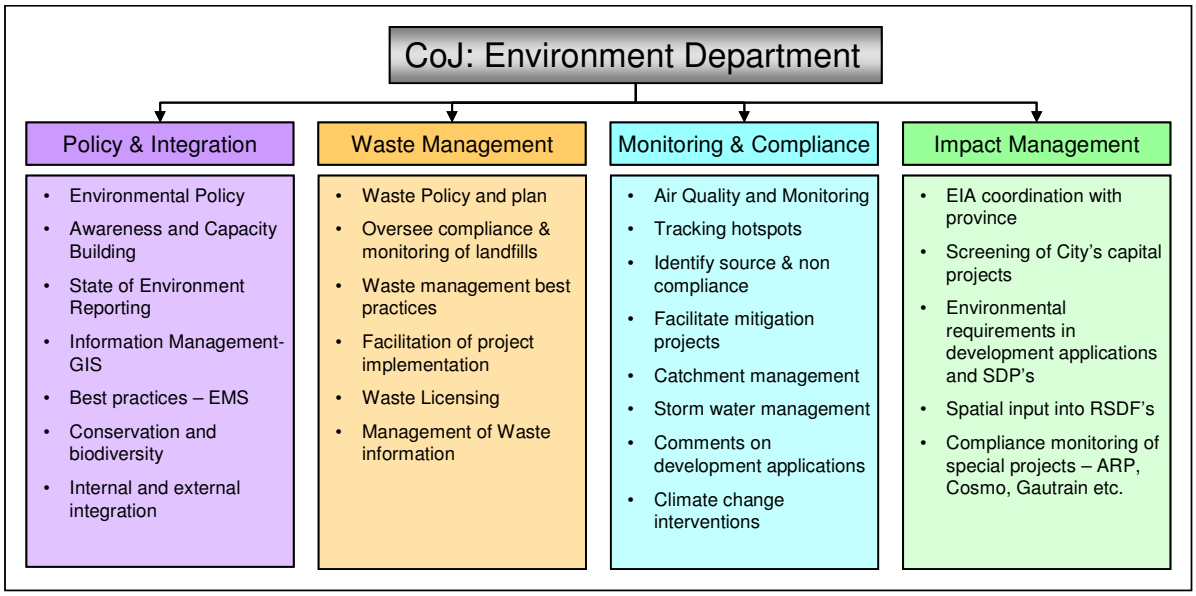

Figure 10: Structure of CoJ Environment Department (Source: CoJ Environment Presentation)

Based on the above structure "Climate Change" as a functional component has therefore been tacked onto an existing unit and resides within a functional group focused on monitoring and compliance which is a largely demanding task. Therefore the attention and focus required for addressing climate change and the associated risks to the environment and water availability, in particular, is diluted.

Another essential aspect is that the pressures placed on local governance structures by national policy makers often compound the challenges already being experience at local-levels. As mentioned by a senior city official, Departments within the CoJ deal with a vast array of needs based issues such as housing, population growth, unemployment, urbanisation, sanitation, health, transport etc. in addition to environmental management aspects. In the larger scheme of things, the impacts of changes in climate are often seen as minor and more distant and attention is therefore prioritised on more visible and immediate problems. Thus the functional "add-on" of climate change aspects is simply seen as an additional burden with limited immediate consequences and is therefore sidelined.

2. Supportive Institutional Structures

In order to ensure that there is effective integration, it is imperative that the requisite institutional structures required to facilitate the trade-offs (Muller 2007; Sadoff and Muller 2009), encourage co-operation and ensure implementation are in place. The institutional support needs to be in the form of strategic guidance and assistance in execution from a practical as well as financial and resource perspective. Strategies

and policies developed by relevant institutional organisations are vital to provide the support structures for implementation of actions at local-levels.

While undertaking the literature survey, focused on the South African legislative framework, attempts were made to obtain strategy and policy documents from the DWA and associated institutions such as the Water Research Commission and the council for scientific and industrial research. The lack of available strategy and policy documents was borne out by senior officials at national as well as local-levels, who acknowledged that there is no formulated or published strategy specific to the water sector, which can be used to inform local initiatives for adaptation and mitigation to climate risk within the sector. National representatives responsible for policy development further indicated that the DWA (at the time of the enquiry) does not consider climate change to be a part of its strategic function but merely sees its role as a contributing authority to a national strategy. The consensus is that the responsibility is vested in the DEA. The irony is that since the elections in 2009, the DWA and the DEA now fall within the jurisdiction of a single ministry. However, there is still widespread fragmentation in functional responsibilities.

During the development of the WC/WDM strategy for the CoJ, the DWA was considered to be a key role-player from a strategic point of view in terms of providing guidance and a supportive institutional framework. Therefore, specific representatives of the National as well as Regional Offices of the DWA were identified and invited to the planned workshop. As evident in Table 2, which indicates the representation at the workshop, Participants 20 and 21 represented the Gauteng Regional Office of the DWA. National representatives were not present despite having received timeous invitations to the workshops.

While it could be argued that the presence of Participants 20 and 21 at the initial workshop provided some strategic institutional support, this was not borne out during the execution of the workshop. Both DWA participants were junior officials with no strategic experience since both had only been employed in the DWA for less than a year. The discussions undertaken in the first workshop were based on strategic level objectives which would inform the WC/WDM strategy and the input of national government from a strategic perspective would have been valuable. This input was not forthcoming since both Participants 20 and 21 did not actively participate in the discussions and based on their lack of experience failed to provide any strategic guidance.

Another critical aspect which demonstrates the lack of institutional support is the fact that the Upper Vaal CMA has not yet been established. As mentioned previously, South African legislation requires the establishment of a CMA for each of the 19 water management areas in the country. Currently the DWA is revising this policy based on a need to identify the feasibility and viability of 19 CMAs from a financial as well as resource perspective. Further establishment of CMAs has been placed on hold until the feasibility and viability aspects have been addressed (DWAF, 2009c). The responsibility of a CMA once it has been established is "to manage water resources at catchment level in collaboration with local stakeholders, which specific focus on involving local communities in the decision-making processes, in terms of meeting basic human needs; promoting equitable access to water and facilitating social and economic development" (DWAF, 2009c – pp 7). Based on this description it is quite clear that a CMA would be an effective institutional structure for facilitating IWRM. Delays in the establishment of the CMA for the Upper Vaal Water Management Area within which the CoJ is located are detrimental to implementation of effective IWRM.

3. Social Learning

The very nature of IWRM is characterised by an ongoing process of learning and adapting (Pahl-Wostl, 2002 and 2007; Pahl-Wostl *et al* 2004; Pahl-Wostl and Sendzimir, 2005) and the constant engagement of stakeholders and capitalisation of local knowledge are essential for effective IWRM. During the planned workshops, the intention was to divide the workshop participants into groups to facilitate identification of key priorities and group these into key focus areas. This approach would conform to the clustering approach as proposed by Pahl-Wostl (2006). This approach essentially requires participants to write down priorities from their perspectives on a piece of paper. Each priority would be written on a separate paper. Once all the participants had completed this task, all the priorities identified would be grouped into similar categories, each of which would be identified by a common over-arching description (Pahl-Wost, 2006). These descriptions would then become the key focus areas.

However, the approach of group break-away or individual priority identification was not supported by the participants. Participant 1, a senior level manager in the Environment Department of the CoJ, expressed the view that such a process would require substantially more time than the participants had available. Participant 9, a senior official from the Central Strategic Unit of the CoJ, strongly supported this view and suggested that the workshop should follow an interactive discussion format. Several other participants supported this approach and it was agreed that the identification of

priorities and key focus areas would be done on an interactive discussion basis, in plenary and not in break-away groups.

Participant 9 also stressed that a critical aspect to be considered in water demand management specifically at local-levels, is the demand placed on resources by factors such as population growth, rapid urbanisation and increasing development. Participant 2 emphasised the fact that the environmental management unit is constantly faced with the ongoing challenges of water pollution, exotic invasive species, negative impacts on land-use due to development pressures and non-point sources of pollution. Kabat *et al.* (2003) highlight the fact that while the ongoing challenges of water resource management are further exacerbated by increased temperatures linked to climate change, most local authorities experience increasing demands for resources based on demographic and economical factors which are often perceived to be more severe that imminent than climate change impacts. Trying to find effective ways to include such considerations thus remains an ongoing challenge.

As a way to help steer the workshop, participants focusing on identification of priorities for the development of the WC/WDM strategy were also asked to rank several listed aspects in order of priority. The ranking was determined after participants were given the opportunity to discuss and debate each of the following aspects:

- Economy – in terms of providing job opportunities and contributing towards poverty alleviation. In essence the discussions centred on pro-poor strategies and economic incentives.
- Climate Change – as an overarching aspect which would impact on almost all functional areas of the CoJ. Participants clearly understood the importance of addressing climate change. The consensus, however, was that while climate change impacts needed to be addressed, the CoJ needed to focus more effort and resources on addressing immediate challenges such as growth, development and job creation. The potential linkages between CoJ and development was clearly not perceived or understood.
- Management Aspects - pertaining to institutional support and structures that will facilitate the development and implementation of the strategy. The discussions highlighted the fact that institutional support is weak and that the current structures need to be strengthened. Most participants agreed that political will would be needed for the implementation of the strategy. The low ranking attributed to this aspect was due to the fact that the participants felt they had limited influence over this aspect.

- Water – as a key factor for the CoJ in terms of WC/WDM and growth and development was also prioritised. It was agreed amongst the participants that without adequate water resources in terms of quantity as well as quality the CoJ's growth and development goals would not be achieved.
- Growth and Development – in terms of providing an environment which will be attractive to entrepreneurs and businesses. The participants clearly expressed the view that growth and development was a priority for the CoJ specifically as it was closely linked to providing job opportunities and contributing towards poverty alleviation.

The graph below represents the results of the participant ranking of the identified priorities in terms of the degree of importance for the CoJ strategic vision. The results clearly indicate that climate change does not feature as a major priority although it was previously identified as an aspect that will need to be addressed for long-term development scenario planning. The links between climate change and development requires much more consideration, discussion and advocacy (IPCC, 2007).

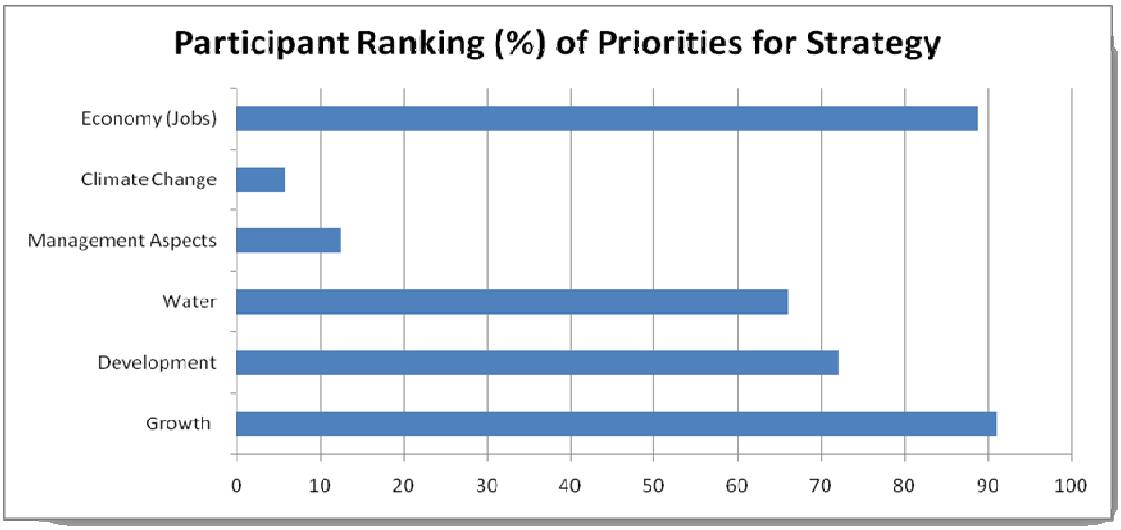

Figure 11: Participant ranking of priorities for WC/WDM strategy

The view that climate change is not being addressed as priority but rather as an add-on function is clear in the WC/WDM Strategy formulation process when climate change initiatives were not identified as a high ranking key focus area as indicated in the graphical representation above. The perception that climate change is not considered to be an overarching aspect for city managers is further highlighted by the fact that the invitations to the workshop were declined by some departmental heads on the basis that the theme of the workshop is not directly relevant to their specific mandates.

In essence the workshops failed to achieve integration amongst the various sectors which were identified as relevant for the development of the WC/WDM strategy for the CoJ. This was largely based on the fact that there was a lack of understanding of the importance of climate change, and the links to climate variability and the resultant consequences of failure to take action. It was clear that there is a dire need to facilitate capacity building of managers on the impacts of the climate change on water resources and the resultant impact on all related sectors within the CoJ such development, planning, transport, roads etc.

4.3 Discussion

4.3.1 Climate Risk in the Water Sector

The driving factor behind the development of the CoJ WC/WDM Framework Strategy was essentially the imperative by the National Department of Water Affairs to reduce water demand within a very limited timeframe. The Vaal WC/WDM Report (DWAF, 2006) determined that Rand Water is consuming the largest volume of water in the Middle Vaal River Water Management System of which Johannesburg uses 36% of the total water allocated. This water is largely used for urban and industrial purposes. Further, the study indicates that there is a critical need to reduce water demand in Gauteng Province in order to ensure that there is sufficient water available for future needs. The projections indicate that Gauteng will experience severe water shortages by 2013, which is 6 years ahead of the 2019 implementation target for Phase 2 of the Lesotho Highlands Water Scheme. As a result, the DWA expects Gauteng Province to achieve a 15% reduction in demand by 2013. This requirement has place an obligation on all municipalities in Gauteng to implement WC/WDM strategies to achieve the target set by the DWA (DWAF, 2008).

An effective means of achieving required conservation targets is to encourage efficient use at all levels from governments, businesses to local households (Sadoff and Muller, 2009b). Such initiatives will only prove to be effective if they are supported by sound regulatory and incentive based strategies. Thus, the development of a robust framework, which supports national imperatives, needs to be developed at local-levels. This approach was adopted in the development of the CoJ WD/WDM Framework Strategy.

4.3.2 Supportive policy framework

Setting up the proper institutional framework is the first step towards IWRM (Kabat *et al.*, 2003). With the advent of democracy in 1994, South Africa embarked on an

extensive water law reform process, which is today considered to be a superior modern legal and policy framework with corresponding changes in national water organizations. Progressive concepts in terms of user rights, allocations, delegation of management and responsibility, institutional reform and public involvement have laid the foundation for a robust and dynamic legislative support. The major challenge experienced is the disproportionate stages of climate change adaptation and links to such water policy at different levels of government. Saleth and Dinar, (2005) surmise that this inconsistency can be explained in terms of the dual pressures of nationwide political, social and economic reform as well as the implementation of broad based empowerment initiatives. In essence the critical challenge with this aspect is that of determining and assigning roles, responsibilities and ultimately accountability.

In the South African context specifically in addressing the risks in the environmental management field, the greatest challenge currently experienced is the serious lack of institutional mechanisms to facilitate the actual management of risks. While the international awareness of climate change has been around for some time, South African government agencies and citizens, do not have access to a cohesive national policy framework which should provide all levels of society with an indication of government's priorities and the individual's level of responsibility in achieving national goals.

4.3.3 Institutional arrangements

Sound strategic management and policy development, for the implementation of actions required to aid successful adaptation to the impacts of climate change on water resources, are dependent on the existence and support of suitable institutional capacity. It is therefore critical that the development of adequate institutional capacity should be considered to be the fundamental aspect of facilitating successful adaptation to climate change in the water resource management regime (Kabat *et al.*, 2003). With the increasing prominence of climate change impacts and the emerging awareness of the lack of suitable adaptation strategies, there are greater demands for competent water management institutions as well as their monitoring and information collection components (Sadoff and Muller, 2009).

Currently within the water resource management sector, information management is not conducive to addressing the challenges of current impacts easily and will need to be strengthened to tackle future solutions. In most cases the need to address aspects such as control and monitoring of illegal water use, enforcement of compliance of licensed use, monitoring of the resource for physical and bio-physical changes,

pollution control, etc (Kabat *et al.*, 2003) is severely limited in terms of knowledge and budget cuts imposed in response to financial pressures.

Adaptation to climate change will continue to remain a challenge until such time that more resources, in human and financial terms, are made available for the efficient operation of water management institutions. Participants of the workshops indicated that the current situation in government structures at local as well as regional and local-levels is exasperated by high staff turnover rates, which result in loss of institutional memory. Sadoff and Muller (2009) maintain that it is essential for management institutions to provide the platform for the interactive engagement of water users and water resource managers to enhance the ability to understand and respond to the emerging challenges. This facility and platform is not easily available in the local sense, which further exacerbates the co-operative governance requirements placed on governmental agencies.

City officials indicated that the perception at local-levels is that there is a general lack of support from national government in terms of finances as well as technical advice related to water conservation measures, initiatives and projects undertaken or planned for climate change adaptation. This was highlighted as a critical aspect by a departmental manager based on the fact that despite timeous invitations, National DWA officials failed to attend both workshops and the Project Steering Committee meeting for the WC/WDM Strategy development for the CoJ. The absence of DWA officials necessitated a separate discussion with relevant officials in the absence of city officials. City officials took objection to this approach since it deprived them of an opportunity to engage in robust discussion with national government.

As mentioned by a senior DWA official in, the current staff turnover rate within the Department is approximately 33% resulting in a constant flow of personnel into and out of the department. Therefore the essential experienced technical support at operational and strategic levels required to build institutions, access and use information to predict, plan for and mitigate the impacts of climate variability is scarce.

4.3.4 Fragmentation of responsibility

The very nature of water and the associated management structures and interfaces with various facets and organisations, not least those focused on development priorities, makes it impossible for resource managers to function efficiently in an environment of fragmented institutional systems plagued by ineffective intra and inter organisational communication (Schulze, 2008). The situation is further exasperated by

the lack of transparency in decision-making, inadequate public involvement processes and the overarching umbrella of lack of sufficient financial support for planning and implementation (Kabat *et al.*, 2003). Climate change places an additional challenge on the management of the impacts on water resources since traditionally the institutional framework for environmental governance has been founded on a chain of command model. Conversely climate change is characterised by a large interface of several processes and systems which involves various institutions operating at a variety of scales (Koch *et al.*, 2007).

The current institutional framework within which water resource management is expected to function, in South Afrcia, is largely flawed based on the fragmented responsibilities for environmental matters. The lack of integration and interaction between functional areas such as water supply, water quality, environmental management, development and planning, disaster management etc. has resulted in the creation of a higher degree of specialisation with institutions. While this sort of progression allows for dedicated focus on a particular aspect, it also prevents integration, interaction and adaptation (Pahl-Wostl, 2007). As Kabat *et al.* (2003) point out; aspects that will foster and strengthen adaptive management include enhanced co-ordination based on cultivating co-operative management and assignment of responsibilities amongst the different entities based on catchment boundaries rather than administrative units. This is a critical aspect if matters such as climate change are to be addressed as an overarching aspect.

4.4 Conclusion

Kabat *et al.* (2003) observe that many developing countries view vulnerability to climate change as a problem, which will need to be addressed in the future since the effects are not distinctly visible in the present scenarios. The DWA, which bears the overall responsibility for water resource management in South Africa, accept that climate change is an accepted global reality but further believe that in South Africa the impact is not yet obvious (DWA, 2009).

Within the South African context IWRM can be a useful tool to facilitate equitable and sustainable social and economic development with the aspect of climate change merely adding another layer of complexity to an already complex management of water resources (Schulze, 2008). Presently in South Africa, climate change can be viewed as an added uncertainty, with impacts that can be mitigated. The DWA believes that the relatively gradual nature of climate change allows time for well-considered adaptation measures. The Department also stresses that the continuous

rigorous monitoring of rainfall and runoff and an improved hydrological monitoring network are essential to ensure that the actual effects of climate change are measured accurately and brought as quickly as possible into the analysis of resources (DWA, 2009).

The clear indication in the policies of the government is the focus on issues related to population growth, economic development, HIV/AIDS and lack of investment in water infrastructure (essentially drinking water and sanitation facilities), rather than on climate change. As a general trend, most water resource managers have already been dealing with some form of natural climate variability and climate related hazards such as droughts and floods. Climate change does not necessarily factor as a new requirement in the strategies that they are already working with or developing. However, an important consideration that water resource managers must take into account is that climate variability may be increasing and the associated variability in water availability will have to be factored into scenario planning and disaster management strategies (Schulze, 2008).

The risk of primarily focusing on physical and ecological modelling is that the identification of responses to climate could be limited to simply developing a list of impacts and responses. The focus should rather be placed on vulnerability assessments, which would factor in flexibility, long-term scenario planning and adaptive management (Pahl-Wostl, 2007). The GEO4 Report (UNEP, 2007) stresses that even if suitable information is available and response strategies and adaptive measures have already been implemented, ongoing monitoring is critical to assess the progress and achievement made towards achievement of set goals and targets. The system implemented should be assessed, re-evaluated and re-designed if required based on monitoring information.

Vulnerability assessments generally address the actual and potential impacts of climate change on human populations and natural systems and are a good indicator of the limits of knowledge and the identification of areas where knowledge and information gaps exist. Kabat *et al.* (2003) emphasise the role of such assessments in ensuring that institutional arrangements are implemented to ensure that vulnerability assessments and the dissemination of that knowledge become integral components of the planning and management functions of relevant institutions. It is therefore critical that while IWRM principles are being applied as evidenced by the CoJ WC/WDM strategy process, these principles need to be entrenched within South African water management policies as a standard operating process.

CHAPTER 5 CONCLUSIONS

Climate change and climate variability may present significant challenges over the next century. As time progresses and more research is conducted, the challenges are increasingly better understood. Substantial efforts have been made in attempts to understand temperature and sea level rise and the associated consequences, such as changes in rainfall and the risk of more, and more intense, floods and droughts. The area that requires specific attention is the ability to cope with the potential impact of climate change on the water environment at a regional, national and local-level (Muller, 2007).

This research project aimed to obtain an understanding of the effectiveness of IWRM in addressing climate change impacts and developing adaptation and mitigation measures within the South African water sector. Based on the investigation and the practical application of IWRM principles to the CoJ WC/WDM Strategy development process, the key emerging areas that require further attention are:

1. Sectoral integration;
2. Supportive institutional structures; and
3. Social learning.

1. Sectoral Integration

Obeng (2009) highlights two key strengths of an integrated approach that make it viable as a means of addressing climate change. Firstly, it integrates the activities of a wide range of sectors that use water, have an impact on water, or are impacted upon by water, ensuring that activities in one sector do not undermine those in another and that overall use does not compromise the sustainability of the resource itself. Secondly, it recognises that managing the trade-offs among different activities and interests requires effective institutions. The future resilience (or vulnerability) of human communities to climate change-related impacts depends, in large measure, on the success of these water resource management interventions.

It is anticipated that in addressing the current and emerging challenges, water will play a large role. These include:

- Addressing and adapting to climate change;
- Reducing poverty, particularly in communities engaged in water dependent activities such as agriculture;
- Growing more food to meet increasing demand; and

- Furthering economic growth while also protecting ecosystems and maintaining ecosystem functions and aquatic integrity.

Currently, climate change is not perceived by a select group of water managers, as this research shows, to feature prominently as a real threat to the reduction of the existing available water resources. This perception also seems to be echoed in water resource management documents e.g. the Water for Growth and Development Framework (DWA, 2009) which does not provide strategic guidance for long-term planning scenarios for adaptation to climate change and variability of water availability. The implication is that strategies have not been developed to adapt to the projected impacts specifically of climate change and climate variability with current water management mechanisms and policies focused on the assurance that existing supply of water meets the growing demand. Although some of the mechanisms may be appropriate to deal with the future lack of availability of water that result from climate variation, robust long-term strategies are required to ensure the demand for water matches supply in times of reduced availability (Mukheibir, 2005).

2. Supportive Institutional Structures

It is critical that policy makers appreciate the role of water as a primary medium through which climate change will have an impact on development, and to ensure that this understanding in integrated into development planning and management (Sadoff and Muller, 2009a). Responses by existing water institutions to mounting stresses have not been forceful and effective and have rather focused on weak initiatives founded on technological, scientific and behavioural innovation. Challenges have been met with changes in organisational linkages and relationships and the creation of new institutional structures to the extent that the risks inherent in unstable political environments are spread across a range of organisations and stakeholders (Lach *et al.*, 2005).

Water services are usually provided based on the development of infrastructure projects, which are designed using safety factors and have a limited life expectancy. Assessments of the effectiveness of water supplies and performance of water infrastructure have typically been done by using observed climate conditions alone (Schulze, 2008). Bates *et al.* (2008) advocate the consideration of the use of climate projections in cases involving systems that deal with floods and droughts. It is important to implement efficient water-use programmes in regions where water availability is *likely* to decrease, as large investments might be required to ensure adequate supplies, either by building new storage reservoirs or by using alternative

water sources (Bates *et al.*, 2008). It is also important for water managers and water users alike to adapt to the unfolding future. An approach to water resource management is needed that can identify and address the challenges – and uncertainties (Sadoff and Muller, 2009a).

Water is not a free good any more but rather an economic good. A paradigm shift is required in ensuring that rather than trying to fulfil increasing water demands and devise new costly supply sources attempts should be made to strive towards increasing the efficiency of water use (Kundzewicz, 1997). Reductions in water use through the development and implementation of water conservation and demand management strategies can delay, or even eliminate, the need for additional infrastructure. One of the quickest ways to increase water availability is through minimising water losses in urban networks and in irrigation systems. Other alternatives for reducing the need for new water supplies include rainwater harvesting as well as controlled reuse (Bates *et al.*, 2008). In virtually all circumstances, water security will require a mix of investments in both hard (infrastructure) and soft (institutions) options. Water pricing is likely to be increasingly important, covering not only the cost of development and water supply but also the cost of resource in terms of loss of a valuable commodity (Kundzewicz, 1997). The optimum solution will be dependent on many hydrological, economic, socio-political and environmental factors (Sadoff and Muller, 2009a).

3. Social Learning

There is still much to achieve in the area of water demand management and the links to climate change. Water management is typically divided into functional areas of expertise: experts who manage flooding; others who ensure that safe drinking water is delivered; still others who work to provide irrigation water; and others who manage water hydroelectric energy supplies. These functional experts see water as a controllable resource (Lach *et al.*, 2005) and place little or no emphasis on the importance of integrated management. This was clearly evident in the case of the CoJ during the development of the WC/WDM Strategy. Departments within the City focus on delivering safe, reliable, and low-cost water to those within their service area while also providing opportunities for growth and development. There is a danger, therefore that IWRM efforts will be sidelined by a focus on development planning. The general policy recommendation is thus that, while focused effort may be required to identify and initiate development and adaptation strategies, these should be integrated with ongoing water resource management work with both being effectively encompassed into broader national development strategies (Sadoff and Muller, 2009a).

Once again, it was evident in the case of the CoJ WC/WDM Strategy development process that the national strategic guidance and support required to facilitate IWRM at a local-level was lacking. This factor, therefore, hampered the development of a sound WC/WDM Strategy which would be able to encompass scenario planning and adaptation to variability in water availability due to climate risk. Climate risk aspects were therefore not considered in as much detail as would be required to facilitate adaptation strategies. The low priority assigned to climate change can also be attributed to inconsistent levels of understanding and learning coupled with limited social learning. Effective communication on climate change aspects needs to form part of cooperative management as a formalised process.

While workshops can be used to facilitate discussions and foster social learning among role-players, it was clear from the CoJ case that there is a serious need for targeted social learning programmes. While some information exchange and social did occur during the discussions in the first workshop, the discussions were dominated by few participants. The lack of actual social learning was evident in the lower number of participants of the second workshop, who were largely from Departments not dealing directly with environmental management.

Overarching Observations

Based on the workshops which were held with the CoJ and the feedback and interactions from the participants, as undertaken in this research, the following conclusions can be drawn pertaining to the South African situation:

- While there are a vast number of national initiatives to address climate change there is a serious lack of a serious cohesive national policy framework in place to assist and enable local implementing agencies to identify and address climate risks in the water sector.
- There is a definite lack of adequate institutional support and associated structures, which would essentially be responsible for managing and addressing an overarching aspect such as climate change.
- Currently water resource and environmental managers at local-levels are overburdened and operate within fragmented organisational structures resulting in dilution of priorities. This is largely due to the fact that aspects such as “climate change” do not have a functional fit in traditional organisational structures and tend to become an added on function to an existing component.

In order for the water sector to contribute to meeting the emerging challenges of climate variability and water availability there will have to be a concerted effort to manage the sector in terms of the kind of approach that IWRM offers:

- consider the integrated and interconnected nature of the resource;
- provide mechanisms for negotiation and conflict resolution among different stakeholders; and
- encourage adaptation and accommodate shifting physical, political and economic realities (Carriger, 2009).

The potential risks and threats posed by climate change with respect to water security can be addressed by seriously considering the following actions:

- Development of a water sector response strategy comprising of adaptation plans and mitigation measures;
- Stimulate a shift in focus from climatic prediction and mitigation to response and adaptation options; and
- Focus on those WMAs or catchments likely to face the greatest risk of water shortages and develop an appropriate and reliable understanding so that risk and disaster management plans can be drawn up and implemented (DWAF, 2009b).

As is evident from the statements above, the DWA has theoretically considered the need to plan for climate risk in water management. The downfall, however, is in the fact that no focussed practical or operational guidelines seem to be currently available for implementation. This is largely based on the DWA view that the long lead time and uncertainties associated with climate change (DWAF, 2009a) do not necessarily justify the need for immediate action. The long lead times and great uncertainties associated with climate change require adaptation responses that can demonstrate almost immediate benefits, while building robust, adaptive institutions designed to ensure enduring flexibility. This can be easily achieved by investing in water resources management.

Both IWRM and AWM have developed as independent concepts and methods with different origins. According to Pahl-Wostl and Sendzimir (2005) IWRM has always been strongly linked to the engineering community while AWM has been closely linked to ecosystem science. Research initiatives in the following components will provide some more insight into the most practical and efficient management strategies for water resources.

- Integration of IWRM and AWM to ensure that the development needs and the conservation obligations are addressed holistically and not in isolation. The challenge in both approaches is to ensure the integration of the human dimension.
- The impacts of climate change on water resources are associated with medium to high levels of uncertainty. Projections and modelling may only justify low confidence in predicted impacts (Matthews and Le Quense, 2009) and therefore more intensive research in modelling coupled with better information is required.
- Currently there is limited understanding of the legal and institutional frameworks required for mainstreaming adaptation into development plans to reduce water-related vulnerabilities (Bates *et al*, 2008). Access to information regarding the appropriate channels for financial support in the water sector for adaptation investment is not easily available or well known.
- Development of practical tools for data capturing, monitoring, communication, modelling to facilitate implementation of IWRM including the development of innovative tools for use by water managers to determine water allocations in the face of potential conflicts which may arise more frequently under climate change scenarios (Mehdi *et al.*,2004).
- There has been very limited evaluation of how effective and widely adopted adaptation strategies may be based on the complex nature of decision making; the diversity of responses across regions; time lags in implementation; and possible economic, institutional and cultural barriers to change (Bates *et al.*, 2008).
- A better understanding of the interdependence of key elements of water management regimes and the dynamics of transition processes in order to be able to compare and evaluate alternative management regimes and to implement and support transition processes (Pahl-Wostl, 2007) will also add value to the integration of IWRM and AWM.

Water management has been shown to be a political process (Schulze, 2008) inspired by constantly changing social priorities. Approaches to water management in semi-arid economies differ in developed and developing countries based on cultural, social, political and economic circumstances (Allan, 2003). Support to core water resources management information systems, institutions and investments conforms to best practice principles for aid effectiveness and provides a durable and efficient framework for achieving water security and ensuring the integration of adaptation efforts into national development plans (Sadoff and Muller, 2009).

It is quite clear the climate change is an emerging science with many variable factors and a host of unknown and unforeseen implications. This is especially critical in the water management sector where there is a critical need for information related to weather, climate, impacts and resource management. Government, stakeholders, and the public are all grappling with information from varied sources, often with contradictory interpretations and views. This aspect of lack of suitable information needs to be addressed by means of further research into critical areas. The following is a list of some possible areas where further research can be conducted to assist in the management of climate change related impacts in the water sector.

> "Adapting to climate change is, to a large extent, adapting to too much or too little water and its central role for climate change adaptation must be acknowledged at this stage"
>
> Global Public Policy Network on Water Management (GPPN), Copenhagen, 2009

APPENDIX 1: BACKGROUND DOCUMENT FOR WORKSHOPS

THE DRIVERS FOR ACTION

There are a number of significant challenges that need to be faced if we are to achieve our goal of sustainable water management and achieve the target of 110 000 Ml/annum.

This framework provides proposed actions and strategies to enable all stakeholders, but especially the CoJ, to address those issues that directly relate to the demand for water. Proposed themes include the broad categories of Water Resource Management, Distribution Management, Consumer Demand Management, Social Awareness and Education, as well as Management and Institutional Aspects.

It is often argued that WDM can hamper economic growth and development, and whilst this may be true for a punitive type approach (adopted in a crisis situation such as a prolonged drought), it is untrue for a properly planned and targeted WC/WDM strategy that aims at reduced demand through the creation of efficiencies, elimination of waste in supply networks, reduction of the wasteful use by consumers, improved institutional capacity, as well as changed perceptions and human behaviour especially at the customer level.

Hence the approach taken in the design and implementation of this strategy is one of *creating efficiencies whilst maintaining development, sustaining service delivery and service delivery expansion*, and also *providing opportunities for economic growth* especially in areas of low socio-economic status.

Due to the labour and management intensive nature of some WDM interventions such as the removal of alien vegetation, repair of leaks on private properties, the replacement of network pipes in built-up areas, implementation of a WDM strategy will lead to the creation of employment and enterprise development opportunities on a significant scale throughout the city.

Given the socio-economic context of South Africa, the need to reduce the service delivery backlog, the impacts of climate change, the current energy crisis and the need to conserve energy, the looming crisis around supply of water, and the imperative imposed by the Department of Water Affairs, it is critical that the CoJ pursue the implementation of this strategy as a matter of urgency.

The Water Management Thrust

In water resource management the focus of WC/WDM is on protection. It must be acknowledged that should matters be mismanaged it will reduce the reliable yield of the source to less than the yield taken as the basis for the original scheme design. For surface water, threats to reliable yield include alien plant invasion, reservoir siltation, and stream-flow reduction activities. For groundwater, changes in catchment land use and care that reduce natural percolation, competing and un-regulated abstractions and mine dewatering are the main threats.

Water retention and recharge are closely associated with drainage issues and current by-laws were formulated before the widespread use of Sustainable Urban Drainage Systems (SUDS). The major obstacles to the wider uptake and implementation of SUDS are to do with their ownership, maintenance and funding arrangements.

Due to the ongoing anthropogenic impacts of urbanization and development on the aquatic environment, wetlands are continuously being modified and changed to such an extent that they cannot function as purifier of polluted water arising. Threats to wetlands include transformation, erosion, pollution, eutrophication, mining and altered hydrology.

In both surface and groundwater management, it is important to identify threats to water quality that may render the source unsuitable for its original intended use to such an extent that more sophisticated and costly treatment is required.

Achievement of the goal of reduced demand will mean that we need to change the way we consume, manage and allocate our limited water resources today. We will need to:

- Reduce the demand for water wherever possible;
- Strive for the most efficient use of water, using water that is fit for its purpose;
- Generate awareness and buy-in within the community;
- Reuse water wherever we can without harming public health;
- Maximise the range and choice of possible uses of water to maximise our economic, social and environmental welfare;
- Have water users pay appropriately for the services they obtain from water; and
- Protect and restore, where necessary, the environments that are the source of our water.

The NWRS has identified water quality as a fundamental element of water resource management and is a primary consideration in the options for the reconciliation of water requirements and availability. To ensure that sufficient water is available it is of utmost importance that the water is also of an appropriate quality for the intended use.

The Energy Thrust

A distinct and quantifiable link exists between water and energy, although this link (or nexus) is not widely exploited nor sufficiently understood. Since significant quantities of energy are required to abstract, treat, transport and store water as well as transport and treat the generated wastewater before discharging back into a water course, any savings in water can be translated into savings in energy and especially electrical energy generated from the combustion of fossil fuels.

For most developing countries the cost of energy embodied in supplied potable water is normally amongst the top 3 costs associated with that supply, and often comes in second after labour costs. This, given the fact that up to half of the volume of water supplied is lost in the supply system before it reaches the end-user, makes it important to implement a WDM strategy and programme.

Work has been done by the Alliance to Save Energy in South Africa around quantifying the amount of energy required in the water supply chain to supply a unit volume of water (1 kl) and treat the generated wastewater before discharge into the water course. The amount of energy associated with this service has been calculated to be 1.7kwh/kl of water supplied to a customer.

Given the crisis in energy supply in South Africa which is expected to become even more acute over the next three to four years, it becomes even more imperative that every effort be made to reduce the demand for potable water in the CoJ, as well as increase the efficiency of energy intensive components in the supply cycle such as pump stations, water and wastewater treatment works.

The Climate Change Thrust

Downscaled climate model projections for the CoJ indicate that the local climate is likely to become both significantly hotter and more humid in future. In addition projections also point to more intense storm events, potentially impacting severely – both directly and indirectly – on built environment management functions such as stormwater management and attenuation, wastewater treatment, road and stormwater

design standards, floodline determination, water conservation and retention, pollution control, etc.

Climate Change Models suggest that temperatures for the CoJ may increase by around 2.3°C in the near future (2056–2065) and by around 4.4°C in the far future (2081–2100). Additionally, according to the CoJ Climate Change Adaptation Plan (2009), there is a risk that the CoJ will experience an increase in annual rainfall characterised by a higher frequency of storm events and a longer rainy season (finishing later in the autumn and possibly starting earlier in the spring). While these predictions seem vague and distant, there are a number of challenges in the immediate future which need to be addressed to combat future impacts.

These include:

- Accommodating the ever increasing populations in the CoJ;
- Only a limited number of rivers – the source of the majority of our water, are in good environmental condition;
- Complying with the DWA imperative to reduce water consumption by 110 000Ml in 2013;
- Providing investment certainty and efficient delivery systems for businesses;
- Providing safe and reliable services to customers; and
- Dealing with the risks posed by climate change.

Potential links identified by CoJ Adaptation Plan:

As a result of higher temperatures water consumption linked to air-conditioning, refrigeration and irrigation will in all likelihood increase. And this combined with current natural population growth and the urbanization trend in South Africa (migration to cities from rural areas) will place more stress on water supply by the CoJ (CoJ, Adaptation Plan, 2009).

An increase in water needs places additional demand on water supplied from sources outside of the CoJ including the country of Lesotho, which in turn places additional stress on the environment in these areas (CoJ Adaptation Plan, 2009).

Due to the increased likelihood of intense weather events such as violent thunderstorms accompanied by high rainfall, built environment management functions assigned to municipalities such as stormwater runoff and attenuation, wastewater treatment, road and stormwater design standards, floodline determination, water conservation and retention, pollution control, etc will be impacted upon and require additional investments in institutional capacity, infrastructure and service provision.

Increased stress on the City's natural surface water bodies due to contamination from failed sanitation and storm water infrastructure will need to be addressed in the longer term through an appropriate climate change adaptation strategy.

The Socio-Economic Thrust

In 2008 the Infrastructure and Services Department (ISD) of the CoJ commissioned a study to conduct research into water consumption patterns in the CoJ with an emphasis on high and middle income areas. The findings of the study entitled "Water Usage and Consumption by Different Categories of Domestic, Institutional and Commercial Users to Inform a Tariff Review and Demand Management Strategy" were intended to inform the setting of water tariffs and the formulation of a Demand Side Strategy. The study also incorporated a survey of more than 1000 residential users around water utilization habits and practices, as well as attitudes towards price increases.

The study established that the number of users falling under each water tariff block for the CoJ was as follows:

Table 1: Relative Numbers of Users Featuring in the Various CoJ Pricing Categories

Type	Monthly Water Usage	NoOfUsers			
		Jan-07	Apr-07	Jun-07	Oct-07
1. Residential (excluding townhouses and cluster developments)	1 - 6 Kl	11,066	9,952	10,132	9,966
	7 - 10 Kl	15,894	14,069	14,022	13,118
	11 - 15 Kl	25,193	22,023	22,382	20,564
	16 - 20 Kl	26,562	22,580	23,901	22,283
	20 - 40 KL	81,802	81,274	85,653	75,504
	41+	103,746	125,015	119,108	126,186
		264,263	**274,913**	**275,198**	**267,621**

This table demonstrates that about 50% of household consumers use more than 41kl per month and there is scope to encourage them to reduce usage in a planned water conservation campaign. The major findings of the report were summarized as follows:

- Residential water consumption is the highest category of consumer in the CoJ accounting for on average of approximately 63% of consumption by water users. Large stand-alone houses account for over 70% of residential consumption. Consequently, a concerted strategy is required to address residential water consumption, particularly in the middle to higher income residential areas.

- Business consumption accounts for approximately 10% of water consumption in the CoJ. This is followed by Industrial, Institutional and Commercial uses.

- Both the Institutional and Commercial water consumption is insignificant in volume compared to the other three large classes (residential, industrial and business).

- The classes of 'Other' (which is a combination of discrete users that could not be grouped under an encompassing name), 'Unknown' and 'Agricultural' were excluded from the analysis. These account for 10 % (Other), 5 % (Unknown), and 3 % (Agricultural) of water consumption across the CoJ, respectively.

In addition the findings of the completed survey were summarized as follows:

- Approximately half the respondents (45% for high income households and 62% from middle income households) are not prepared to pay more than the current R4.50 that water costs per kilolitre, i.e., the 1st price tier in the block tariff system employed by the CoJ. The remainder of respondents were willing to consider paying more for water up till about R15 per kiloliter. The implication for a proposed DSM strategy is that there is an existing margin to apply an economic measure such as a tariff increase in order to help curb wasteful water practices.

- Encouragingly, as much as 56% (middle income households) responded affirmatively when asked if they perceive water to be wasted in any way in their households. About two thirds of respondents are willing to consider reductions in water usage. The areas identified as having a potential for water savings varied from lesser toilet flushes, reductions on lawn watering as well as lesser water usages in the shower and bath. This has implications for a proposed DSM strategy in that the use of newer technology water fixtures equipped with pressure / velocity restrictors could help consumers to achieve this objective.

- Respondents (86% - middle income; 77% high income) felt that there is current existing effort in their households to conserve water, although some respondents could not say where exactly. This, together with the fact that respondents were also able to positively respond to a question about consciously using separate flush loads for urine and solids means that a concurrent educational / awareness campaign on water conservation directed at CoJ residents would be a key component in any envisaged DSM strategy (together with the use of dual flush toilet cisterns, for instance).

- Such an awareness campaign would, ideally, also aim to inform the public about the actual cost of water as the vast majority of respondents appeared to be unaware about water tariffs and generally assume water to be a social

responsibility as opposed to an economic commodity. That awareness on the cost of water would then, hopefully, trigger an interest in the water balance in any household or institution such that people would be more observant about water losses through leakages.

A brief investigation was also carried out to establish the price elasticity of demand of water for high and middle income households in the CoJ. The price elasticity of demand for water ranged from just less than –0.12 to over –0.16. This shows inelasticity or that water demand is not sensitive to price increases. The wording of the questionnaire indicated an option: “No, I am not willing to pay more as the price of water is already too high”. This reasoning seemed to resonate with the majority of respondents (although less than 50%). Such responses though should be treated with caution as the majority of people interviewed did not know the actual price of water and had to be educated first. In addition, most respondents indicated that upon receipt of a municipal bill, they only focus on electricity usage since it has a considerably significant impact on the eventual municipal bill. Again, for middle income households across the CoJ the price elasticity of demand is considerable and on average less than 0.1 as compared to the higher income households. Randburg and Midrand exhibit the least tolerance to prospective price increases in this regard compared to Sandton and the southern suburbs of Lenasia and Bassonia.

Hence a relatively mild price increase coupled with an awareness programme that teaches the CoJ residents about the scarcity of water in the city and sub-region, the cost of water to bring to point of use, and the available water conservation measures, would perfectly complement other non-price DSM measures.
The following recommendations were made in the final report:

- The JW database be enhanced to include a “linkage” that enables it to communicate with other databases. This will enable the easy incorporation of population density and distribution data which will, in turn, lead to the easy identification of water supply stressed areas and conversely, areas where water is used excessively,
- The database could be enhanced to incorporate aerial photography to be able to remotely identify and diagnose areas with anomalous usages of water, and finally
- A follow up study be commissioned to investigate the reasons why certain suburbs identified had anomalously high water usage figures compared with other areas of similar zoning parameters and remedial measures be recommended.

Based on previous studies for low-income areas in Johannesburg, it has been established that high volumes of water are being wasted on domestic properties due to faulty and broken plumbing fixtures.

Both the findings of the Water Usage and Consumption Study as well as studies undertaken by JW for Low-income areas have been used to inform this Strategy Framework and the various interventions proposed herein. It is noted that various of the proposed intervention measures should be targeted at the different socio-economic groups across the city, as this will yield the most effective results both from a cost and water savings point of view.

Key Issues and Challenges in the CoJ

The CoJ faces significant challenges relating to the implementation of a comprehensive WC/WDM strategy as listed below. Some of these challenges have been outlined in the WSDP of the CoJ (2008 version).

Attitudinal

Many water users are under the impression that Gauteng has ample freshwater resources and that no significant risk exists. This misguided view is largely based on the fact that the transfer schemes feeding the Gauteng Region are well managed and operated ensuring a steady supply of water to the region. The general public as well as the commercial users in the region need to be made aware of the magnitude of the water crisis in order to ensure a paradigm shift which will result in the required attitudinal change necessary for the effective development and implementation of a WC/WDM Strategy.

Another perception that needs to be addressed is the view that the human economy and human-built infrastructure are separate from the environment and can continue to grow indefinitely. This perception has undoubtedly led to the depletion of vital natural resources such as water. It is critical to foster an attitudinal change which will recognise that development needs to take place in harmony with availability of natural resources.

Institutional

Policy

Since a number of interventions proposed below especially relating to Consumer Demand Management such as rainwater harvesting, reclamation and re-use, water

efficient appliances, etc, are new to the CoJ, appropriate policy is generally lacking and will need to be developed. Policies will need to focus on rebate funding, control of use, implementation, product recommendation and specification, and policing by the municipality.

Supply Chain Management

Crucial to implementation and success of this strategy will be the procurement of goods and services provided by private sector companies. Supply chain management departments internal to the City and certain of the MOE's will be challenged to ensure that consultants, contractors and product suppliers are competitively procured, appointed and that water-tight contracts are entered into. Appointed goods and service providers will need to be effectively managed to ensure value add and adequate performance.

Entrenched non-payment

At the heart of this strategy is the need to change behaviour and perceptions relating to water, its use and value at a social and economic level. Linked to these issues is the culture of non-payment for services.

Although non-payment for services is mostly attributed to the socio-economic conditions prevalent in many communities, the real value of potable water provided by the city goes unrecognized by many consumers who consequently do not take ownership for their consumption or installed plumbing fixtures. This gives rise to massive wastage of potable water, the cost of which is ultimately borne by the city.

In implementing a demand side strategy that aims to eliminate known high volumes of water wastage to help achieve required savings, it can be expected that certain interventions will be challenged by communities. At an institutional level the city will need to take a position on various water related issues and present a strong case for actions taken in support of adopted policy.

Cost Factors

Funding of interventions

Estimated costs to implement this strategy and achieve the required savings in demand by 2013 is R3.4bn. This figure includes updated estimates provided by Johannesburg Water in its previous approved WD/WDM strategy (2008), as well

as expenditure associated with additional listed interventions. This is *in addition* to Capital Expenditure requirements allocated to MOE's and JW.

It is noted that by far the largest portion of this budget is for the replacement of aging infrastructure – mostly steel pipes – that have reached the end of their useful life. Many of these pipes are leaky and contributing to the high levels of NRW experienced by the city.

Much of this cost can be recovered through the achievement of the required savings of 110 000 Ml/annum which will result in savings in operational expenditure for water purchases by JW from RW of R363m/annum (at the approved RW tariff to municipalities for 2010/2011 excluding VAT). This is equivalent to almost R1.5bn over a 4 year period.

Additional funding of R1.9bn will need to be secured by the city for the implementation of all aspects of the WC/WDM strategy over a 4 year period.

Application should be made to DWA for grant funding to partially offset the cost of implementation.

Dedicated WDM fund

As a solution to addressing the WDM funding challenge described above, an internal fund should be established that accrues savings in operational expenditure resulting from the implementation of WDM interventions, to be used in furthering WDM objectives and the implementation of additional interventions. Establishment of this fund should also consider the imposition of a WDM levy on the water tariff to fund ongoing interventions.

Payment Levels

Payment levels are lower than expected, with the result that bad debts are on the increase. The problem is further compounded by the global economic situation and increasing operating costs. As per the WSDP for the CoJ (2008 version), prepayment metering is seen as a means to addressing this challenge and reducing bad debt and the need to write off service delivery costs. Prepayment is considered to be a demand management tool that can greatly assist in reducing especially water wastage.

Credit Control Processes

Linked to the problem of bad debt is the lack of an effective credit control process in many supply areas. When consumers do not pay for the service provided, the real value of the product or service is not recognized, leading to irresponsible use and wastage of water. This can be remedied through punitive measures including credit control processes that enforce restriction and termination of supply in the event of wasteful use.

Although credit control processes are complex and require an intensive level of management, they are effective in reducing water demand and creating a culture of ownership of consumption in the eye of the consumer. The city should strengthen its credit control program as a major institutional intervention linked to this strategy.

Management

Measurement and monitoring protocols

The measurement of key indicators is critical to the targeting of demand interventions and the success of the overall WDM programme. Of necessity measurement protocols are required to provide the necessary management information to inform the decision-making process.

Many of these measurement protocols are either not in place or sufficiently developed in the CoJ region to allow for the focused implementation of appropriate interventions. The strategy proposes addressing lacking or incomplete measurement protocols.

Contracting Mechanisms

In addition to challenges related to procurement processes, it is considered that traditional contracting mechanisms may not be the most suitable for especially the implementation of technical interventions involving retro-fitting of water infrastructure and plumbing fixtures. Innovative contracting mechanisms involving concepts to do with shared savings and performance contracting will need to be tried and perfected during the execution of this strategy. These same contracting mechanisms have been successfully used and refined in many countries in the past decade.

Technical

Age of Infrastructure

More than half of the water mains and sewers in the City are over 50 years old. These mains consist of steel and Asbestos Cement pipelines that have reached the end of their useful life and because of leaks, are contributing to the high levels of NRW experienced by the city. The international benchmark for water and sewer network renewals is 2 to 3% per year. The City is currently renewing 1% on its water networks and 0.5% of its sewer networks annually. This strategy proposes an increase of at least two-fold in the rate of expenditure on this item towards achieving the necessary water demand savings.

Lack of technical staff to implement a comprehensive WDM strategy

The shortage of technical staff at the municipal level across South Africa is well documented and indeed is also a problem endemic to the city and JW, who will be responsible for almost all of the technical interventions proposed herein. The shortage is both a quantitative problem in terms of absolute numbers and qualitative in terms of skill-sets and experience related to WDM.

The lack of technical capacity in both the city and relevant MOE's will need to be addressed as part of the implementation of this strategy. Many technical functions linked to proposed interventions can be outsourced and the necessary services provided by the private sector. Successful procurement of Service Providers is dependent on the effectiveness of procurement processes. Public Private Partnerships also represent an option to addressing the financial, technical and managerial needs of this strategy.

Timeframes

Based on the fact that the entire WDM programme for the Gauteng region has been compressed from 5 years to 10 years, with only 3.5 years remaining of the original 10 years, implementation will be challenging and require a high level of project management.

Use of new technologies

Although new innovations and technologies have been developed around the world relating to WDM, they have not necessarily been piloted in the CoJ, or other cities in South Africa. Although their use in other countries may have been successful, limited knowledge and experience relating to relevance and large-scale rollout in this country is available and hence application in CoJ is without precedence and could lead to many technical challenges as part of the implementation process.

Availability of products

Since rollout of this strategy would be on a large-scale in a compressed timeframe, stock and availability of products may be limited, which in turn could lead to delays in implementation. Careful planning and securing of sufficient stock through procurement processes would need to be undertaken.

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