

Water distribution and purification by Tlokwe Local Municipality: The case of Mooibank farms

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It all starts here TM

I certify that the mini-dissertation submitted by me for the Masters Degree in Development and Management at the North West University is independent work and has not been submitted by me partially or fully to any other university.

Mashonelo Phillip Mulovhedzi

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"Good friends are like stars, you don't always see them, but you know they are there, remember yesterday, dream about tomorrow, but live today" John D. Rockefeller III

ABSTRACT

The goal of water distribution is to deliver sufficient quantity and quality water cost effectively to the public interest and other stakeholders. The Department of Water and Sanitation (DWS) attempted to solve water distribution problems in Tlokwe through the implementation of Water Administration System (WAS). WAS is highly recommended by most scientific communities and other stakeholders as it's viewed highly efficient in water distribution. However, besides its implementation by the Mooi River Government Water Scheme (GWS) in 2004, Tlokwe water scarcity continued to be a major challenge facing the Mooibank irrigating farmers and Tlokwe water purification works. Hence, the study explored water distribution challenges and/or problems that were facing Mooibank irrigating farmers and Tlokwe Local Municipality (TLM) purification water works. The researcher had to take into consideration that the water programmes (i.e. WAS) used in Tlokwe's water distribution operate with or through water service authority's personnel. Therefore, the aspects of morality and work ethics get involved in water distribution. Hence, the study followed qualitative and quantitative (mixed method) design or approach.

Furthermore, access to sufficient water is one of the basic rights, as outlined in the bill of rights section 27 1(b) of the 1996 South African Constitution. However, this basic right (access to sufficient water) need to be balanced with other sectors as well. More especially agricultural sector, which is vital for producing fresh foods i.e. humans cannot live without food and/or water, these two components (*food and water*) are naturally interlinked. Hence, the study explored the water distribution (and even challenges) at Mooibank irrigation farms, Mooi River GWS and TLM purification water works in the North West Province.

The recommendations of this study might (hopefully), prompt the main water service stakeholders (i.e. Mooi River GWS, TLM and DWS); to reform their organisational strategic plans and/or personnel functions with regard to the application of Integrated Water Resource Management (IWRM) system(s) such as WAS. Furthermore, lessons may also be learned possibly elsewhere in the country wherein there are having similar water distribution challenges.

ACRONYMS

ANC:	African National Congress
AGRISA:	Agriculture South Africa
AMD:	Acid Mine Drainages
CMA:	Catchment Management Agency
CSIR:	Centre for Scientific and Industrial Research
DPLG:	Department of Provincial and Local Government
DWS:	Department of Water and Sanitation
FBW:	Free Basic Water
GA:	General Authorisations
GDP:	Growth Domestic Product
GIS:	Geographic Information System
GMO:	Genetically Modified Organisms
GWS:	Government Water Scheme
ICOLD:	International Commission on Large Dams
IDP:	Integrated Development Plan
IWRMS:	Integrated Water Resource Management Systems
MAR:	Maximum Abstraction Rights
MIG:	Municipal Indigent Policy
MVC:	Middle Vaal Catchment
NWRI:	National Water Resource and Infrastructure
NEPAD:	The New Partnership for Africa's Development
NWA:	National Water Act
RSA:	Republic of South Africa
SAP:	System Applications Product
SM:	Systematic Model
STATSSA:	Statistics South Africa
TLM:	Tlokwe Local Municipality
UN:	United Nations
UNESCO:	United Nations Educations and Scientific Organisation
WAS:	Water Administration system
WARMS:	Water Administration and Resources Management Systems
WRC:	Water Research Commission
WSA:	Water Services Act

WSP:	Water Service Providers
WUE:	Water Use and Efficiency
WWF:	World Wide Fund

METRIC UNITS

mm:	millimetre
m ³ :	cubic meters
km ³ :	cubic kilometres
V:	volume
Q:	water discharge
ℓ:	Litres

KEYWORD(S)

Genetically modified organisms
 Integrated water resource management
 Irrigation productivity
 Irrigation structures
 Irrigation water application
 Maximum abstraction Rights
 National Water Act
 National water resource strategy
 Potable water
 System model
 Strength weakness opportunity threats analysis
 Water administration system
 Water distribution
 Water services Act
 Water purification
 Water resource management
 Water use and efficiency

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CHAPTER 1: ORIENTATION AND PROBLEM STATEMENT

South Africa is internationally regarded as a semi-arid country because it has an average rainfall of approximately 500 mm/annum, which is considerably lower than the world average of nearly 850 mm/annum. The distribution of rainfall is also uneven, with the western parts of the country arid and rainfall in the east to the southeast more plentiful (Meyer, 2007:27). With little more than a per capita allocation of fresh water estimated at about 1200 m³/a, the country is potentially on the threshold of becoming significantly water stressed. According to Pereira *et al.* (2009:1) water scarcity is defined as a situation in which water availability in a country or region is below 1000 m³/person/year.

In more general terms, the quest for sustainable water resource management programmes is a key concern in efforts to address the contemporary and long-term needs of both humans and ecological systems (Grigg, 1996:112). In terms of these concerns, water resource development programmes should be designed and operated in an environmentally friendly manner, while taking into account basic human needs and socio-economic development (Pereira, *et al.* 2009: 58).

It is clear that solutions to sustainable water distribution lie with the efficiency of a particular water programme and, more importantly, its user within a given organisation or department. As Pierce (2008:29) notes, water programmes should be backed up by good fieldwork, quality data and sound analysis of that data. Grigg (1996:6) defines water resource management as the application of structural and non-structural measures to control natural and man-made water resources systems for the benefit of both humans and the environment. However, increasing population and higher levels of human activity, along with effluent discharges into both surface and groundwater sources have made the sustainable management of water resources a complex task throughout the world (Biswas, 1997:119).



In South Africa, various water resource management tools are available to respond to the various dimensions of water resource management challenges. These tools include the Water Administration and Resource Management System (WARMS), the Arc Geographic Information System (GIS), the Water Administration System (WAS), the Integrated Water Resource Management System (IWRM) and groundwater modelling programmes (DWS, 2009:43). This study comprises an analysis of WAS on water distribution in the context of the water resource management strategy in the city of Potchefstroom, under the jurisdiction of the Tlokwe Local Municipality in North West Province. There is consensus in the water sector that the government faces consistent demands for more water due to increasing population growth (DWA, 2009:12). Hence there is a need to put in place strategic water resource management systems. Before this can happen, a systematic information-gathering process has to be undertaken

Furthermore, the DWS's strategic management process should, logically consist of three stages: strategy formulation, implementation and evaluation. This study will focus on the latter stage because as an employee of DWS, it has come to the attention of the researcher that the impact of WAS has not been adequately evaluated in recent years. In terms of water distribution challenges, all structures have certain forms of water losses. As Biswas (1997:151) states, all water programmes typically exhibit constant returns to scale with respect to water input from the water source to the end user. This implies that losses through the water infrastructure be it a pipe, canal or siphons, is always constant, which is not practical. The inability to capture losses using the WAS has led to water shortages, especially for the end-point farmers on Mooibank farms.

The canal structures in Potchefstroom were constructed primarily to supply water in accordance with the farm approved scheduled area. However, with the growth of modern commercial farming, it became vital for farmers to adopt new irrigation methods such as the use of pivot irrigation systems in order to increase productions. The electric pivot irrigation system enables farmers to irrigate large scheduled areas with minimal water loss and in a shorter time. It is much better than the traditional furrow flooding irrigation (which is a manual operation and labour intensive). However, for this system

to be effective, the rate of flow in the canal has to meet pivot irrigation demands. The reality, as argued by Pereira *et al.* (2009:58), is that fixed canal structures and pipelines cannot accommodate the increasing demands because water from the resource is typically moving through gravitational accelerations.

An advantage of using the WAS programme is its ability to capture water usage and ultimately send bills to the water user through the System Applications Product (SAP). These processes automatically decrease human error, which is a common phenomenon when data is captured manually. However, even this advantage is undermined by two other water resource management problems. The first is the variation of velocity in the parabolic water canal. It is difficult to capture or log regularly using the WAS (DWA, 2009:13-15), because poor management of DWS farm servitudes and inadequate maintenance of canals can have a serious impact on the gravitational flow of water inside the canal or water structures. The second problem that can result in inaccurate readings is population growth. According to Biswas (1997:1- 8), there is a direct relationship between population growth and water demand. These are but two factors that have been singled out for the purpose of this study. There are many more, but population growth seems to be a dominant factor.

The overall population of Tlokwe Local Municipality (TLM) is growing yearly. It had reached approximately 430,000 when data was collected for a recent provincial Statistics South Africa report (STATSSA, 2011:11). Population figures and growth rates indicate potential impacts on a specific location and can cause major problems for an authority if it is not adequately prepared. This phenomenon is evident in most municipalities in South Africa in respect of service delivery in the form of housing, infrastructure maintenance, water, sanitation and electricity (STATSSA, 2011:6). A major emphasis in this study with respect to water distribution, is the fact that population increases hampers water resource management sustainability. However Pereira *et al* (2009:47) argue that water scarcity cannot be blamed entirely on population increases. Also at fault is the mechanism used to allocate water resources in the context of poor infrastructural conditions. Another factor is the preponderance of poor technological



programmes that are ineffective in distributing water efficiently. Surface water systems are a key component of hydrological systems. The management of surface water covers allocations and withdrawals, water quality and various environmental issues (Grigg, 1996:383). The South African public service has a history of poor water management (DPLG, 2007:25). A department of local government report in 2007 stated that most municipalities lack water development plans and programmes and that the problem starts, as a rule, at the national level of the DWS. According to the TLM Manual report (2012:240-2) water shortages in most of Potchefstroom's extensions (i.e. Promosa, Ikageng extensions and Mohadin) are a result of the DWS's infrastructure's inability (canal limitations) to provide efficient and sufficient water from Boskop Dam coupled with poor infrastructure maintenance and development.

1.2 STATEMENT OF THE PROBLEM

The goal of water distribution is to deliver sufficient quality water cost effectively to the public and to farms in a given area. The DWS attempted to solve water distribution problems by implementing the WAS. However, Tlokwe's water scarcity seems to be persistent, with some farmers opting to construct their own illegal waterworks along the Mooi River to supplement their canal quota allocations. Moreover, a 2010 study by UNESCO (2014:64 on local government and risk reduction found that an age old challenge that is still present in many governments around the world, namely an inclination to respond to disaster and/or crises instead of planning in advance and thinking of disaster reduction and preparedness. This seemed to be the case with the Tlokwe Local Municipality.

Although planning techniques have been around for a long time, systems analysis has evolved since about the 1980s. There has been significant progress since computers became increasingly availability. However, the foundation of systems analysis is mathematics, while the foundation of the planning process is politics (Craig, 2009:118). In light of this, Biswas (1997:15-17) presents an excellent argument to support the notion that, the set of practices used in water resource management for analysing a



single alternative water resource management system and submitting it to lawmakers for a yes-or-no decision is no longer in the best interests of the public.

Another factor that poses a serious challenge to the WAS distribution system within the newly demarcated Middle Vaal Water Management Area, as stated in a report by the DWS in the mid-2000s (DWAF, 2007:1a,16), relates to the integration of the old 1956 Water Act into the new National Water Act (NWA) of 1998, bringing about a new holistic concept called Integrated Water Resource Management (IWRM). The concept of IWRM is based on the understanding that water resources are fundamental components of an ecosystem and essential to achieving economic, social and political sustainability.

According to the Gauteng region DWS water crimes report undertaken by Snyman and Vennote Attorneys (DWAF, 1998:14), some of the farmers in the Middle Vaal catchment (MVC) area still use riparian cultivation system that was permitted by the old 1956 Water Act, which seems to indicate that they still consider the pre-1998 arrangement to be legal. According to DWA (2005:54) the riparian landowners' rights allowed for property owners to:

- divert stream flow;
- make reasonable use of water body, as long as other riparian's are not damaged or affected.
- prevent erosion of the river-banks; and
- claim title to the river-beds of non-navigable lakes and streams.

However, the old water rights of the Water Act of 1956 were repealed with the implementation of the new National Water Act, 36 of 1998.

The area of study is also facing increasing water distribution problems as stated in the Gauteng Region approved *State of the Rivers: Technical Report* (DWA, 2009:12).The underlying factor seems to be water use and the efficiency in the operation of the WAS.



Increasing challenges have resulted in tug of war between Tlokwe Local Municipality (TLM) and the farmers, who accuse each other of increased water usage.

In this study the performance of WAS will be explored in the context of its use by DWA to distribute raw water to the Mooibank farms and TLM water works for potable water use, and also determine whether the increase of potable and raw water shortages is a result of WAS inefficiency, environmental conditions or socio-economic factors.

1.3. RESEARCH OBJECTIVES

The primary objective of this study is to ascertain the effectiveness of WAS in distributing raw water to the Mooibank farms and TLM Purification Water Works.

The secondary objectives are to:

- determine whether WAS's performance has any effect on TLM's General Authorisations (GA) and Mooibank annual quota allocations;
- determine the relationship between WAS's performance and the DWS's water infrastructure management; and
- ascertain whether there is any relationship between WAS's performance and illegal abstractions along Mooi River.

1.4. RESEARCH QUESTIONS

Based on the above objectives the questions that will guide the research include the following:

1.4. i Primary question

The primary research question is to ascertain whether the WAS has any socio-economic impact on the two main water users, i.e. Mooibank farms and TLM potable water users in the Potchefstroom area.



1.4. ii Secondary research question

The secondary research questions are:

- Does the WAS have any effect on the TLM's water abstractions specifications (i.e. TLM General Authorisations (GA) or water use licence) and also Mooibank farm annual water allocations or quotas?
- Is there any relationship between the management of water infrastructure by the DWA (Potchefstroom) and the WAS's performance?
- What are the relevant water resource management systems theory, legislation and policy pertaining to the water resource management programme including WAS?
- Is there any relationship between the WAS's performance and illegal water abstraction along the Mooi River Catchment from Klerkskraal to Mooibank.

1.5. CENTRAL THEORETICAL STATEMENT

A number of factors could positively or negatively affect the performance of the WAS in water resource management in South Africa. According to Grigg (1996:56) monitoring programmes are necessary to assess water quantity and quality, and to provide information for management to use in the public decision-making process. The overall water management system includes control of reservoir capacity, control of in-stream and canal flow, as well as endpoint discharge (CSIR, 2005:13).

According to Biswas (1997:10-12) the key features of water monitoring programmes are water storage, flow over period of time, diversions, returns, release and dam levels. However, the water flow or storage characteristics in the intended study will be based on the Boskop left bank canal (Western side of Mooi River), which provides water to TLM purification water works and Mooibank farms. According to Grigg (1996:45) water programmes such as WAS are used mainly to monitor water distribution in specific

scheduled area, and also to provide the rate of water inflow and outflow. This is technically referred to as the water budget.

According to Grigg (1996:45), the simplistic water budget formula, for a set period, for any catchment area is:

$$\text{Inflow (I) - outflow (O) = } (\Delta s) \text{ change of storage}$$

Technological innovations form part of human development. However, Pierce (2008:29) argues that technological advancement usually results in a change of social patterns in societies across the world. Pallet (1997:37-38) argues that the convenience of having water piped to houses also inevitably pushes up consumption and tends to lead to excessive water use or wastage. The use of potable water for cleaning cars and irrigating lawns seems to confirm the wasteful attitude towards water use and consumption. The importance of using the WAS to administer water usage is fundamental to curbing wasteful practices, especially considering that increasing population demands in Potchefstroom are straining water usage for agricultural production.

1.6. RESEARCH METHODOLOGY

In an effort to achieve the objectives outlined above, the research was conducted using a mixed-method approach. Mixed-methods research involves collecting, analysing and interpreting quantitative and qualitative data in a single study or a series of studies that investigate the same underlying phenomenon (Du Plessis & Majam, 2007:1-3). The mixed research method was chosen for this study because it was appropriate for examining both the performance of WAS and water users' attitudes towards public policy and legislative regulations as a result of the implementation of water management systems by the DWS. The study, which was undertaken along the Mooi River catchment (from Klerkskraal to Mooibank), was a single case study focusing



primarily on water distribution and water resource management in the Potchefstroom area.

The qualitative aspect of the research involved in-depth structured interviews and observations with a view to learning and understanding the underlying values of individuals and groups (Pierce, 2008:45). The quantitative aspect consisted of numeric data collection and the statistical (scientific) analysis.

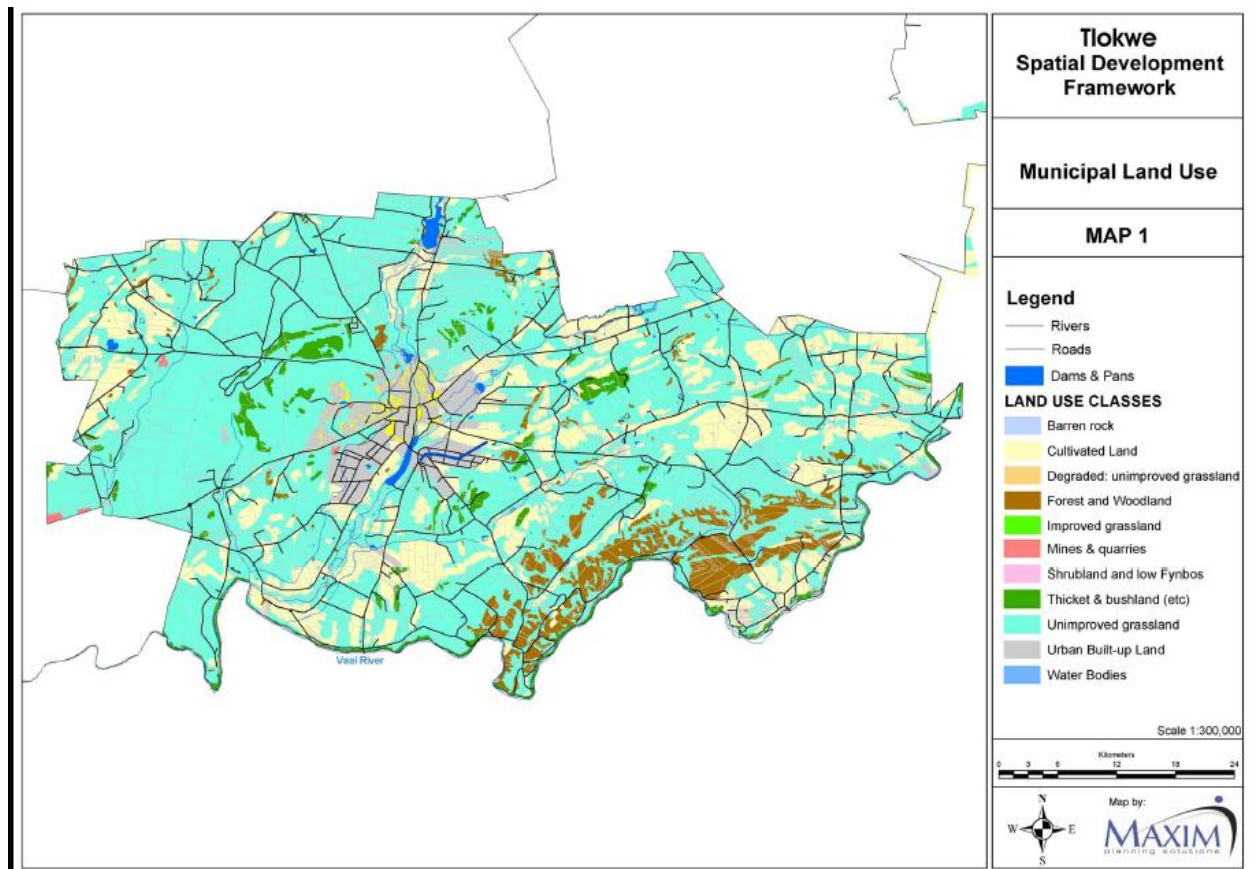


Figure1.1 Tlokwe Local Municipality land use map

(Source: Municipal Demarcation Board <http://www.demarcation.org.za>)

1.6. i Literature review

According to Pierce (2008:101) the purpose of a literature review is to establish the state of current knowledge or argument about a research topic. He further explains that knowledge includes views, concepts, theories, understanding, evidence, schisms and their main authors. In this study WAS, which is a water resource management programme, was explored with a view of bringing understanding or new knowledge. Therefore the main theories, views, arguments, disagreements and agreements of relevant authors on this subject were reviewed, while noting fresh criticism where applicable.

Sources related to evaluating the impact of water resource management systems, with WAS as the main focus, were consulted. This included both local and international sources, particularly with reference to the application of water resource management systems in artificial water infrastructure and natural water resources. The following DWS publications were consulted;

- *White Paper on a National Water Policy for South Africa of 1997;*
- *South African national water quality and quantity monitoring programme series (2002-2012);*
- *Water Research Commission(WRC) reports of 2009-2014;*
- *State of the South African rivers reports of 2009-2014*
- *Quality of Domestic water supply of 2009- 2014;*
- *National Water Bill of 2001; and*
- *Water Services Act of 1997 ,*
- *National Water Act of 1998,*
- Other documents include environmental, hydrological and dam water distribution (civil) reports of 1998-2014.

1.6. ii Empirical Study

As noted above, a mixed research method was used in this study. Furthermore, as this was a single case study research project, there was direct interaction with the concerned group of water users, Mooi River Government Water Scheme (GWS) and the TLM purification waterworks in the Potchefstroom area. Pierce (2008:53) states that a case study is an essential “building block” of empirical research. That is, it must provide the basic minimum information to enable the research question to be answered and the research hypothesis to be tested.

1.6. ii.a. Research design

Webb and Auriacombe (2006:589) state that a research design consists of clear statements of the research problem and the methods to be used for collecting, processing and interpreting the observations that are intended to answer the research question posed. The primary question will be the first to be answered in this research paper, that is, to ascertain whether WAS has any impact on two of its main water users i.e. agriculture (Mooibank farms) and TLM potable water works in Potchefstroom and its extensions.

This research was based on a case study. The benefit (advantage) of a case study is that, unlike in a laboratory (experiment) studies, the researcher is able to study or observe the complex relationship between different variables or phenomenon in the subject real-world context (Bailey, 1994:23). Hence, the researcher in this case was able to study WAS water distribution variables or components in a natural environment i.e. Tlokwe Local Municipality and Mooibank farms.

Furthermore, as this research was based on a case study, it was necessary to base the collection, presentation and analysis of data and information on feedback from the intended research groups (Mooibank farmers and TLM potable water users. However, Fowler (2009:112) argues that no matter how similar the real-world conditions are

results (findings) of the case study cannot be generalised, simply because variables such as human behaviour differs as a result of culture, politics and beliefs(e.g. religion).

1.6.ii.b Data sampling

Data simply means information (Oxford dictionary, 2007). Sampling can be defined as a process of selecting subjects or units from a specific subset of a population in order to make inferences about the nature of the total population itself (Babbie & Mouton 2001:202). Sampling is usually done to save money, time and costs as it is practically impossible to interview everyone in the entire population. The data was divided into two main categories or population groups, the reason being that the study followed both a quantitative and qualitative research approach.

The first population sample consisted of top managers of TLM purification waterworks and the random sampled household's heads from each location (Potchefstroom town, Promosa, Mohadin and Ikageng extension1-11). The second population sample included past and/or recent Mooi River GWS discharges or outflows in Boskop Left Bank feeding canal to Mooibank farms and TLM potable water quality and quantity data.

Stratified data sampling was used in this study. This method, as stated by Jarbandhan and Schutte (2006:660-661), involves the division of a population into recognisable, non-overlapping sub-populations (strata). The division in this study was into TLM (purification water-works) officials and Mooibank irrigating farmers. A random sampling was drawn from each stratum because of the limited time and cost constraints.

1.6. ii.c Data collection

The data for the study was collected from primary sources (i.e. interviews with the representatives (officials) of Mooi River GWS, TLM water purification works and

Mooibank irrigating farmers). The second group of data sets was obtained from government publications and reports (i.e. WRC, STATSSA, DPLG, DWS and TLMIDP).

1.6. ii.d Data analysis

In this study qualitative and quantitative data analysis was integrated so as to interpret the data derived from the WAS in descriptive statistics, as well as using structured interviews. Norusis (1990:211) argue that data analysis by means of statistical techniques assists us in investigating variables, as well as their effect, relationships and their patterns of involvement within our world. Furthermore, Babbie and Mouton (2001:418) note that the quantification of data is necessary when statistical analysis is desired. However, the observations describing each unit of analysis need to be transformed into standardised codes for the purpose of retrieval and manipulation by computer programmes.

The data analysis was conducted by focusing on the research questions in order to determine insightful relationship between different variables. Meanings were then obtained from these relationships.

1.6. ii.e Limitations and delimitations

The researcher is a DWS water resource management employee, which could be perceived to undermine objectivity. However, the data collected from the respondents was analysed objectively in order to maintain a high standard of professionalism. Furthermore, some of the past hydrological data is unavailable, missing or damaged as different directorates stored them.

1.7. ETHICAL CONSIDERATIONS

According to Babbie and Mouton (2001:546) in addition to technical and scientific considerations, social research projects are likely to be shaped by practical, ethical, and

political considerations. He defines ethics as that which people agree on about right or wrong (and good or bad).

In the research interviews, the respondents were treated with respect and dignity. All the participating stakeholders were given a consent form to indicate that their participation was voluntarily and that no form of compensation was given. The information gathered is also confidential to prevent potential harm to respondents and their personal interests. According to Pierce (2008:10-11) harm could be physical, financial, social or physiological.

The researcher followed the code of ethics outlined by North-West University. Other important ethical considerations considered were those listed by Pierce (2008:11), which include:

- the voluntary consent of a human subject is absolutely essential;
- the research/experiment will add value to the society,
- research will not be conducted when there is prior reason to believe that death or injury may occur, and
- a participant/respondent subject will be at liberty to end his or her participation, especially if he/she feels that he/she is in a mental state that renders continuation impossible.

1.8. SIGNIFICANCE OF THE STUDY

The intention of the study is to broaden understanding and bring a new body of knowledge to bear on the field of water resource management in the area of study. The focus is on the application of the WAS by the Mooi River Government Water Scheme (GWS) in its efforts to bridge the gap between demand and the supply of available natural water resources to TLM potable water users and Mooibank farmers. This study is significant because it will serve to highlight problems and their possible solutions in the implementation and application of modern technology (water resource management



programmes) and the impact of these programmes on various sectors of potable water users and farmers in the TLM community.

The findings of this study might also help to lay a foundation for further academic research on water resource management programmes or systems and assist the top management of DWS and Mooi River GWS in their development of future strategic plans.

1.9. CHAPTER LAYOUT

The research paper has been structured as follows:

Chapter 1: Water distribution orientation: The chapter constitutes a general introduction to the research topic and the background to the study. It also includes the problem statement, highlights research objectives and questions, and a description of the research methodology that was used.

Chapter 2: Water resource management systems (WRMS). This chapter includes a description of the on-going debate about Water Resource Management Systems, disagreements and agreements (arguments) on the WAS, drawn from the available literature on the subject. Theoretical views about water resource management systems promulgated by various local and international authors will also be outlined, as well as their recommendations.

Chapter 3: Research methodology and WAS calculation methods. This chapter comprises a description of the research method that was used to analyse the WAS. As the study will be grounded in a mixed-methods approach, both quantitative and qualitative research methodology was explored for WAS assessment.

Chapter 4: Data collection, analysis and representation. This chapter comprises a description of the data collection from the water resource management system WAS 2.0 and the TLM focus group, data analysis using the statistical or mathematical model for

the WAS, analysis of the perceptions of employees and water users (agriculture and potable water user) in Tlokwe and data representation by making use of charts/maps. The empirical data is analysed in a quantitative contexts and then interpreted in a qualitative manner, based on the contributions of individuals and groups of stakeholders and their perceptions of the relevant issues.

Chapter 5: Conclusion and Recommendation. In this chapter the details of the findings and possible solutions regarding the implementation of WAS water resource management system by DWAGR are provided.

1.10 CONCLUSION

In this chapter the background to the study problem was outlined. This included the uneven distribution of the South African scarce natural water resource and a brief outline of the Water Administration System (i.e. a water resource management system) used in responding to the country water resource management challenges. This was then followed by the sections of the study objectives, questions, central theoretical statement and research methodologies.

The next chapter provides literature review. The purpose of the next chapter is to establish the state of the current in-depth knowledge and/or arguments about water resource management systems.

CHAPTER TWO: WATER RESOURCE MANAGEMENT SYSTEM (WRMS)

2.0. INTRODUCTION

These chapter deals with literature review pertaining water resource management and/or its systems. The review of the literature begins with world water distribution and then followed by the in-depth exploration of water administration systems (WAS) components. Various components of WAS in both irrigation and potable water supply or distribution in the international and local arena i.e. South Africa(SA) will also be explored in the coming sections.

However, Water resource management systems or components in a current global world or environment affects social, economic and environmental conditions. Hence, this chapter also explored the concept of Integrated Water Resource Management (IWRM) principles in the country (SA). This will then be followed by an exploration of (water) policies and regulations governing the country's natural water resources, irrigation and potable water supply.

2.1 WORLD WATER DESTRIUTION

The world population has been on the rise since the appearance (existence) of the first humans. According to King and Black (2009:3) approximately two billion people are currently living in areas faced with water stress or scarcity. Adding to this challenge is the fact that natural water resources are limited. The growth in populations has caused pressure on the domestic, industrial, agricultural and municipal water supply to mount.

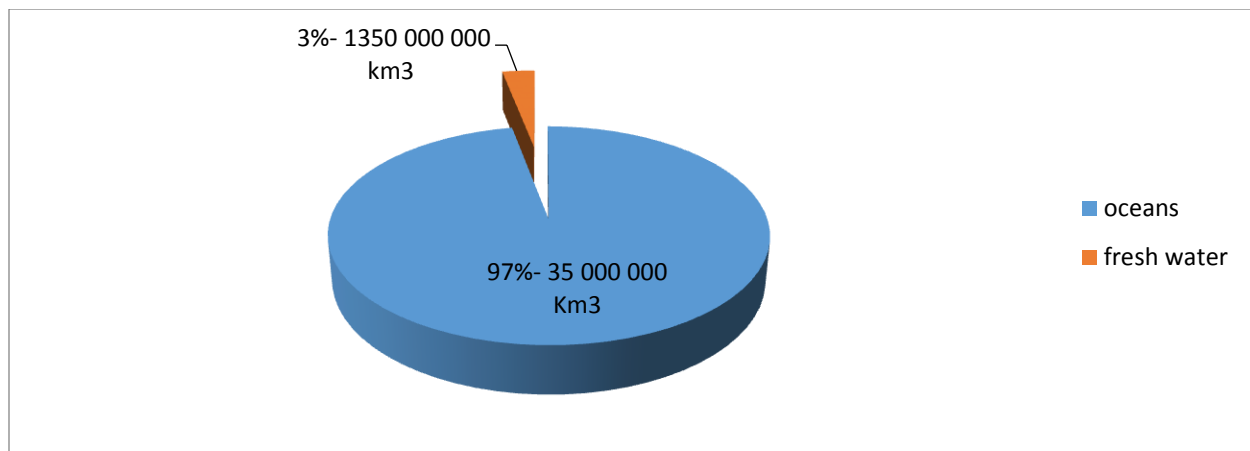


Figure 2.1: Water distribution on earth

(Source: DWAF, (2003:45))

Furthermore, DWAF (2005:45) indicates that only 3% of the total water in the world is available as natural freshwater (as indicated in figure 1) and is currently distributed as follows:

Volume		Proportion (%)
Ice caps and snow	28 000 000 km ³	70%
Groundwater	8 450 000 km ³	29%
Lakes	23 000 km ³	0.4 %
Ground Moisture	67 000 km ³	0.3 %
Atmosphere	13 500 km ³	0.16%
Rivers and streams	1 500 km ³	0.14%

However, natural fresh water bodies have a limited capacity to respond to increasing demands and to receive the pollutant charges of effluents (discharges) from expanding urban, industrial and agricultural uses. These existing imbalances between demand and supply might be addressed through the use of modern technologies and management tools, which must be adaptive to socio-economic, environmental and institutional needs. A good example is the implementations of modern technology such as WAS in South



African irrigation systems. In many parts of the world large quantities of fresh water are used for irrigation purposes (Pereira *et al.*, 2009:1-5). Concurring with Pereira *et al.*(2009:1-5), King and Black *et al.*(2009:15) indicates that agriculture remains the biggest global water consumer, at an estimated 65% of total water usage, while industry uses roughly 20%, domestic 10% and ecological reserves 5%.

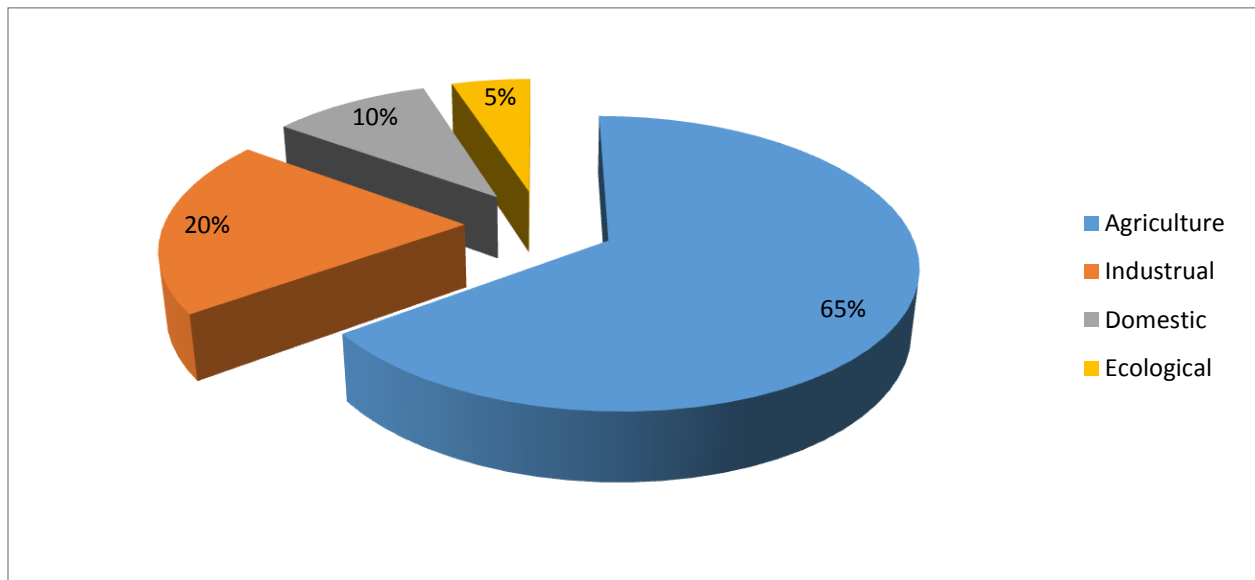


Figure 2.2: Total composition of world usage per sector

(Source: King and Black, *et al.*, 2009:15)

Although more than one third of the world's total water is used for agricultural purposes, (as presented in Figure 2), industry remains the biggest employer (UNESCO, 2014:13-14). The fact that humankind depends on water while water is becoming increasingly scarce presents a serious challenge. Adding to this complication is the fact that fresh natural water resources are finite (limited) and are becoming increasingly polluted as a result of increased industrialisation in many parts of the world (Meyer, 2007:2-5). The increase in population also exerts significant pressure across all sectors. According to Biswas (1997:32), if governments do not introduce proper water management strategies water conflicts might rise in water-scarce regions. The proper management strategies cited by Pereira *et al.* (2009:2) include water resources and environmental protection

regulations, modern technologies for efficient water distribution and proper development and management of water institutions.

2.2. WATER RESOURCES MANAGEMENT

Water management can be defined as the activity of planning, developing, distributing and managing the optimum use of water resources (Thompson, 2006:2). The major challenge is the fact that water resource management focuses only on the environmental conditions. In South Africa, for example the need for water resource protection is considered supreme. According to DWS (2014:14), directives issued by the department are mandatory and should be enforced. However, the biggest challenge that could be posed by these directives could be the fact that bringing the full might of law to bear on organisations (such as farms and industries) that flout these directives might result in a loss of productivity, leading to their employees being retrenched.

Pereira *et al.* (2009:3) indicate that the adoption of water resource management regulations fails to address socio-economic needs; hence the concept of Integrated Water Resource Management (IWRM) was introduced by many governments across the world as a new holistic approach. IWRM was adopted as an attempt to bridge the gap between socio-economic and environmental considerations (Biswas, 1997:42). This means that water resource utilisation for economic and social activities should pose no threat to current or future ecological water demands.

This view is supported by Van der Vyver (2009:22) who indicates that water and poverty interface in more than one way and therefore the integration of human development into water resource management is vital for sustainable environmental and economic development.

2.3. INTEGRATED WATER RESOURCE MANAGEMENT STRATEGY

Integrated water resource management (IWRM) can be defined as a process that promotes and co-ordinates the development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Global Water Partnership, 2012:4). This implies that the utilisation of all water resources needs to take into account future water requirements. Over-withdrawal of the natural resources can have a severe impact on the surrounding ecosystem and the community.

According to Ward (2013:9), IWRM is centrally concerned with understanding the variability of water resources and using that knowledge for:

- controlling water availability or efficiency;
- providing the society with its social and economic benefits.

Agricultural production is vital for food security, but the increase in water usage for irrigation seems to be a major challenge. Biswas (1997:45) indicates that the increasing agricultural water demands across most parts of the world have influenced governments to apply or use new technological instruments as a way of trying to improve water use efficiency. In South Africa, the use of WAS was adopted in 2004 across GWS and WUA to address irrigation water distribution challenges that the country was facing (DWS, 2013:14).

It is clear that the DWS, adopted technological programmes such as WAS in agriculture as a way of trying to minimise irrigation water distribution challenges facing the country. However, Biswas (1997:14) argues that the use of water resources technology instruments (as part of IWRM strategy) should go hand in glove with proper public management and/or personnel functions for it to be effective. Supporting this concept is Van Vuuren (2009:12), who indicates that the poor functioning of public management, due to factors such as a lack of skill and committed personnel across South Africa's public water sector, has resulted in water service delivery challenges in the country. The development of systematic water models such as WAS could theoretically not only

improve agricultural productions but could also address the principle of equity in distributing irrigating water. Before the implementation (introduction) of WAS in 2004, the manual capturing of water orders were time consuming, stressful and sometimes subject to errors (DWA, 2009:45).

According to Ward & Brown (2013:45) the intentional and/or unintentional(human errors) capturing of wrong irrigation water orders affects not only the performance of water distribution programmes but also the distribution of water to the end users (e.g. irrigating farmer). One can therefore argue that without proper public management functions (e.g. skilled and committed personnel) water models might become ineffective in promoting equitable distribution of natural water resource, which is a basic principle of IWRM.

2.4. WATER RESOURCES SYSTEMS, PUBLIC PARTICIPATIONS AND INSTITUTIONAL ARRANGEMENTS

Some researchers (e.g. Biswas, 1997:2-3, Ward, 2013:11 and Pereira, 2009:102) suggest that it is fundamental to develop and adopt technological innovations for use in water resource management and distribution processes. However, poor training and development of water professionals in the water industry could pose another serious challenge. In South Africa, for example, the state used to have a racially skewed *apartheid* policy (DWS, 2012: 15). Hence, since 1994 the democratic government tried to bridge this gap with its policy of affirmative action, that is, by employing “previously disadvantaged groups” in strategic positions. Gouws (2010:109-114) argue that by trying to bridge this gap (apartheid to democratic) in this way, without first ensuring that “previously disadvantaged “people were properly educated or skilled, the SA government might have left a void, because some top management officials do not have the necessary skills or professional qualifications to effectively perform when trying to solve current water problems. In other words, poor performance by those in positions of authority or senior official government positions as a result of affirmative action and employment equity could be another factor fuelling water scarcity in South Africa.

However, Riccucci *et al.* (2008:112) argue that a lack of proper management and necessary professional skills by senior management officials (SMO) can be dealt with only by means of effective performance-based management systems coupled with training interventions. However, one might argue that as South Africa is a democratic country, the public (citizens) should also be given an opportunity to give input or make suggestions in water service provision by government entities. This could easily be achieved if citizens were also allowed to voice their opinions during decision-making processes, i.e. public participation. This could reduce service delivery protests. One might also suggest that beside social intervention programmes (which are a form of public participation) such as “*Baswa le metsi*”, Working for Water (WFW) and formations of water user associations as part of community social development programmes, there is a need to develop or monitor the current scientific water programmes such as the Water Administrations System (WAS) and/or Water Resource and Management System (WARMS). This WRM programmes are used for the allocation of water use licences to various stakeholders (i.e. GWS, WUA, Water Service Providers or boards and business industries). Hence, it is vital to see if they (WRM programmes) are addressing social, environmental and economic challenges in the societies which they service. This could only be achieved through effective public participation.

Secondly, institutional arrangements might also be influential in the management of water resources systems. One could argue that institutional arrangements (laws, policy and organisations) are probably the greatest single barrier to the effective management of water resource systems. According to (Marino, 2000:4) in many countries, institutional arrangements are generally complex, bureaucratic, competitive, inflexible, unresponsive, poorly integrated and they result in systems that have poor accountability, lack of foresight and prevent open communication and robust debate between stakeholders. In South Africa, for example, only two out of nine proposed Catchment Management Areas (CMAs) are currently functional. This indicates a gap in terms of reforming the water industry or institutions. According to DWA (2013:22), some of the previous irrigation water boards are still not integrated into Water User Associations.

The following cases highlight the lack of public consultation or participation in institutional arrangements. One is a South African example and the other is a foreign water case:

Bolivia: Cochabamba

The Bolivian national government privatised municipal water and then had a massive backlash. It was later referred to as the “Cochabamba water war” (UNESCO, 2014:14). The greatest challenge in the case was that most consumers were not able to pay more expensive and ever-increasing private water bills. To persuade them (the community) to do so, the private water company (Aguas del Tunari) started to cut off potable water supply to defaulting consumers. This led to violent protests across the city. This could have been avoided if there had been proper consultation before taking any step towards privatising potable water services. In this case the public felt cheated by the Bolivian authorities; hence they voiced their concerns through violent protests.

Nkonkobe: South Africa

In 1995 a subsidiary of Suez won a 10-year contract in Nkonkobe Municipal district in the Eastern Cape. The contract was cancelled following a legal judgment in 2001. The mayor explained in a letter to the government that it was impossible for the municipality to pay the R400, 000 a month management fees demanded by the foreign company for potable water supplies and sewage treatment (Holland, 2005:75). This contract was cancelled before going public because it transpired that there was no public engagement or participation. This case also highlights lack of norms and moral standards by some of the political office and/or government officials.

2.5. THE INTEGRATED WATER RESOURCEMANAGEMENT SYSTEMS ANALYSIS

In general, IWRMS can be divided into two categories, i.e. programming and descriptive models (Biswas; 1997:9). According to Ward & Brown (2013:4) programming models attempt to exhibit one or more of the following types of hydrological data:

- water velocity;

- water capacity(volume);
- inflow and outflow;
- durations;
- water quality; and
- meteorological data (such as rainfall and evaporation rates).

Furthermore, Biswas (1997: 9) indicates that the water resource managers should find IWRMS relevant as an aid to decision making, since they are designed to obtain optimal efficiency. However, problems might arise from manual capturing of data. An example of a manual system is domestic meter reading by public officials, who might be subject to human error. According to DWA (2009:14), an omission such as the failure to capture one 0 can lead to a loss of millions of rands. However, in some cases, failure of the meter (expired), tapping and/or bridging of an analogue meter (illegal) by consumers might result in the water service provider trying to predict the actual reading. This could then lead to that consumer receiving excessive water bills.

2.6. IRRIGATION WATER MODELS

The adoption of irrigation systems (IS) or models is one way to address the problem of unregulated irrigation by farmers. According to Winter (2009:14) irrigation models facilitate the equitable and efficient allocation of water for irrigation. In other words, it can address the issue of nepotism or subjectivity in allocating water. Manual data can be erased more easily than computerised data. With controlled programmes such as WAS it becomes difficult to distort or erase the captured data.

According to Winter (2009:9) to adopt fairness in irrigation water models, regulations to protect each farmer's rights need to be drawn up, and this should be backed up by data from irrigation systems. It is also imperative that there should be fairness in the application of the water distribution system regulations. This application of water management systems, according to some researchers (e.g. Biswas (1997:14) and Benade (2011:2), is important for conserving and managing available fresh water resources. These might ultimately prevent water conflicts among water-users such as farmers, because irrigation water programme such as WAS (Water Administration

Systems) are programmed instruments and operate following a recommended or approved data set. For example each volume of water per scheduled area (quota) is allocated equally, irrespective of a farmer's social status.

2.6.1. Water productivity in irrigation systems

Nowadays, there is a trend to speak of water productivity (WP) instead of water use efficiency (WUE) in irrigation systems (Molden *et al.*, 2004:33). Water productivity in agricultural irrigation is generally defined as the ratio between actual crop yields achieved (Y_a) and the irrigation water use (Biswas, 1997:154 & Pereira *et al.*, 2009: 230)

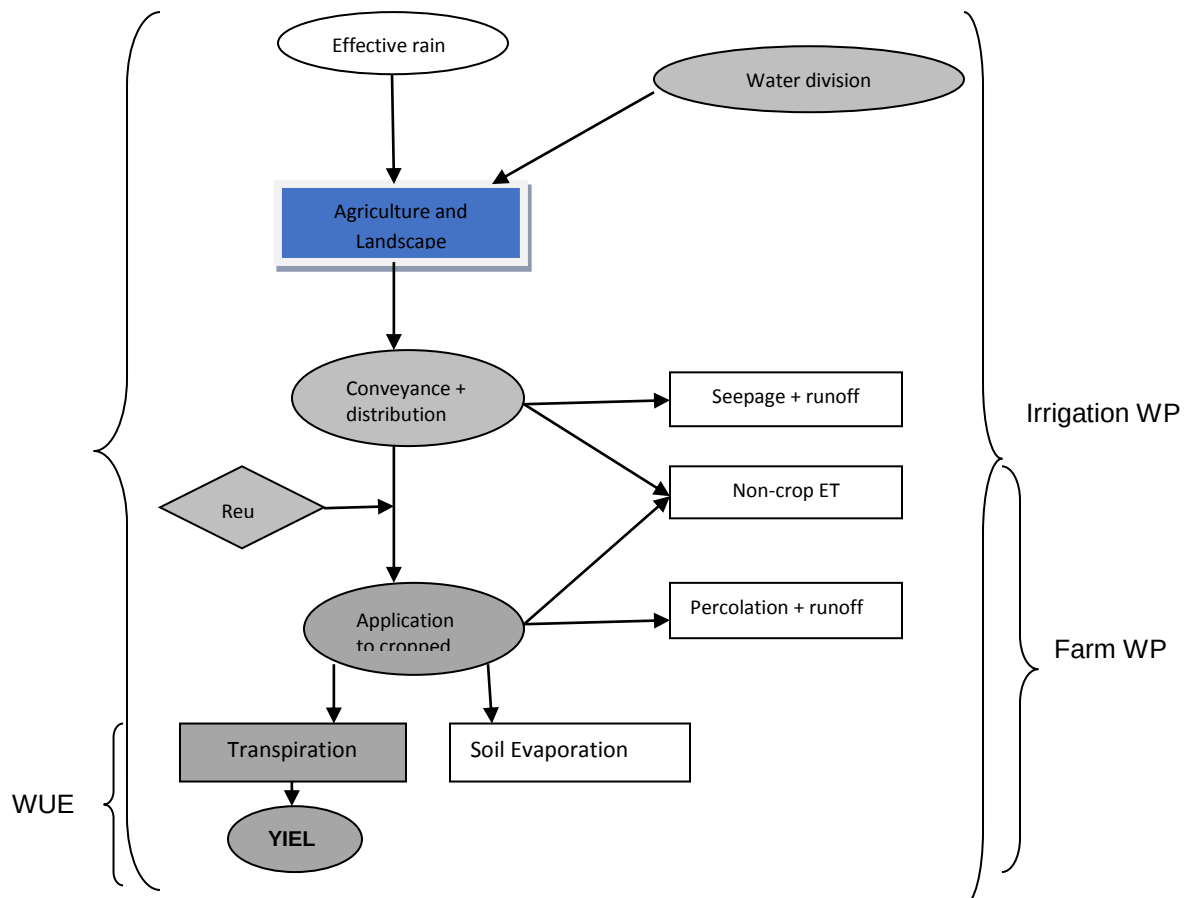


Figure 2.3: Water productivity in agriculture at various scales

Source: Pereira *et al.*, 2009:230

According to Pereira *et al.* (2009:228) the two terms (WP and WUE), are sometimes used interchangeably (see Figure 2.3). Different crops have different water requirements, in other words, the quantity of water that will support its ecological survival. For landscapes such as gardens, golf courses or lawns, Y_a has to be selected as they produce quantitative yields, meaning that they might include rainfall data.

According to Pereira *et al.* (2009:228), this results in two different indicators or equations:

$$WP = \frac{Y_a}{TWU} \quad (1)$$

And

$$WP_{\text{Irrig}} = \frac{Y_a}{IWU} \quad (2)$$

Where:

Y_a = Crop Yield achieved

IWU = Irrigation Water Use

TWU = Total Water Use

The difference between the two equations (1) and (2) is the denominator. Equation (1) has TWU, which includes rainfall distribution during crop season, while equation (2) is irrigation water only. However, there are some challenges in terms of calculating WP or IE. One of these challenges is the adoption of genetically modified crops.

2.6.2. Irrigation water productivity of genetically modified organisms

According to Panse (2013:2) genetically modified organisms (GMOs) include crops, such as vegetables and fruit that have been created using genetic engineering

methods. Some sub-Saharan countries in Africa, including South Africa, cultivate genetically modified (GM) crops with the aim of increasing farm production. Furthermore, African centre for bio safety (2012: 14) indicates that 72% of maize seeds, 80% of soya beans and 20% of cotton sold in South Africa during 2012 were GM, further indicating that GM crops are advantageous as they are:

- more productive (increase farm income);
- drought tolerant;
- highly nutritious;
- resistant to harsh climatic conditions;
- resistant to pests, weeds and diseases;
- environmentally friendly as they require less pesticides and herbicides;
- capable of thriving in region with poor soil minerals;
- are an answer to feeding an ever-growing population; and
- high yielding.

Not all scientists support the use of genetically modified organisms. Whitman (2012:4) argues that GMO have the following non-intended side effects (unnatural):

- can poison water (chemical pollution);
- cross pollinate non GMO plant (distort natural plant genetics); and
- are allergenic to certain groups of people;

The crop composition of any irrigation zones should therefore be an important factor in determining the appropriate irrigation management strategy of that region, i.e. different crops tend to have different water requirements e.g. GM and/or non-GM crops. It is clear that GMO foods act as an answer to ever-growing population as indicated by ACBIO (2012:14) and Whitman (2012:5). However, researchers such as Panse (2013: 2-3) argue that the problem of hunger is not a result of food shortages but of poor management in food allocation.

2.6.3. GMO in mono-cropping

Mono-cropping refers to the practice of growing only one type of agricultural product on a large area of land, year after year (Panse, 2013:2). In industrial crop production, mono-cropping is often used to facilitate planting and harvesting across large tracts of land. Pesticides and fertilisers are often applied with specialised farm equipment in order to increase farm production, hence profit. This implies that instead of hiring workers, the farmer uses specialised mechanical equipment. The cost of production becomes low, so it ultimately results in the lowering of crop prices by the farmers.

However, Molden & Fraiture (2004:63) indicates that mono-cropping ultimately imposes additional costs on the society due to environmental damage and human health threats. Environmental damage (as a result of agricultural practice) in this case includes a distortion of the quality of surface water, which might even lead to eutrophication. Oberholster and Ashton (2008:3) define eutrophication as the enhancement of biological production processes in a natural water body as a result of nutrients enrichment from compounds such as phosphates and nitrates. Fertilisers are rich in phosphates compounds; hence they are the main cause of eutrophication in the irrigation (farming areas).

- *Human health impacts from the eutrophication process*

Eutrophicated water causes negative effect to the human health. According to Harding and Paxton (2001:14) algal and cyanobacterial blooms are usually found on the surface of the eutrophicated natural water resources. Hence, WHO report (2013: 17) indicates that the high dosage of the cyanotoxinated and/or eutrophicated water results in to liver haemorrhage or liver failure to humans.

2.7. SOUTH AFRICAN WATER IRRIGATION MANAGEMENT

According to the DWA (2013:15) agriculture is the main water user in South Africa with an estimated total usage of 60% of the country's natural water resources. According to Winter (2009:14), water demand for irrigation in South Africa largely exceeds that of all the water sectors combined.

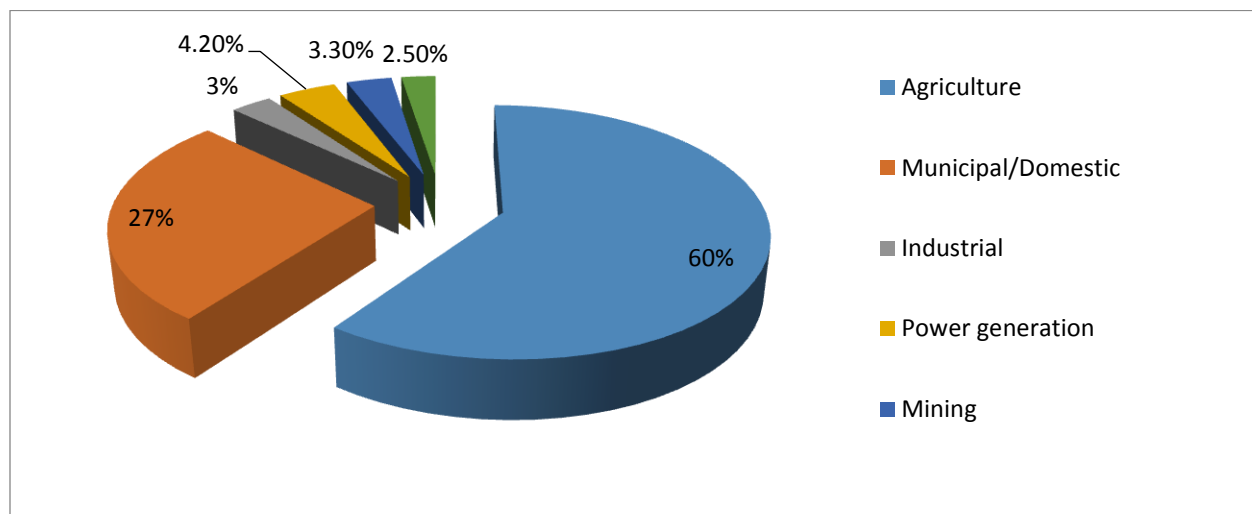


Figure 2.4: South African proportional water usage per main economic sector
Sources (DWA, 2010: 13)

It is quite clear that agriculture remains the biggest water user in South Africa, as it does across the world (Figures 4 & 5). One of the main reasons for increased agricultural water demands could be the increase in population demands in most parts of the world. One might argue that the increase in population also requires food (natural need) availability, and this can be achieved if there is an adequate supply of irrigation water. Therefore, should irrigation water become increasingly stressed, it might pose a threat to the food security of the country and/or even the economy. According to the Department of Agriculture, Fish and Forestry (2012:2), the total gross value of agricultural production (total production during the production season valued at the average basic prices received by producers) for 2012/13 was estimated at R180 360 million, compared to R163 672 million in the previous year (2011/12), representing an

increase of 10,2%. This increase (agricultural production value profits) signifies that agriculture is a crucial sector and an important engine of growth for the rest of the South African economy.

Due to an increase in the population over the last decades hence water demands for fresh food productions, it became crucial that the SA government developed a tools or systems to manage water distribution specifically for agriculture (or irrigation). A step taken by the DWS was a directive that was issued in 2004 to implement WAS programmes in all South African government water schemes (GWS) and water user associations. According to Winter (2009:12) the purpose of implementing WAS, in SA agricultural sectors, i.e. GWS's and WUAs was to conserve large volumes of irrigation water.

2.8. THE SOUTH AFRICAN WATER ADMINISTRATION SYSTEM (WAS)

The Water Administration System (WAS) is a uniquely South African water administration system aimed at increasing the productivity of water in the agricultural sector. It was developed by Dr Nico Benade with the funding from Water Research Commission (Winter, 2009:12-13). WAS essentially provides irrigation schemes with decision support for effective and efficient water management. Currently the WAS programme is in use at all the major irrigation schemes across South Africa and it manages an irrigated area of more than 142,000 ha, including land belonging to 9,500 farmers (Benade, 2011:2). This is a vast area which, one might argue, requires a large workforce to manage it properly. Hence, WAS was introduced for the purpose of assisting water user associations (WUAs) and GWSs to manage their irrigation water distribution. According to Winter (2009:13), WAS makes use of following seven modules:

- administration;
- water orders (applications);
- measured data (scheduled area of the water user(WU);

- water releases, e.g. reservoirs' and canals'(pipeline) end-point outflow;
- crop water use;
- accounts(billing information sent to the water user); and
- water disposal reports.

These modules are fully integrated, making it possible to cross-reference data. However one of the main challenges is the farmers' perceptions of WAS performance (Winter, 2009:12). These perceptions might include dissatisfaction with WAS's performance. According to the DWA (2012:12), water loss in agriculture is very high in comparison to potable water supply to domestic consumers. Infrastructure efficiency is supposed to be at least 95%. However, according to winter (2009:68) the average loss in most SA agricultural schemes is between 25 and 30 % in conveyance structures due to spillages, leakages, blockages, and sometimes poorly maintained infrastructures (see Figure5 below).



Photograph 1: Canal overflowing due to poor maintenance, *Location: Haaskraal, Mooibank*
 Photographer: T Chupeco

Some of these water losses are man-made (see photograph 1 above). However, through effective application of WAS components, these losses can be avoided e.g. Maximum Abstraction Right (MAR). MAR is a Water Resource Management terminology used to describe the volume of water allocation per farm scheduled area over a specific period (DWS, 2005:45). One might argue that applying MAR (through WAS) before the canal overflowing point, gives the service team the opportunity to maintain or service the *grey point* (spilling point). In other words, irrigation water will be distributed through MAR such that none is left before the *grey point*, so as to give the maintenance team a chance to repair any damage.

2.8.1. The benefits of WAS

According to Winter (2009:1) WAS is designed to be a water management tool for GWS, WUA's, CMA's and water management offices that want to manage their water usage, water distribution and water accounts. This programme (WAS) seems to be an essential component of the effective distribution of bulk water. According to Benade (2011: 1-2), the main benefits of using the WAS programme are:

- minimising water distribution losses;
- excellent management of water allocations and water usage per farmer;
- the management of date and time-related flow data collected from electronic loggers or mechanical chart recorders;
- the availability of an extensive list of water reports at the farming and scheme level;
- the increased productivity of scheme management personnel;
- for an integrated debit accounting system that improves debit management, and
- the improvement of the overall water administration management of irrigation schemes

Benade (2011:22) further indicates that before the implementation of WAS in 2004 all water orders, balances, cancellation, water requests/applications and disposal water



reports were captured and calculated manually. This (manual system) seems to have been a laborious and time consuming process, which might have left much room for human error. However, one might even argue that the implementation of WAS by the GWS and/or other water service providers does not necessarily result into effective water distribution. Winter (2009:14) indicates that effective training in the application of WAS and other hydrological programmes is necessary to enhance skills development, further indicating that this could ultimately improve water service delivery to the affected societies or communities.

2.8.2. WAS data applications

According to Benade (2011:3-4) WAS is an integrated database driven system with many water management capabilities. Provision is made for the efficient administration of:

- Information sent to the water user, e.g. municipality, water service provider, GWS, WUA and farmer;
- scheduled or list of rateable areas;
- water allocations;
- water deliver through pressure-regulated sluice gates, measuring structures and water meters;
- water reporting including the Water Use and Efficiency and Accounting (WUEA) report;
- water transfers between users (automatic and manual);
- water use calculations for planted areas based on crop water use data;
- date and time related flow data collected from electronic loggers or mechanical chart recorders;
- discharge tables (DT) to do conversions between water depth and flow rate for measuring structures or vice versa;

- calculation of water releases for water distribution through canal networks; pipelines and rivers taking lag times, evaporation, transpiration and seepage into account;
- billing system that links to the water usage information;
- e-mailing of invoices; and
- flexible user charges based on water usage, a flat rate or scheduled area.

According to Winter (2009:3-4) all these data applications are integrated into a single module, which is then stored in a single personal computer (PC) or network server making it possible for the scheme manager, accounts personnel and water office personnel to access the database from their PC's in their offices. What makes this programme unique and important is the fact that almost 85% of irrigation water supply in South Africa is control by this programme (DWS, 2012:13). Unlike the water resource management billing system wherein the user is billed according to the registered water volume in the water licence (GA), the WAS billing system is based on the amount per use. Therefore, farmers are able to control their water use charges by reducing their water usage. The reduced water usages by the farmers equate to the increase in the surplus of natural water reserves in the hydrological cycle.

2.7. IRRIGATION STRUCTURES (DAMS)

With the exception of the Great Wall of China, dams are probably the largest structures ever built. They also rank among the oldest types of human-made structures. Dams are important because they store water even during dry periods. Historically, the oldest known human-made dams were probably built more than 5,000 years ago in arid parts of the Middle East, such as in Mesopotamia to divert river water to irrigate crops (DWA, 1998:147). It is quite clear that the earliest known dams were built to provide water for irrigation. However, due to the increase in population across the world, dams have become important civil structure for distributing domestic, industrial and commercial water supplies.



Photograph 2: South Africa's biggest dam (the Gariep) in the Orange River in the Free State Province. Photographer: J De Ridder

As indicated above, farmers usually require water through-out the year to sustain their agricultural endeavours. However, in areas or catchments with non-perennial river(s) infrastructure(s) such as dam(s) is usually a viable option for a sustaining steady flow for irrigation. A good example is South Africa's largest dam, the Gariep Dam (see Figure 6 above). Its current supply area includes Bloemfontein urban and rural areas and also irrigation schemes such as that of the Vanderkloof Dam further downstream in the Orange River.

According to the DWA (2010:121) dam's do not only serve as important hydrological balancing structures, but they are also constructed in rivers to ensure a dependable water source for irrigation, domestic use, power supply and industrial consumers. It is therefore clear that dams are extremely valuable. However, not everyone supports dam



construction projects. Environmentalists across the world are concerned by the declining population of the fish in major rivers and the deterioration of the water stored in these dams. According to UNESCO (2014:12) dams disturb fish migrations in major rivers as they act as an aquatic barrier. There are currently more than 500 000 dams around the world, the overflow walls of which are mostly lower than 15m (International Commission on Large Dams, 2014:14).

The following criteria have been set by the International Commission on Large Dams (ICOLD: 2014:16):

- minimum height of 15m; or
- dam height between 5-15 m, with a reservoir capable of storing 3 million m³ of water.

ICOLD was founded in 1928 to provide a discussion forum for the exchange of knowledge of and experience in dam engineering for engineers, water resource professionals and other concerned parties such as environmentalists (ICOLD, 20014:18). Its strategic objectives have recently been criticised by some environmentalists and civil society groups. One of the recent protests was in Brazil. In 2013, the Amazon Indians occupied the construction site of the Belo Monte Hydro-electric Dam on the Xingu River. They demanded that the Brazilian government put the construction work on hold because the dam would affect their land and livelihoods (UNESCO, 2014:11).

The Colorado in United States of America (USA)

In the 1920's, the USA water authorities began diverting the Colorado River's water, building dams and diverting its flow hundreds of Kilometres to Los Angeles, San Diego, Phoenix and other fast growing cities. The Colorado River now serves more than 30 million peoples in US cities and parts of Mexico, with 70% of its water siphoned off to irrigate 3.5 million acres of cropland (Koundouri, 2003:15). The damming and diversion of the Colorado River highlights the importance of proper planning, not only in terms of water resources management but also on the engineering side (dam). Although

environmentalist and opposition groups objected to the development, the Colorado River boosted the agricultural sector in the area. Cohen *et al.* (2013:30) indicate that various conservation scenarios involving regulated deficit irrigation and advanced crop shifting irrigation technologies were implemented in the Colorado Basin. They further indicates that as part of crop shifting the Colorado farmers have started focusing on planting more useful crops such as sorghum, barley, corn, sugar beets and seed crops instead of wheat and hay only.

2.9.1. Large dams and irrigation activity in Africa

According to ICOLD (2014:14) 70% of dams in Africa are constructed to facilitate irrigation with the remaining percentage shared by municipalities and industries for recreational purposes. Poor irrigation practices can have a negative effect on dams. WAS is therefore, essential as an irrigation tool and to facilitate the effective management of dams.

Furthermore, dams can also be used for water sport and flood control (disaster risk management) to lessen the impact of flood damage downstream of the dam. According to ICOLD (2014:7), there are more than 33,000 dams registered in the World Register of Large Dams, of which South Africa is ranked 7th and first in Africa with a total of 1,114 registered dams.

2.9.2. Large dams and irrigation in South Africa

In South Africa, the average annual rainfall is 500mm, and it ranges from less than 100 mm/y in the western deserts to about 1,200mm/y in the eastern part of the country. Furthermore only 35% of the country's surface area has a precipitation of 500mm/y or more, while 44% has a precipitation of 200-500 mm and 21% has a precipitation of less than 200 mm (DWAF, 2004:44). These poor climatic conditions require the country to have large dams for storing surplus water for use in dry periods.



According to the DWA (2012: 4), dams are required in the country for the following reasons:

- to store water in times of surplus and dispense it in times of scarcity;
- to ensure a dependable water source for irrigation;
- for efficient and sufficient domestic water supply;
- to generate hydro-electric power;
- to service industries (commercial and industrial);
- for recreational values; and
- flood control.

There is a belief that more dams are required to meet increasing water demands. However, building more dams to meet current demands without considering ecology (the environment) will not only affect our current generation but future environmental sustainability as well. According to the DWAF (2005:31) dams reduce downstream water quantity and this ultimately leads to:

- a lower ground- water table;
- a disturbance of water flow;
- increased salinity due to soil leaching;
- a decline of downstream aquatic ecosystems; and
- an accumulation of toxic material.

Due to the fact that dams are used for various purposes, there is a need to balance between agricultural, domestic and ecological water demands.

REGION	NUMBER OF COUNTRIES	OF COUNTRY WITH THE MOST DAMS
AFRICA	38	South Africa- 1114
WESTERN- EUROPE	19	Spain-987
SOUTHERN -AMERICA	12	Brazil- 1431
EASTERN-EUROPE	16	Albania- 306
NORTH & CENTRAL AMERICA	20	USA- 9265
ASIA	36	China-5191
AUSTRALASIA	4	Australia- 507

Figure 2.5: World Registered Dams

Source: (DWS, 2013:47)

Most of SA's large dams are used for irrigation purpose. According to the DWS (2013:14), most of the WUA's and some of the GWS's increase their dams' water intake in an attempt to compensate for high water losses in the canals. This has resulted in the depletion and capacity reduction of some of South Africa's large dams. An increased water intake from these large dams was largely a result of mismanagement by the water use managers. The WAS programme was rolled out with the aim of managing water losses in most of the South African GWS's, forming part of dams management under NWRI.

2.10. HUMAN DEVELOPMENT AND ENVIRONMENTAL RIGHTS

According to Fisher (2009:87) an environmental right is a complex idea that incorporates both human and ecological values. In other words, these two cannot be separated; humans are part of the environment. Therefore water for survival becomes a

right. This right is stated in section 1 of the NWA (36 of 1998), i.e. the right of all persons to a secure, healthy and ecologically sound environment. On the other hand, environmental rights are also fundamental; that is, a right to an ecologically sound and healthy environment free of pollution. Furthermore, the UNESCO (2014:42) states that human rights, an ecologically sound environment, sustainable development and peace are interdependent and indivisible. This implies that there should be a balance between human and ecological water demands which Pereira *et al.* (2009:9) sometimes referred to as an equilibrium water status.

2.11. SOUTH AFRICAN POTABLE WATER

Although 85% of the population has access to tap water in South Africa there is a great variation in the ability to access potable water across rural and urban districts (William, 2009:16). According to Meyer (2007:51) large-scale investment will be required to meet the projected urban population's demands in the coming decades. However, Holland (2005: 13) indicates that an increase in the unemployment rate means that many people cannot afford to pay for basic water and sanitation. This in itself is a problem because government needs capital investment in order to expand or maintain the existing water infrastructure.

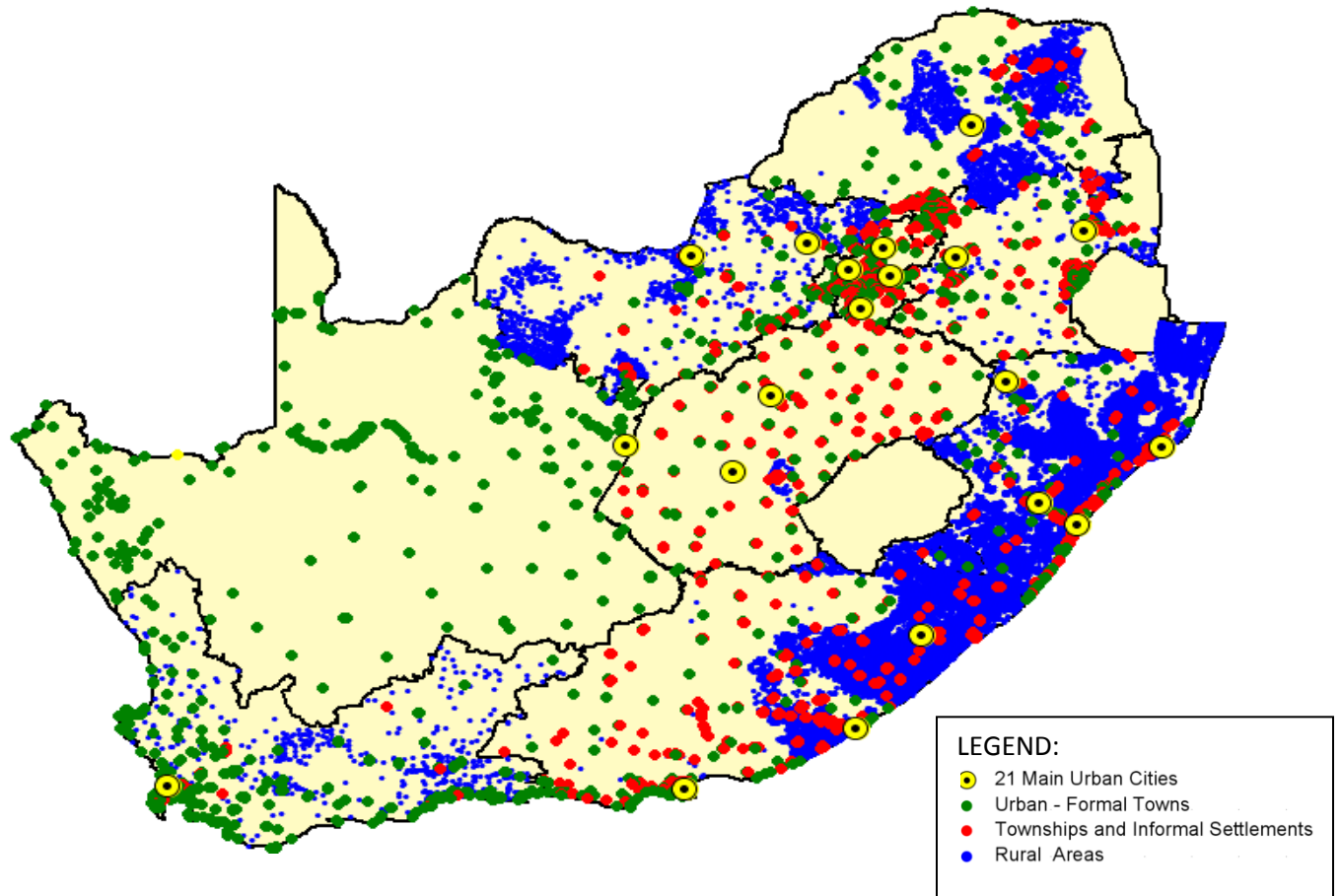


Figure 2.6: Distributions of human settlement in South Africa

Source: DWS, 2013: 8

Furthermore, sometimes those who can afford to pay do not do so, because they consider potable water to be their basic right. Research done by DPLG (2007:14) indicates that in South Africa there is a culture of non-payment. This could have been influenced by the ruling political party's campaigns promoting benefits such as free education, health and houses for all. Therefore, people may think the ruling party owes them for their votes, and that they should therefore receive free potable water services from their respective municipalities.

2.11.1 Status of potable water usage in South African urban and rural areas

In South Africa (SA) the provision of free basic water for all is still a major challenge facing water service providers. According to DWA (2012:71) potable water usage in SA urban areas is about 90 to 120 $\ell/p/c/d$. It is quite clear that rural areas use less water than urban areas in SA. Most of the low-income areas are rural settlements. Furthermore, unless a new technological breakthrough is made and adopted, the level of potable water supply to the urban areas is unlikely to increase faster than the demand, and this could pose a serious threat to the environment.

Major WU	Water user /sector	Proportion of allocation
	Agriculture	62%
	Domestic	27%
	Urban	23%
Minor WU	Rural	4%
	Industrial	3.5%
	Afforestation	3.0%
	Mining	2.5%
	Power generation	2.0%

Table 2.1: SA water resource use per sector

Source: (DWS, 2012: 4)

Table 1 indicates several interesting features. The urban settlements consume five times more water than the rural areas in South Africa. Moreover, the water demand in South African urban settlements is still growing. One of the causes could be the urban population influx. According to STATSSA (2011:24) population influx to the urban area has almost doubled since 2001, especially in the Gauteng Province.

The constitution of South Africa of 1996 provides a legal basis for allocating powers to different spheres of government. This means that all three spheres of the government have to work co-operatively to achieve national objectives.



Figure 2.7: Horizontal coherence model of co-operative governance approach in South Africa water management

Source: DPLG (2013: 14)

The DWS is the custodian of the natural water resources in SA (DWAF, 1999:14). Provincial government gives administrative support to local government, which according to the WSA of 1997, is mandated to provide water and sanitation services to communities. However, at the beginning of 2014 the new configuration of the DWS, which incorporated sanitation, was established. This might bring co-operation between local municipalities and the DWS. However, since municipalities are headed by political office bearers that report to the responsible MEC of the province, it might become a challenge as to know the municipality should report to when trying to address sanitation service delivery challenges.

The most significant concept in co-operative governance is that the national department needs to interact with both local and provincial government (DPLG, 2007:14). The DWS, as a national department, has the role of developing national water policies and legislation for both provincial and local government. Furthermore, it also needs to monitor the implementation of the WSA of 1997 and the NWA of 1998. Parliament has an even bigger role to play in co-operative governance. According to Van der Molen & Matheson (2002:14) parliament has to ensure that the planning outputs are

democratically embraced by all spheres of the government that is national, provincial and local government. However, in the definition of co-operative governance (COG) indicated by Van der Molen & Matheson (2002:14) communities or society is left out of the co-operative governance structure. This could be one of the major reasons for potable water service delivery protests.

2.12. CHALLENGES IN CO-OPERATIVE GOVERNANCE (COG) IN THE SOUTH AFRICAN WATER RESOURCE MANAGEMENT INSTITUTIONS

There are numerous challenges that exist in the different spheres of South African institutions with regard to water resource management. For example, in 2012, after consultation with various stakeholders on CMA establishment in the Vaal region a Water Research Commission report (Muller *et al.*, 2012:19) highlighted the following challenges:

“Rand Water has been involved in the Vaal since 1996 and it was a driving force in the formation of forums with the involvement of the community and stakeholders. Rand Water was a driving force to take the forums further. These forums were combined to establish the catchment executive committee to form a CMA. Industries, mining and agriculture had representatives in the committee. Thus all the stakeholders in the Upper Vaal looked to Rand Water to lead the process. But the Department of Water Affairs did not take the process forward. As a result Rand Water gave up under mutual agreement with stakeholders as this was a waste of time. The lack of funds also contributed to the initiative failing. The general feeling was that there was lack of political will from the Department of Water Affairs”.

This example highlights the fact that sometimes a lack of cooperation exists between various institutions of the government. These could be a result of a political or public administration issues. In this case, it was the national government, represented by the DWS, and the parastatal Rand Water. In other words, there was a lack of cooperation between the two. This can lead to discontent in future in the surrounding community (in

the Vaal), especially if the majority of stakeholders such as farmers, mining companies and civil society are in support of the proposed CMA initiative.

2.13. SOUTH AFRICAN POLICIES AND ACTS THAT GOVERN SURFACE AND GROUND WATER

The Constitution of South Africa of 1996 is relevant to potable water distribution for two reasons: firstly, the Bill of Rights indicates that everyone has the right of access to sufficient water (RSA Constitution, 1996). It is the national government's primary responsibility, in this case that of the DWS's, to ensure that everyone's right of access to sufficient water is fulfilled. Secondly, the constitution provides the legal basis for allocating powers to the different spheres of the government, and is thus relevant to institutional regulations regarding potable water. South Africa's natural water resource management is governed by following regulations: the National Water Act of 1998 and the Water Services Act of 1997.

2.13.1. The National Water Act (NWA) of 1998

According to DWAF (2007:14) the National Water Act came into effect on the 1st of October 1998, with the purpose of ensuring that the nation's water resources were protected, used, developed, conserved, managed and controlled in a ways that take into account:

- (a) meeting the basic human needs of current and future generations;
- (b) promoting equitable access to water;
- (c) redressing the results of past racial and gender discrimination;
- (d) promoting the efficient, sustainable and beneficial use of water in the public interest;
- (e) facilitating social and economic development;
- (f) providing for growth demand for water use;

- (g) protecting aquatic and associated ecosystems and their biological diversity;
- (h) reducing and preventing pollution and degradation of water resources;
- (i) meeting international obligations;
- (j) promoting dam safety; and
- (k) managing floods and droughts.

However, the existence of laws that are not applied does not serve any purpose. In other words, it is meaningless to pass laws without applying them. According to DWA (2013:71) even though South Africa has good laws governing potable water distribution, most of the SA rural areas still have no access to potable water supply from their local water service supplier or authority.

2.13.2. The Water Services Act (WSA) of 1997

The WSA of 1997 makes provision for an institutional legal framework for deliveries of potable water supply and sanitation, and it includes the following main objective:

- (a) setting of national standards and norms and standards for tariffs in respect of water services;
- (b) preparation and adoption of water services development plans by water services authorities;
- (c) regulatory framework for water services institutions and water services intermediaries;
- (d) establishment and disestablishment of water boards and water services committees and their duties and powers;
- (e) monitoring of water services and intervention by the minister or by the relevant provincial government;
- (f) financial assistance to water services institutions, e.g. Rand Water;
- (g) gathering of information in a national information system and the distribution of that information;

- (h) accountability of water services providers; and,
- (i) promotion of effective water resource management.

Notwithstanding the advantages of the aforesaid acts and policies, certain weaknesses remain. For example, the NWA of 1998 does not cover the problems that were created before 1998; this means that the environment or waters that were damaged prior 1998 are likely to remain as they are unless there is an immediate intervention by the national department. For example, most of the acid mine drainages (AMD) on the West Rand was as a result of poor mining practices. According to the DWAF (2004:14), pre-1994 there was no proper legislation that directly dealt with AMD. Furthermore, both the WSA of 1997 and NWA of 1998 failed to address the issues of human resource challenges, i.e. performance of the employees within DWA and other water service providers such as municipalities.

2.14. EXPLORATION OF SA POTABLE WATER POLICIES, SHORT AND LONG TERM OBJECTIVES

According to Biswas (1997:13) water policies in the 21st century must consider the important changes that have occurred during the past decade, and also the changes that are likely to occur in the coming years. It is not unexpected, therefore, that the NWA of 1998 highlights the need to redress the results of past racial and gender discrimination with respect to the allocation of potable water.

However, all water policies have risks and uncertainties associated with them. These could be social, economic or political challenges. One of the biggest challenges in any democratic society might be canvassing by politicians; with the aim of attracting votes. According to Moutloug (2010:25) voters believe that any promise made by the politician is likely to be fulfilled. This could become a challenge when they fail to keep their promises. “Vision 2030”, for example, indicates that by the year 2020 every household in South Africa should have a tap in their yard. This is a long-term objective of the South African government, which can be politically motivated.



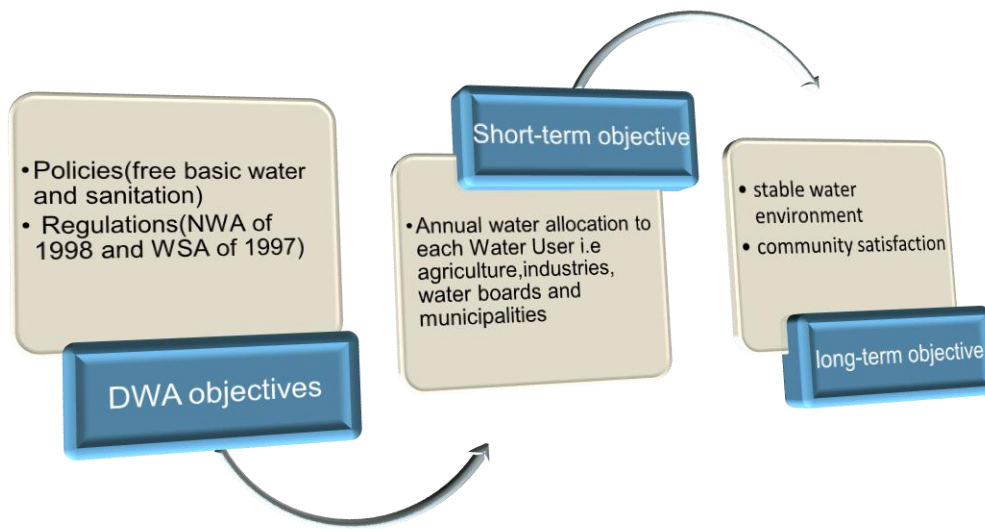


Figure 2.8: Long-term strategic process on water resource and distribution

Source: DWA (2012:12)

Having said that, the efficient use of the WAS programme for agricultural water distribution (irrigation) is also a long-term objective, which, according to Winter (2009:7), aims at conserving or controlling water usage in SA's agricultural sector. This control mechanism helps to create a stable water environment, which is a long-term objective of the department. However, the performance of WAS might also be largely influenced by the DWS's human resources and management. According to Benade (2011:15) while the WAS enabled WUA's to keep all their water usage information up to date and accurate, it also faced tremendous challenges due to the lack of proper skills and management within the SA water sector.

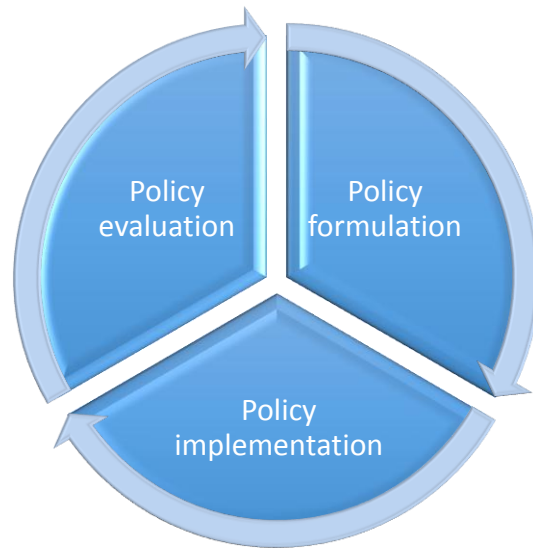


Figure 2.9: Policy management processes

Source: DPSA (2007:13)

As indicated in Figure 2.9 above, the strategic management process has to consist of three stages, namely strategy formulation, implementation and evaluation. As noted above, formulating policies and not implementing them serves no useful purpose. Thus the policy must not only look good on paper but it must also be applicable. The FBW policy stipulates the provision of 6000 ℓ free litres of potable water to poor households per month. This policy must be implemented by every municipality in the Republic of SA.

Any organisation in the world needs to have a long-term objective or plan, and in order to achieve that objective it first needs to set and meet short-term goals (Ricucci *et al.*, 2008:112). Failure to meet short-term targets can lead to failure in terms of achieving the long-term objectives. Hence policy evaluation is necessary, as indicated in Figure 2.9 above.

The following is a set of policies and regulations that guide South African potable water distribution:

(i) Basic sanitation policy

According to the World Health Organisation (2013:14) it is widely recognised that sanitation has an important impact on people's health. Toilets (both private and public) that are properly used and maintained can serve as a barrier to the faecal transmission of pathogens. The WSA of 1997 indicates that sanitation is not only about providing toilets, but also about the provision of health and hygiene education (DWAF, 1998:4). Furthermore, Winter (2009:33) indicates that, apart from sewage pipe leakages, rainfall run-off is the main carrier of dumped waste. However, there seems to be a challenge in South Africa when it comes to the implementation of sanitation programmes. According to DPLG (2007:45) municipalities are required to provide efficient sanitation to the communities at a local level. However, since the incorporation of sanitation into the DWS from 2014, some of the communities might not understand which authority is now responsible for providing sanitation programmes.

(ii) Free Basic Water (FBW) and sanitation policy,

The basic minimum standard of potable water supply can be defined as a sufficient quantity of potable water delivered within 200m of each household that has no municipal tap water connection, at a minimum flow rate of not less than 10 litres per minute (DWAF, 2008:21). However, it is a challenge to implement this regulation especially in illegal concentrated settlements such as *squatter camps*, in which there is no formal planning of human settlement by the designated authority (e.g. municipality).

The lack of formal planning in the city's squatter camps can be a serious challenge with respect to delivering potable water and sanitation. According to the DWA (2012:45) water loss through illegal tapping continues to be a major problem, especially in the informal settlements (*squatter camps*). Most of these informal settlements are found near urban developments such as cities and towns. Furthermore, according DPLG



(2007:24) members of poor rural communities across the country tend to migrate into metropolitan areas looking for a better life. One might then argue that the influx of rural communities into the urban areas put tremendous pressure on the metropolitan municipalities in terms of service provisions e.g. FBW and sanitation, simply because not all of them (migrants) get employed. STATSSA (2011:14) indicates that the number of people migrating into urban provinces such as Gauteng has almost doubled since 1999.

(iii) Interruptions in the provision of potable water services

According to the (DWAF, 1997:14) water service institution such as municipalities need to take reasonable steps to ensure that potable water supply is not interrupted for more than 24 hours. Water interruptions seem to be a major problem in most of SA's municipalities. According to DWA (2013:3) of approximately 5,900 protests recorded by the South African Police Service (SAPS) between 2004 and 2012, the majority were about inadequate water and sanitation service. The potable water service delivery protest in SA highlight performance challenges in some of the municipalities.

(iv) Quality of potable water

With the introduction of formal water quality regulations in South Africa, a survey was conducted among municipalities to determine the extent of drinking water quality monitoring (DWS, 2009:14). It was shocking to discover that more than 50% of the Water Services Authorities (municipalities authorised to govern the water service function) did not monitor the quality of tap water provided to their constituencies. Hence, the “blue and green drop certification programme” was established by the DWS minister to enhance co-operative governance in water and sanitation delivery by the municipalities. It is generally thought that the blue and green drop certification programme highlights the level of municipal performance when it comes to the delivery of quality potable water. According to the DWS (2011:13) the blue drop certification programme for drinking water quality management regulation was launched to monitor

the municipalities' compliance in terms of potable quality water delivered to the community. However, it places some municipalities in a disadvantageous position because the best performing municipality receives potable water from one water service provider, i.e. Rand Water. According to DWS (2013:14), the City of Johannesburg, Ekurhuleni and Sedibeng District Municipalities are among the top 10 achievers but they are all Rand Water Board recipients.

According to Muller *et al.* (2012: 15), the intention of the blue drop certification programme is to ensure (and/or monitor) that water services authorities provide potable water that is safe:

- for human consumption;
- for food preparations and personal hygiene;
- not harmful to water supply installations; and domestic appliances.

To facilitate the easy interpretation and reporting of water quality information, the water quality guidelines are presented in terms of a simple colour-coded system. Holland (2005:65) indicates that uneducated consumers also need to understand the water quality status of their potable tap water. Therefore colour coding can easily be interpreted by those who are illiterate.

Blue	(Class 0)	Ideal water quality -Suitable for lifetime use
Green	(Class I)	Good water quality -Suitable for use, rare instance of negative effects
Yellow	(Class II)	Marginal water quality -Conditionally acceptable. Negative effects might occur in some sensitive group
Red	(Class III)	Poor water quality - Unsuitable for use without treatment. Chronic effects might occur
Purple	(Class IV)	Dangerous water quality - Totally unsuitable for use. Acute effects might occur

Table 2.2: SA potable water Coded Classification System

Source: DWS (2008:47)

The above table outlines water quality information in terms of colour. This is also known as the water quality colour coding system.

pH	Manganese
Conductivity	Magnesium
Residual Chlorine	Aluminum
Turbidity	Antimony
Suspended Solids	Arsenic
Total Dissolved Solids(TDS)	Cadmium
Colour	Chromium
Ammonia	Copper
Chloride	Lead
Fluoride	Mercury
Nitrate	Nickel
Phosphate	Uranium
Sulphate	Zinc
Calcium	<i>E.coli</i>
Hardness	
Iron	

Table: 2.3: South African water quality macro-determinants

Source: DWS (1998:14)

Table 2.3 indicates macro water quality determinants that need to be assessed regularly by water service providers. For the purpose of implementation, the water service provider needs to regularly conduct water sampling at all water service points (i.e. water treatment plants and reservoirs outlets). Furthermore, according to the Department of Health and Social development (1998: 5) people have their own sense of what good and bad quality water is, without giving it too much thought. If water looks clean, they think it is of good quality. However, water that is murky, or has colour is considered bad. However, the reality is that clear water, without any smell, is not always safe to drink, because it might contain dissolved substances or disease-causing organisms that are harmful to health.

2.14.1. IWRM principles and NWRS regulations governing SA basic water provision

The concept of IWRM is an important factor, especially when one considers pre-1994 water laws in South Africa. The right to have access to water was racially linked. According to the DWS (2009:44) most of the Africans in the former colonial homelands were denied full access to water resources, land ownership and even the right to vote. This resulted in poor water infrastructure establishments, especially in most parts of SA's rural areas, which were mainly in the former homelands. Furthermore, the right of access to water was tied to land, which, according to DWAF (1997: 22) affected the majority of the Africans, who were segregated into smaller residential units that were usually densely-populated, and with limited potable water supply.

The previous water legislations in South Africa also failed to address the concept of environmental sustainability. One of the reasons could be that the previous apartheid government was only interested in promoting economic growth for the minority, especially in agriculture and the mining industry. According to the DWS (2007:24) before 1994 the right of access to water was linked to land ownership. This was a major problem because the majority of the Africans did not own land and were largely living in homelands. Therefore the previous apartheid policy also left a mark on the development of potable water infrastructure in the country. Some of the country's rural areas, especially in the former homelands, are still accessing potable water through communal taps (DWS, 2010:11). Kemerink *et al.* (2011:3) argue that communal taps can be traced back to the apartheid period, and that they are still in existence in the former homelands areas. However, not all of SA's potable water challenges were caused by apartheid; the increase in water service delivery protests also highlights poor performance by many of the local governments (municipalities).

Furthermore, the NWA of 1998 requires the minister to establish a National Water Resource Strategy (NWRS). The NWRS provides a framework for ensuring that water resources are protected and conserved for the long term, but also contribute to the attainment of the social and economic goals of the country (DWA, 2013:2). The attainment of these social and economic goals in potable water allocation is also



outlined in Section 27(1) (b) of South African Constitution, which indicates that everyone has a right of access to sufficient water.

However, the constitution does not define how much water is considered sufficient. The current free basic water policy indicates that 6,000ℓ per household (of 8) per month, is considered adequate. This is a major problem because culturally most African families consist of extended family members, especially in the rural areas.

2.14.2. National Water Resource Strategy (NWRS)

The purpose of the NWRS is to ensure that national water resources are protected, used, developed, conserved, managed and controlled in an efficient and sustainable manner towards achieving South Africa's development priorities (DWS, 2013:4). These priorities include sustainable economic, social and environmental development. However, it might be difficult to realise all these prioritised goals, because South Africa is a water stressed country. Furthermore, the NWA requires the NWRS to be applied across all spheres of government. According to the DWS (2013:4) the NWRS is the legal instrument for the implementation and alignment of the National Water Act (Act 36 of 1998), and it is thus binding on all authorities and institutions implementing the Act. In terms of the National Water Act (36 of 1998), the purpose of the NWRS is to:

- provide a framework for the protection, use, development, conservation; management and control of water resources for the country as a whole;
- provide a framework within which water will be managed at regional or catchment level, in defined water management areas;
- provide information about all aspects of water resource management, and
- identify water-related development opportunities.

The provision of a reliable information framework outlined in the NWRS1 of 2004 resulted in the installation of the WAS programmes most South African GWSs in that same year (DWA, 2009: 6). However, at that time, there were deficits in more than half



of the water management areas. The implication was that there was no surplus water available for allocation in those water management areas. Moreover, despite its achievements, the NWRS1 faced various challenges which were then addressed in the NWRS 2. The outstanding challenges of NWRS1 were (DWS, 2013:23):

- achievement of water conservation demand management targets;
- streamlined water allocation reform to redress past racial and gender imbalances in terms of access to water for productive uses and to address poverty and inequality;
- implementation of environmental flow monitoring;
- establishment of water management institutions and the decentralisation of water resources management;
- strengthening of the regulation of water resources and water quality;
- improvement of technical and management skills to implement developmental water management;
- improvement in the integration of monitoring and information management and
- reduction in the backlog of infrastructure.

According to the DWA (2013: 22) NWRS 2 responded to the National Development Plan (NDP) of November 2011, which was aimed at reducing inequality, expanding infrastructure and eliminating poverty. The most important factor in the NWRS2 is an adequate availability of water (sustainability) for the planning and development of all sectors. The NWRS2 is an addition to NWRS1. According to the DWS (2013:27), the intention of the NWRS2 was to place water at the heart of all planning in South Africa, so that any decisions that relied on the steady supply of water could be implemented. The general weakness of all these strategies might well be the lack of enforcement and implementation due to a lack of willing personnel. The national water policies and existing legislations failed to address this issue.

2.15. STAKEHOLDERS PARTICIPATION IN SOUTH AFRICAN BASIC WATER PROVISIONS

According to Riccucci *et al.* (2008:23) public participation is viewed as an activity undertaken by one or more individuals previously excluded from the decision-making process. Creating an environment of dialogue with respect to water-related issues is important. The standard problem of public participation might be when major stakeholders are left out of the process. Chrislip and Carl (2002:124) indicate that stakeholders who are left out of the public consultation process are likely to look for other means to raise their concerns. Koundouri (2003:1-12), further argues that although participation is encouraged in a democracy, reality shows that in most poor or developing world countries it might be limited due to the fact that:

- some activities require technical knowledge and most communities in these countries are under-educated or un-educated(illiteracy); and
- there is a diversity of languages.

Thus public engagement regarding some of the government policies or regulations, e.g. the NWA 36 of 1998 and WSA 108 of 1997 might be difficult to achieve. This could be largely influenced by the fact that most of the people in the rural communities in South Africa are illiterate (STATSSA, 2011:42). This could be a serious challenge, especially when the government wants to adopt policies that contain technical terms that are difficult to translate into a SA indigenous language. The water and sanitation policy in South Africa, for example, highlights the need to allocate 6000ℓ of potable water a month free of charge to poor households. This could be difficult to interpret for some of the uneducated (or poorly educated) households heads. However, the Constitution of the South African Republic requires that the institutions of the state ensure that they incorporate public participation in all government programmes (RSA: 1996).



2.16. CONCLUSION

In this chapter various facets of potable and irrigation water, IWRM, and some water supply challenges facing our natural resources globally were discussed. The chapter started off with a section on IWRM, in which models (systems) of managing surface water were noted. Complex irrigation systems such as water productivity in the irrigation systems were then described, with a subsection on GMO (irrigation productivity). The South African irrigation system, in particular the uniquely SA water programme WAS was then explored, along with how it contributes to promoting IWRM principles and whether it fits with the DWS's NWRS strategies, followed by the irrigation civil structure. The state of SA potable water and its legal framework, which is vital to socio-economic development, were also discussed. The latter included the NWA 36 of 1998, WSA of 108 of 1997 and the Municipal Indigent Policy which focuses primarily on the provision of free basic water services to the indigent (poor residents who lacks basic necessities). The chapter concluded with various potable water provisions as stipulated in the WSA section 108 of 1997.

In the next chapter the methodology used for potable water distribution and the WAS used in Potchefstroom (Mooi River GWS) as part of IWRM (social, economic and environmental) will be discussed, weigh and explored using both a qualitative and quantitative approach.

CHAPTER 3: RESEARCH METHODOLOGY

3.0. INTRODUCTION

The research explores a set of three research approach as discussed below. However, the study utilises the mixed research methodology. The primary reason, was indicated earlier in section 2.8 i.e. Water Administration System (WAS) components entails quantitative (scientific or numeric) and qualitative (personnel functions) data. Hence, the research approach (mixed methodology) enabled the researcher to explore both the qualitative and quantitative data of the studied phenomenon (water distribution in Tlokwe Local Municipality).

The chapter conclude by exploring the two selected methodology or models i.e. Strength Weakness Opportunity and Threats (SWOT) and System Model(SM).

3.1 THE RESEARCH DESIGN AND METHODOLOGY

According to Delport *et al.* (2011:435) one of the major problems with research is the gap that exists between policy makers, practitioners and the researchers. A possible solution for closing this gap could be by studying problems that are of great relevance to policy-makers and practitioners, and possibly by disseminating the results (Van der Vyver, 2011:62). At present there are very few water resource management specialists in South Africa, and this has left a void (knowledge gaps) in understanding how water resources and its management affect our society as a whole. Gouws (2010:4) indicates that in 1992 the United Nations Conference on Environment and Development (UNED), stipulated that by 2000 all countries should have action programmes for water management, based on catchment and/or sub-basins catchment, along with efficient water use programmes.

The development of WAS water use and efficiency programmes in the SA agriculture sector started in about 2004. However, as mentioned earlier, the intended purpose of developing and implementing WAS was to control and manage the increasing water

losses and usage across all GWS's and WUA's. According to Benade (2011:14), WAS typically involves technological, business and environmental perspectives. Therefore the system requires a combination of different paradigms or disciplines (i.e. social and scientific) in order to fully explore its social, economic and environmental implications in Tlokwe local Municipality (TLM) jurisdiction. Apart from the increase in agricultural consumption (irrigation) across SA, as indicated in the previous chapter, most municipalities seem to be facing potable water delivery challenges. According to Motloung (2010:79), the population increase in SA is placing tremendous pressure on municipalities as they are expected to meet the increasing potable water demands.

Due to all of the above mentioned challenges, a proper research methodology is required in order to fully explore irrigation and potable water distribution. Therefore, the focus in this chapter is to discuss the methodology that is most suitable for exploring the irrigation components used by Mooi River GWS, e.g. the implementation of WAS, water policies and regulations (e.g. WSA of 1997) in the provisions of potable water service by TLM. The end result of determining the best methodology is not to take side but to explore the perceptions and, where necessary evaluate, analyse and explore the problems and give recommendations.

3.2. RESEARCH METHODOLOGY

The WAS typically involves technology, water use (distribution) and management components, and this invariably leads to the combination of different disciplines and paradigms. However, there are various methodological approaches that can be used in an evidence-based or action research strategy. In the following sections various methodologies, designs and data collection methods that are available will be discussed, and the one that is more relevant for this study will be indicated.

3.2.1. Qualitative research methodology

Creswell and Plano (2007:14) defines qualitative research as process of enquiry aimed at understanding social or human problems based on the complex holistic picture, with reporting of views from informants and conducted in a natural setting. From this definition, one can then say that the researcher partly becomes a participant in the qualitative research. This view is supported by Coulter *et al.* (2009:45), who argue that in most qualitative or social research the researcher aims to be detached from the studied phenomenon. However, this is not entirely possible; according to Delport *et al.* (2011:48) humans are largely influenced by ethnological, ontological, epistemological and axiological beliefs in the interpretation of their surrounding environment.

Because of the physical characteristics of the studied phenomena (WAS and potable water distribution components), the use of qualitative research methodology alone cannot fully explore the studied phenomenon. However, it might be useful to trying to explore the “deep feelings” or perception of various stakeholders in Potchefstroom, i.e. the irrigating farmers and TLM.

3.2.2. Quantitative research methodology

De Vos *et al.* (2011:142-157) classify quantitative research designs into two main categories namely experimental and non-experimental designs. According to these authors, non-experimental designs are used mainly in descriptive studies in which the units that have been selected to take part in the research are measured on all relevant variables at a specific time without manipulation. For example, the quantity of water supplied to the farmer over a period under a scheme, in this case the Mooi River GWS, can be measured. The most widely used non-experimental research design is surveys. Field surveys were employed in this research in order to gather a high degree of reliable data (on irrigation at Mooibank farms and TLM potable water distribution components).

According to Delport *et al.* (2011: 144) the advantage of using a quantitative research methodology is that the experimental variables are independent from the researcher. In

other words, the researcher acts as an observer. Therefore the interpretation of the actual data collected is independent of philosophical interpretations by the researcher, i.e. ontological, axiological and epistemological constructs.

3.2.3. Mixed research method

According to Creswell and Plano (2008:34), the mixed-methods research design incorporates techniques from qualitative and quantitative methods to answer the research questions. Other authors such as Delport *et al.* (2011:435) describe mixed-methods research as a procedure for collecting, analysing and mixing both qualitative and quantitative data at some stage in the research process within a single study to understand a research problem more completely. This study was conducted in light of the latter view of the mixed-methods research approach or methodology. Using this approach will comprehensively answer the research questions stipulated in section 1.4. Furthermore, according to Creswell and Plano (2007:6-9), also quoted by Delport *et al.* (2011:435), the following major elements are important in a mixed research methodology:

- the research involves the collecting and analysing of both quantitative and qualitative data, meaning a researcher collects both numerical and text information;
- the mixing of data is a unique element of mixed research. It means that it is not enough to simply collect and analyse quantitative and qualitative data, they need to be mixed in some ways so that together they form a more complete picture than they would when standing alone; and
- mixed-methods studies might involve collecting and analysing qualitative and quantitative data within a single study or within multiple studies in a programme of inquiry.

3.3. RESEARCH DESIGNS (STRATEGIES) AND FOCUS

There are various research strategies or methodologies that can be used by the researcher in the quest for gaining new knowledge. According to Fowler (2009:14)



research design (strategy) refers to how a study is planned and carried out, further indicating that it is likely to involve more than one research method or technique of investigation. The following are some of the examples of research strategies (Van der Vyver : 2010: 66-67):

- case studies, which focus on one instance of a particular phenomenon with a view to providing an in-depth description;
- surveys or viewing with the aim of obtaining detailed data about the situation;
- internet or e-research, which provides access to huge volumes of data at a relatively low cost;
- experimentation, with the aim of isolating individual factors and observing their effect in detail;
- ethnography, which aims at providing a detailed and permanent account of people's cultures;
- action research, normally associated with hands-on, small-scale research projects with a focus on practical issues;
- grounded theory, in which theories are developed on the basis of empirical research, which then build up general theories that emerge from the data; and
- the phenomenological approach, which deals with personality, in other words how each person perceives, understand and interprets the world (or things) around them.

Prior to the 1990's, water resource management was viewed as an environmental concept. However, following the United Nations conference on water and the environment in 1992 in Dublin, most of the governments introduced the concept of Integrated Water Resource Management (IWRM) in their allocation of natural water resources (Biwas, 1997:14). This was largely due to the fact that water plays a vital role in social and economic development. Gouws (2010:58) argues that for sustainable development to continue social, economic and environmental development need to be approached simultaneously. This means that if one component lags behind (i.e. social, economic or environmental) the other two will suffer; hence sustainable development can no longer be achieved. In other, words humans are simply part of the environment; therefore their social and economic activities have an effect (impact) on their

surrounding environment. With this said, it is therefore vital to use more than one research methodology, so that all the (IWRM) concepts are fully addressed, with respect to the provision of irrigation water to the farmers and potable water to the Potchefstroom community.

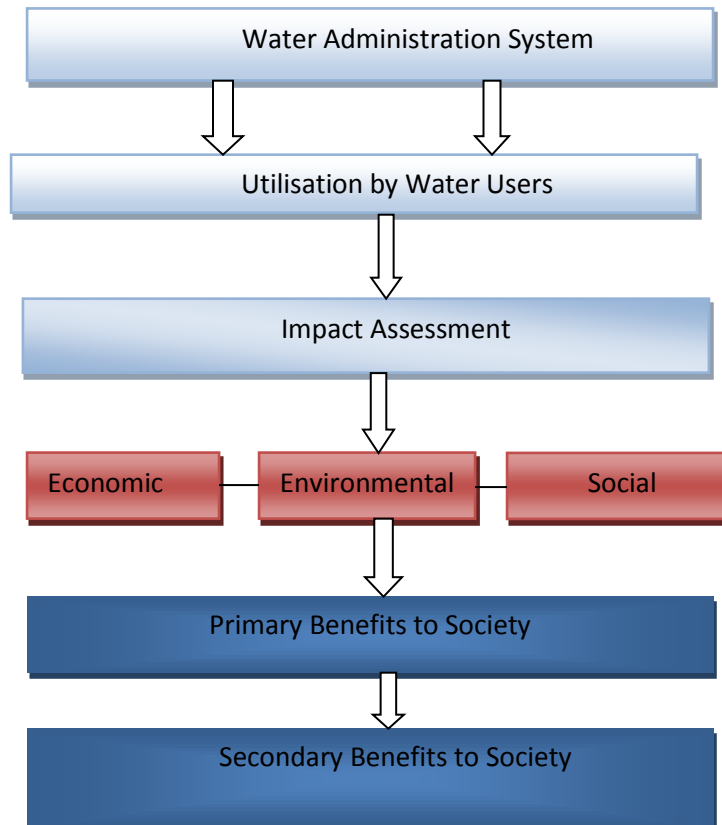


Figure 3.1: Overview of WAS impact assessment

Source: Winter (2009:18)

Figure 3.1 above illustrates how the WAS operation affects the society in most of the environment, in this case the area of study (Potchefstroom). This study is a field design, which according to Bailey (1994:124) is a study conducted in the field or natural habitat of the subject being studied as opposed to an artificial experimental laboratory.

3.4. RESEARCH DATA COLLECTION METHODS

There is an array of data collection techniques available that can be employed by the researcher to discover the necessary valid information. Even though water distribution (or resource management) is primarily a natural scientific field, its operation affects societies (socially and economically). By taking these socio-economic factors into consideration, as well as a factor such as the physical properties of natural water resources (environment), it is necessary to collect data by means of field survey. Delport *et al.* (2011:235) indicates that when conducting surveys, researchers usually use one or both of two basic research methodology approaches, i.e. data derived from two types of variables, namely quantitative and/or qualitative variables. However, the ultimate goal of any social and/or scientific research is to generate facts, or to correct or validate information as much as possible (to the highest degree).

In this research both primary and secondary data is used in the quest to explore water distribution and efficiency at Mooibank farms provided by Tlokwe Local Municipality (TLM) purification water works. In this study the primary data refers to the data collected in the field, while secondary data denotes the data collected from other sources.

3.5. WATER DISTRIBUTION COMPONENTS AND BENCHMARK (LEVELS)

Gouws (2010:81) indicates that in South Africa, equitable water allocation has been an emblematic policy goal driven by the imperative to create a more equitable society, indicating that it was influenced by the apartheid system of separate development and racial inequality, with the majority of black people excluded from the provision of basic water, and secondly, by the poor climatic conditions, namely an average rainfall of less than 500 mm per year. In light of these major trade-off factors, it was necessary for the post-apartheid South African democratic government to implement policies and regulations that would address equity, efficiency and sufficiency in the distribution of



natural water resources in the interest of all its citizens. These included regulations such as the Water Services Act (WSA) of 1997 and the National Water Act (NWA) of 1998, which was discussed in section 2.13.1 above. Most of the current policies and water laws in SA are based upon these two major regulations (the WSA of 1997 and NWA of 1998).

Furthermore, potable water components have absolute minimum and maximum values, with which water service providers (WSPs) such as municipalities need to comply in terms of water quality and quantity. The benchmark levels and management components (of potable water supply) with which TLM is expected to comply will be discussed later on. But first the expected irrigation water components benchmarks in Mooi River GWS will be discussed below.

3.5.1. Agriculture water use (irrigation)

Mooi River GWS is one of the three irrigation schemes in North West Province that make use of WAS programme in distributing irrigation water to the farmers (DWS, 2007: 24). Regardless of the fact that major GWS make use of one programme (WAS), their methodology in distributing water for irrigation differs. That means each GWS will distribute water in the way that it feels most suitable. As mentioned in section 2.1 the SA agricultural sector uses about 60% of the country's surface water for irrigation purposes. By taking into consideration the SA population dynamics (i.e. immigration and population increase) as highlighted in STATS (2011:42), the productive usage of irrigation water (to enhance food security) remains a critical issue. Hence, there is a need for an effective use and conservation of water for irrigation by various water users (WUA, GWS and Water Irrigation Boards) across the country. However, Biswas (1997: 45) argues that theoretically most water programmes are considered highly efficient in a scientific community, but poor personnel functions might render them to be ineffective. One might then argue that the application of water programmes in distributing irrigation water (methodology) is not only reliant on the scientific recommendations but is also influenced by human behaviour.

In the following sections each method used for managing and controlling irrigation water by various SA GWSs will be explored:

(a) Maximum Abstraction Right (MAR)

One of the distribution methodologies (strategies) to control the amount that each farmer may request per period is the Maximum Abstraction Right (MAR):

- $$\text{MAR} = \frac{T}{A} * (Q - L)$$

$$= \text{m}^3/\text{hectar/period (units)}$$

Where in:

MAR = Maximum Abstraction Right of each farmer,

T = Time/duration of water flow of the scheme/WUA (s) ,

A = Scheduled area of the farm (m³)

Q = Water discharge (m³)

L = Water losses (m³)

Note* 1 m³ = 1000ℓ

(b) Scheduling

According to the DWAF (2007:34) scheduling refers to the area of the farm that a farmer is allowed to irrigate. It is considered illegal water use, when a farmer irrigates a portion of land that is unscheduled by the GWS or WUA. However, the GWS or WUA benchmark differs, as it is largely dependent on the climatic and hydrological characteristics of the catchment.



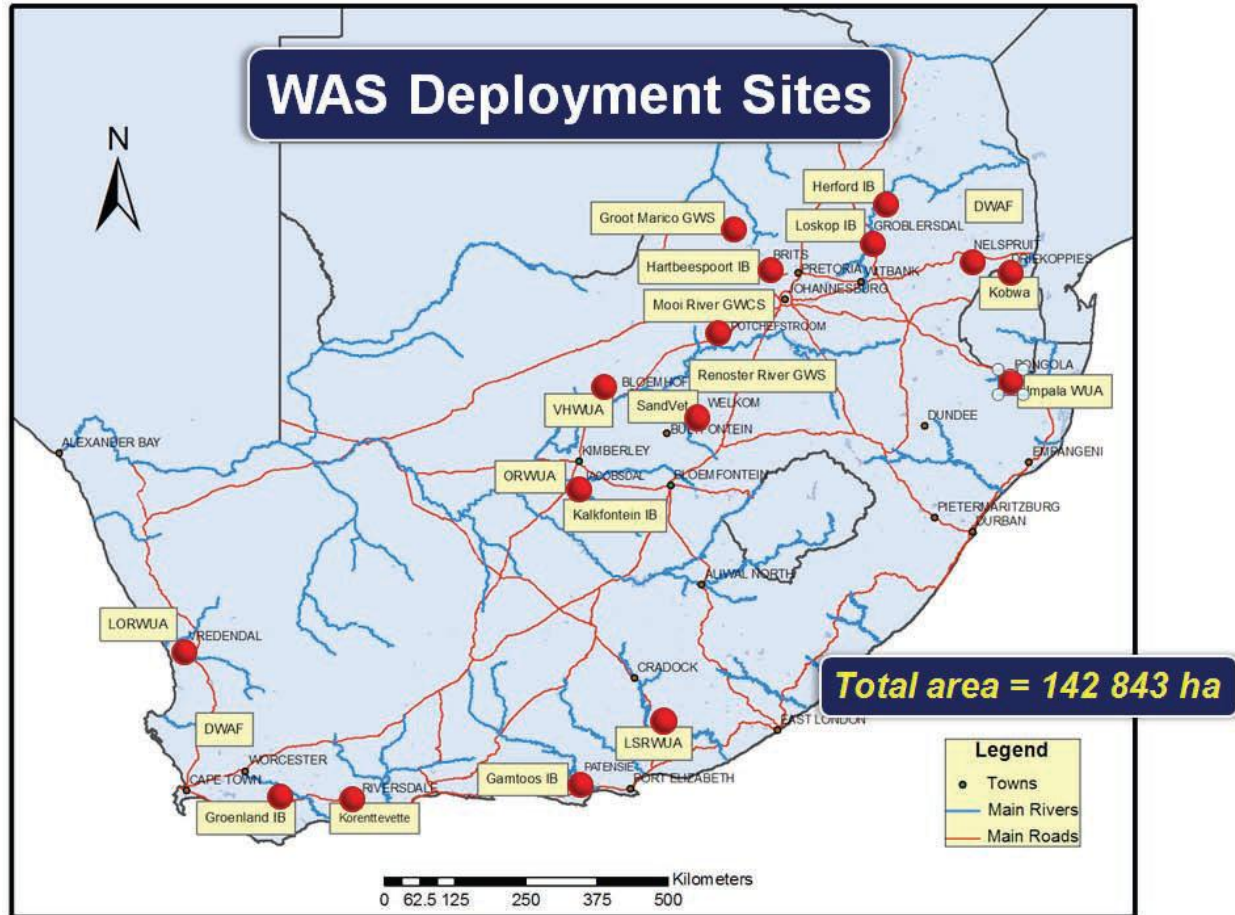


Figure 3.2: Location of irrigation schemes utilising the WAS by region

(Source: Winter, 2009: 13)

Figure 3.2 indicates the location of irrigation schemes utilising WAS in SA. According to the DWA (2013:14) all the major schemes (GWSs) employ the MAR and the scheduling method in supplying water to the irrigating farmers. As indicated in section 3.2, the application of WAS has a serious impact on the economic, social and the environmental conditions in its area of operation. Therefore, a GWS has a responsibility to ensure that the WAS application is applied in a proper manner. In other words, it should not be used as a tool for suppressing (some of the) irrigating farmers.

Based on previous work done by Benade (2011:14) Mooi River GWS has an annual quota allocation of 7,700 m³/ha. This can therefore be viewed as a benchmark for allocating irrigation water. Any deviation from this can be considered illegal or mismanagement on the part of the service provider (Mooi River GWS). According to the

DWA (2013:12) irrigating farmers usually deplete their annual quotas before the end of the water year primarily as a result of:

- A lack of proper communication between GWSs and WUAs (i.e. in terms of water(irrigation) regulations and their implementations);
- poor climatic conditions (prolonged dry periods);
- over-cultivation; and
- administrative errors and/or mismanagement by the WSP (GWS).

Some of the irrigating farmers might even increase their water intake (illegally or legally) from the GWS irrigation networks in order to increase food productions. However, even though the irrigating farmer might view this as good practice as it potentially generates profit, it might unfortunately lead to a fast depletion of the natural reserves. The bottom line is that farmers in the Mooi River GWS are expected to comply with their approved water allocations.

3.5.2. Canal water use and efficiency (WUE)

One of the most crucial elements in water distribution is the method used to deliver water to the user. There are various methods that are used to deliver water. DWAF (2005:32) indicates that the common method of delivering water includes canals, siphons, ducts and pipes. However, all these methods have certain types of water losses. According to the Winter (2009:23) most of South Africa's GWS's (including Mooi River) deliver irrigation water through canals. These canals have certain types of accepted losses. It is impossible to distribute water through a canal system without incurring losses, but it is imperative that these losses should be limited to the absolute minimum. According to the DWS (2007:19) the efficiency of control (loss from canal leakages and spilling) should at least be less than 15% of the total water supply from the point source. This implies that the canal system should have an efficiency of not less than 85 %.

$$\text{Efficiency of Canal} = \frac{\text{Total-consumption}}{\text{Total-released}} \times 100$$

∴ Benchmark level = 0.85



Photograph 3: Mooi River GWS Boskop right back canal (Source: Phillip Mulovhedzi)

3.5.3. Irrigation water applications methods

Irrigation farmers are required to submit an application indicating the day, time and quantity of water that they want per period (or week). The handing in of the water application to the water service provider (GWS) for irrigation has time-frames. However, this (time-frame) differs among various irrigation water service providers, i.e. Mooi River GWS will have its own regulations, as agreed upon by both the irrigating farmers and the management. In cases in which the irrigating farmer cannot make it in time, he may fill in a special addition form. This indicates that the capturing of application forms (shown in Figure 3.4 below) in time on WAS is necessary for the preparation, management and control of the irrigation water allocated to the farmer.

DW 246 E

DEPARTEMENT VAN WATERWESE EN BOSBOU
 DEPARTMENT OF WATER AFFAIRS AND FORESTRY

SPESIALE AANSOEK OM WATER • SPECIAL APPLICATION FOR WATER

Ek die ondergetekende, doen hiermee aansoek om water soos aangedui; redes;
 I, the undersigned, hereby apply for water as set out below; reasons;

.....

.....

	Sluis No. Sluice No.	Vloeitempo Rate of flow	Ure Hours	M		D/T		W		D/T		V/F		S		S	
				D	N	D	N	D	N	D	N	D	N	D	N	D	N
Aanvraag Application																	
Goedgekeur Approved																	

Besproeier Datum Toevoer voor Periode
 Irrigator Date Feeder Period

Aansoek is op ontvang en word toegestaan/nie toegestaan soos aangedui.
 The application was received on and may/may not be allocated as indicated.

Handtekening Rang Datum
 Signature Rank Date

Ek aanvaar hiermee die bostaande toekenning van water deur die Departement.
 I hereby accept the above-mentioned allocation of water by the Department.

Besproeier Datum
 Irrigator Date

Opmerkings/Remarks

Phuthuno (012) 335-9134

Figure 3.3: Special water application form (Source: Mooi River GWS, 2015)

3.6. SOUTH AFRICAN WATER DISTRIBUTION SYSTEM ANALYSIS

The system analysis can be defined as an analytical or exploratory study that helps a decision maker to identify the problems using a set of scientific and/or social methods on which a studied phenomenon is based on (Biswas, 1997:7). As indicated in section 1.5, the Tlokwe water distribution system analysis provides the answers to the problems facing Mooibank irrigation farmers and TLM water purification works. Hence the researcher applied both the physical and social techniques and models available to explore water distribution challenges in the area of study.

It was highlighted in section 1.3 that the SA government has to ensure that every citizen has an adequate supply of potable water. The access to “adequate potable water”

seems to be an area of disagreement (contention) between Mooibank irrigating farmers and TLM (water purification works). According to Motloun (2010:42) most of the communities or civic organisations across the country demands that government meet this specific obligation (supply of adequate water), notwithstanding the huge financial costs that is associated with it. These demands could be a result of political campaigns or promise made by some of the politicians.

Furthermore, according to the DWA (2013:51) the financial cost that municipalities or any public water service provider need to bear, includes the cost of maintenance and upgrading of water infrastructure. This might include services costs for the water pumps, canals, reservoirs and other water reticulation networks components. However, besides the infrastructural obligations (possible maintenance or expansions challenges) there seems to be other factors as well, e.g. the South African political environment. Motloun (2010:42) indicates that the conflicts between municipalities and most of the SA communities is a result of political parties' campaigns. He indicates that since 1994 the ruling political party, i.e. African National Congress (ANC), has been promising to provide free basic services, i.e. houses, sanitation and water to all poor communities.

However, one might further argue that the current government (ANC) is not the only one to take the blame. The previous apartheid government also shares some of the blame. A study by DPLG (2007:14) indicates that the previous historical injustice, namely the *apartheid policy*, undermined blacks or indigenous communities, especially those living in the townships or former Bantustans, and resulted in the imbalance of basic services provisions.

In light of the highlighted background (both the historical and current public government system), two models (methodologies) were used to explore water distribution in the area of study, i.e. the Systematic Model (SM) and SWOT (Strength, Weakness and Opportunity and Threat) analysis. Both models will be explained in the following section.

3.6.1. The Systems Model

According to Van Zyl (2010:87-102) the systems model(SM) is an effective method for establishing the quality or effectiveness of public (departments) service providers to fulfil their communities' needs, i.e. Mooi River GWS and/or TLM are both government and public institutions. The community's needs in this case is an adequate supply of potable and irrigation water (see Figure 3.4 below).

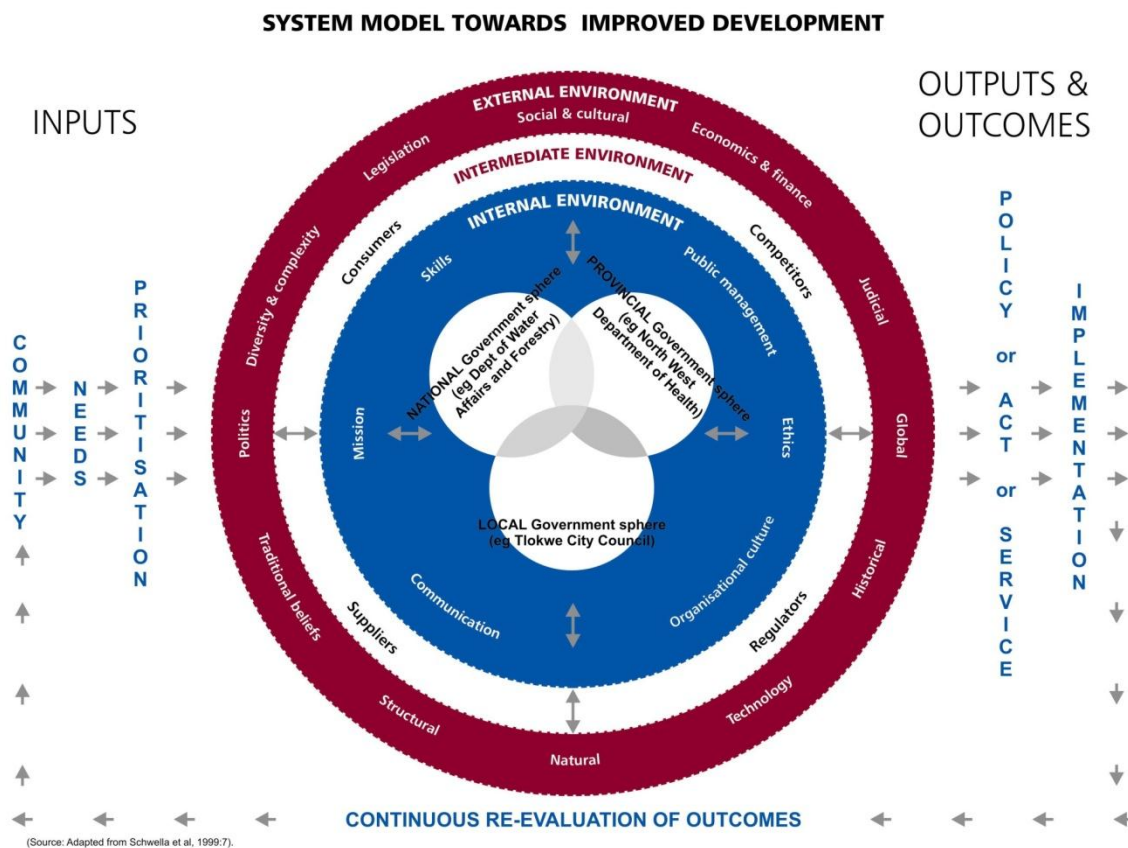


Figure 3.4 System model towards improved development.

Source: Van Zyl (2012: 78)

The assessment of SM components towards improved development of potable water service will be the most suitable approach for determining or evaluating potable water provisions by Mooi River GWS and/or TLM. This type of methodology allows the researcher to explore the situation of water distribution holistically, and furthermore

reveal how the inputs (e.g. community needs), output processes and systems affect water service provision (Mooibank farm irrigation and/or potable water) in Tlokwe. Hence, the SM will determine or explore the underlying factors that might be causing tensions (water conflicts) among major water stakeholders in Tlokwe i.e. Mooibank irrigating farmers and TLM (purification water works).

3.6.1(i) The SM internal environment

COMMUNITY NEEDS	POLITICIANS	PUBLIC MANAGER	NON-MANGERIAL TASKS
e.g. potable water	Political responsibility	Managerial tasks	
	• Liaise with politicians • Liaise with community • Policy-making	• Planning • Organising • Personnel • Financing • Control	• Functional work

Table 3.1: Management method in the public sector

(Source: Fox & Meyer, 1995: 77)

The management of public sector services as indicated in table 3.1 above takes place within various environments, such as political, economic, social, cultural and technological environments. Fox and Meyer (1995:77) define public sector management as one of an official's tasks, which have to do with policymaking, organising, leadership, control and evaluation. By implication, the supply of potable water by TLM and Mooi River GWS (as public institutions) will be directly dependent on political, managerial and non-managerial tasks. Therefore, through interviews (qualitative assessment) and also

quantitative analysis (scientific data) the researcher might be able to assess or explore the level of potable and irrigation water service provisions by both the Mooi River GWS and TLM (purification water works).

The best approach to analysing both the collected quantitative and qualitative components in relation to potable and/or irrigation water provision will be through benchmarking. Delport *et al.* (2011:77) indicate that benchmarks are effective in analysing the efficiency of any service provisions. The idea behind benchmarking is that it enables one to determine whether outputs meet the set targets. According to Fowler (2009: 54) all the water resource components encompass optimum and minimum values of use. Hence, it will be termed non-compliance if either one of the WSP (Mooi River GWS or TLM) is deviating from the approved benchmarks (minimum or maximum values). In terms of the potable water provisions WSPs, in this case TLM is expected to comply with approved potable water distribution benchmarks in relation to the elements of quality and quantity. In other words, TLM is expected to provide a certain quantity of quality water to each household, e.g. Free Basic Water (FBW) policy requires WSP to allocate or supply 6,000 ℓ litres to poor household within its jurisdiction.

In terms of farm water supply or irrigation, Mooi River GWS is expected to comply with the recommended scheme MAR and more importantly it is expected to have proper (efficient) canal infrastructure. According to DWAF (2005:43) the canal water losses should fluctuate between 9 and 17% (i.e. minimum and maximum optimum values).

3.6.2. SWOT- analysis methodology

According to Coulter *et al.* (2009: 145) SWOT-analysis is important in order to identify the tactical unit or the department's strengths, weaknesses, opportunities and threats. As indicated in section 1.5, there is pressure due to the growing demand for water by TLM purification water works and Mooi bank irrigating farms, which has resulted in contentions between the Mooibank irrigating farmers and TLM (purification water works). One might concur with Coulter *et al.* (2009: 145) by suggesting that the SWOT-

analysis is important for this study as it might give insight into the organisation's performance in relation to the implementation of its strategic goals or policies.

As indicated in section 2.11 strategic goals or policies are the foundation of planning; hence SWOT-analyses provide water institution managers with insight in terms of whether some of the goals (strategies) need to be changed. After analysing the current status of water distribution and environment, the managers (TLM and Mooi River GWS) might (need to) assess what they have learnt in terms of opportunities that their organisation can exploit, and threats that they must counteract or buffer against. Besides managers, SWOT-analyses might give insight to the TLM community members (stakeholders) on how they might need to change some of their ways with respect to water usages.

3.7. CONCLUSION

In this chapter various research methodologies required for the assessment of Mooibank GWS (irrigation) and TLM potable water distribution components were discussed. The chapter started off with a discussion of various research methodologies, further indicating one that is suitable for exploring TLM irrigation and potable water distribution components. The first section on this chapter, was on the calculations of irrigation water components which are basic concepts of the WAS programme. This was followed by the section on the assessment of the SM components aimed at improved development. Thereafter, the chapter concluded with a discussion of the SWOT-analysis. In the next chapter the actual or empirical data collected (i.e. quantitative and qualitative) from the Mooi River GWS, Mooibank irrigating farmers and TLM purification water works will be described and analysed.

CHAPTER 4: EMPIRICAL FINDINGS: WATER DISTRIBUTION AND PURIFICATION BY TLM (THE CASE OF MOOIBANK FARMS)

4.1. Introduction

Introduction this chapter, the Tlokwe water distribution data collection process and the analysis thereof, using both a quantitative and qualitative approach, will be outlined. The first sections comprises an outline of the quantitative data that was collected, i.e. the physical irrigation data pertaining to the Mooi River Government Water Scheme (GWS), the sampling procedures used and the analysis of the data. This will be followed by an evaluation of data collected from the respondents through face-to-face interviews. The manner in which the interviews were conducted was determined by the status of the respondents (officials). For example, the Mooi River GWS and Tlokwe management officials understand the basics of the National Water Act (NWA) of 1998 and the Water Services Act (WSA) of 1997. Therefore they were interviewed to establish an understanding of the underlying problems that they encounter and their coping strategies with respect to the distribution of both irrigation and potable water in Tlokwe.

This is followed by sections on the analysis of the collected qualitative data using systematic model (SM) and SWOT methodology.

4.2. Data collection

According to Grinnell (1993: 441) research data collection is defined as a procedure (or collection process) in which the techniques to be employed and the measuring instruments that will be utilised in the research are specified. In addition Bailey (1994:32) indicates that this data collection process could take various forms. However, as mentioned in Chapter 1, the study follows a mixed-methods approach. This is due to the fact that irrigation water distribution components and domestic purposes involve physical, socio-economic and environmental dimensions i.e. integrated water resource management (IWRM) concepts. Therefore, the application of only one methodology in

the study, for example the qualitative approach as mentioned in chapter 1, would have excluded important physical water distribution components such as chemical (e.g. water quality data) and physical components (maximum abstractions rights, canal water use and its efficiency) that form part of the Water Administration System (WAS).

As outlined in Chapter 3, these physical water distribution components are fundamental to analysing some of the policies, with a view to determining the compliances of water supply by the Mooi River GWS and, in some respects, the analysis of the Tlokwe potable water abstractions data. This research into water distribution covers a 10 -year period, namely the 2005/6 to 2014/5 financial year.

4.3. Data source(s)

The data for this study were obtained from the Mooibank canal data loggers, the Water Administration System (WAS), Mooi River GWS and Mooibank irrigating farmers. Please see appendices A and B for the research questionnaire and the Tlokwe Local Municipality (TLM) purification work chemical data. The research for this study, took the form of a field survey to collect primary data. Secondary data was sourced from TLM, Mooi River GWS and Department of Water and Sanitation (DWS) publications. According to DWS (2009:23), the accuracy of the data from WAS is 95% assured. In other words, it has a scientific standard error of 5%. In addition to the collection of water distribution statistics or scientific data, questionnaires were distributed and interviews conducted in the area of study. These questionnaires and scheduled interviews were given to and conducted with all the affected stakeholders, that is, Mooi River GWS and TLM purification water works officials and Mooibank irrigating farmers.

4.4. Data collection and sampling procedure used

.According to Grinnell (1993:240) sampling is the choosing of a small portion of the total set of objects, events or persons that collectively become the subject of the study. As

indicated in 1.6.2 above, the study applies stratified data sampling. The population was divided into recognisable, non-overlapping sub-populations or strata. According to Jarbandhan and Schutte (2006:661), the sampled strata must differ from one another by taking into consideration the variables that are required in the investigations.

It is therefore clear that if different strata are identified, the data can be easily analysed. The analysed data can in turn lead the researcher to arrive at findings that might determine the root causes of the studied phenomenon and even how some of the data components overlap with other strata. In this case, Boskop left bank canal (also known as LRO), acts as the main water supplier to the TLM purification water works and Mooibank irrigating farms. Therefore the collected data analysis of Boskop LRO canal (water distribution) automatically indicates the water trends that are causing bad relations between TLM purification water works, and then lastly Mooibank's irrigating farmers.

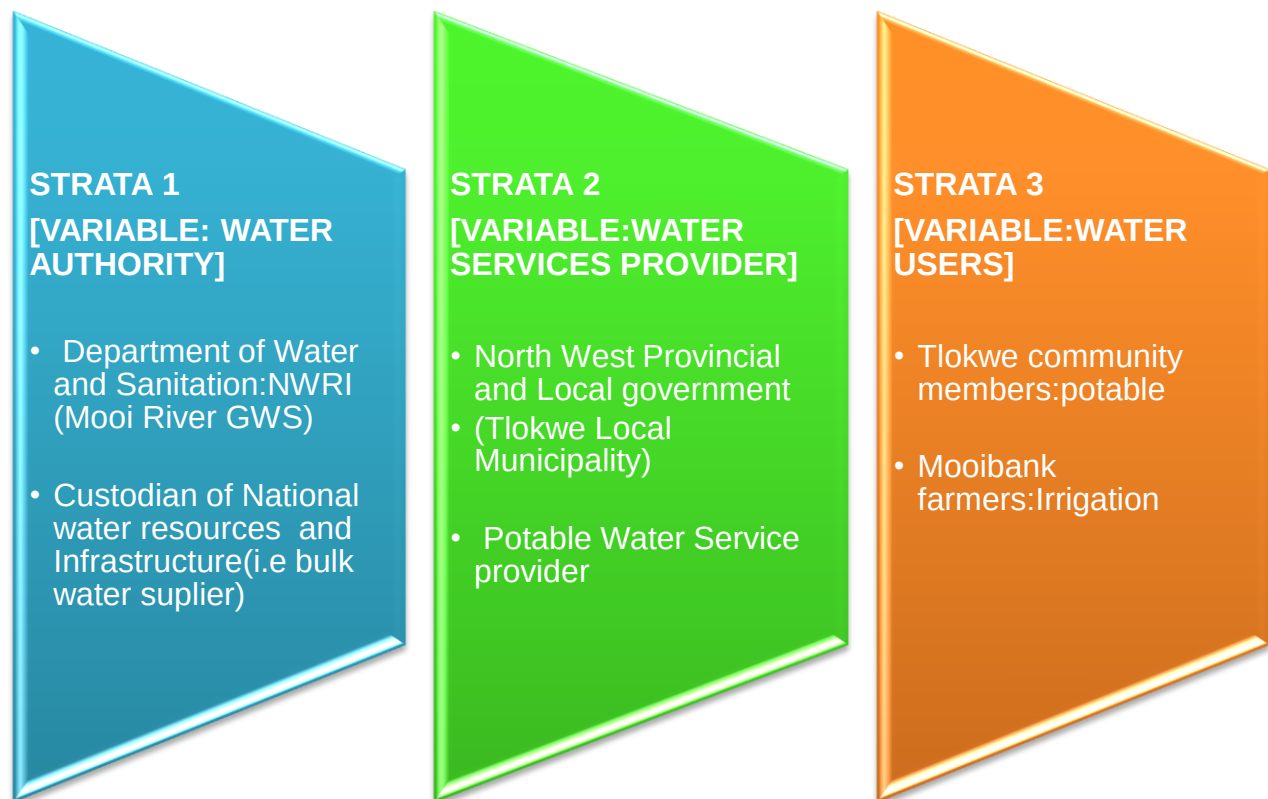


Figure 4.1: Stratified random data-sampling structure



A random sample (qualitative) was drawn from each stratum (as indicated in Table 4.1) in which each stratum differs from the other on the basis of the variable designated. The main custodian of natural water resource in South Africa (SA) is DWS, which has the primary responsibility of managing, controlling and conserving the country's natural water resources. Furthermore, the sampled and collected data gathered in the area of study differs with water stakeholder status in Tlokwe. The first component is Mooi River GWS which is the main water service authority in the area of study. This is followed by an evaluation of the data collected from TLM purification water works, and then lastly Mooibank irrigating farmers.

4.5. Data collection and its analysis

The following procedures of data analysis, adapted from Creswell *et al.* (2004:14), were adopted:

- Data gathered from the interviews in the form of field notes were transcribed. The idea was to immerse the researcher in the details of the interviews and to get sense of the interview or responses as a whole;
- In the process of the in-depth reading of transcriptions of the field notes, noteworthy themes, patterns and central tendencies were identified. The aim was to determine the respondents feelings and get a sense of the phenomena under study;
- Quantitative data gathered from the Mooi River Water distribution system, that is the Water Use and Efficiency Accounting Report (WUER), was analysed in relation to approved national benchmarks;

In the following sections the actual data collection and its analysis in relation to each water stakeholder in Tlokwe is described.



4.5.1. Mooibank farms irrigation

The following data volumes (for both Mooibank irrigation and dam structure) were collected for Mooi River GWS.

Financial year	Annual average dam capacity (Boskop) in percentages (%)	Annual average releases to Mooibank/LRO canal ($\times 10^6 \text{ m}^3/\text{h}$)	Average Mooibank farm requests/orders ($\times 10^6 \text{ m}^3/\text{h}$)	Average Tlokwe water works abstractions from LRO canal ($\times 10^6 \text{ m}^3/\text{h}$)
2005/06	101.3	6.173	5.950	1.491
2006/07	103.4	6.520	5.821	1.542
2007/08	101.5	6.445	5.824	1.455
2008/09	103.4	6.590	4.924	1.577
2009/10	108.4	7.465	5.043	1.476
2010/11	107.6	6.711	4.949	1.491
2011/12	98.2	5.412	5.558	1.541
2012/13	97.4	6.541	5.732	1.579
2013/14	101.2	5.623	8.567	1.588
2014/15	101.4	6.650	7.991	1.594
Average	102.32	6.413	6.026	1.533

Table 4.1: The water volumes (quantitative data) in Mooi River GWS

(Source: DWS, 2015:4)

RED indicates dry periods in which the dam was not spilling water over the weir

GREEN indicates abundant water in LRO canals (overflowing)

GREY indicates the year(s) with major overflow of purification plant capacity

∴ The following average values of data collected (refer to Table 4.1) can be determined:

(a) Annual average release to Mooibank/LRO canal (MavgR-LRO)

$$\begin{aligned}\text{MavgR-LRO} &= \frac{\sum \text{Mooibank canal water release}}{\text{Number of years (i.e. 2005-2014)}} \\ &= \frac{\sum 6.173+6.520+6.445+6.590+7.465 +6.711+5.142+6.541+5.623+6.3650}{10 \text{ years}} \\ &= \underline{6.413 \times 10^6 \text{ m}^3 \text{ per annum}}\end{aligned}$$

(b) The annual average Mooibank farm water orders (MavgR)

$$\begin{aligned}\text{MavgR} &= \frac{\sum \text{Mooibank farm water orders}}{\text{Number of years (i.e. 2005-2014)}} \\ &= \frac{\sum 5.950+5.821+5.824+4.924+5.043+4.949+5.558+5.732+8.567+7.991}{10 \text{ years}} \\ &= \underline{6.036 \times 10^6 \text{ m}^3 \text{ per annum}}\end{aligned}$$

(c) Annual average TLM works abstractions (TLMavgA)

$$\begin{aligned}\text{TLMavgA} &= \frac{\sum \text{Mooibank farm water orders}}{\text{Number of years (i.e. 2005-2014)}} \\ &= \frac{\sum 1.491+1.542+1.455+1.577+1.476+4.491+1.541+1.579+1.588+1.594}{10 \text{ years}} \\ &= \underline{1.833 \times 10^6 \text{ m}^3 \text{ per annum}}\end{aligned}$$



4.5.1(i) The actual amount of water delivered to Mooibank farmers

During field visits a degree of discontent was observed among some of Mooibank's farmers. This related to the handling of farm water orders (requests) by the irrigating water supplier. The interviews with some of Mooibank's irrigating farmers (Coetzee, pers. comm., 2015; Potgieter, pers. comm., 2015; & Botha, pers. comm., 2015) indicates that their water allocations were regularly reduced, sometimes without their knowledge, by the irrigation water supplier. Furthermore, they (Eddie Coetzee, Henry Potgieter and Hardus Wynand Botha) felt that there was an adequate amount of water release from the source, i.e. Boskop Dam to meet their needs. In order to have a clear assessment of the respondents' complaints, quantitative data was then collected.

Annual average release to Mooibank farms(in million cubic meters)									
Financial year	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
X 10 ⁶ m ³	3.941	3.874	3.645	3.612	3.591	3.547	3.457	3.352	3.212

Table 4.2: The annual average delivered to Mooibank farmers

(Source: Mooi River GWS, 2015)

Table 4.2 indicates the Mooi River GWS water volumes over a period of 10 years (from the 2005/6 to 2014/5 financial year), while Figure 4.2 below indicates water volumes in the form of a bar chart over the same period. The component value of 0-100 gives an indication of Boskop dam's carrying capacity, in the indicated financial year(s). An optimum value of 100 (%) indicates that the dam is at a full capacity, and < 100 % (greater than a hundred) indicates that the water is spilling over the weir.

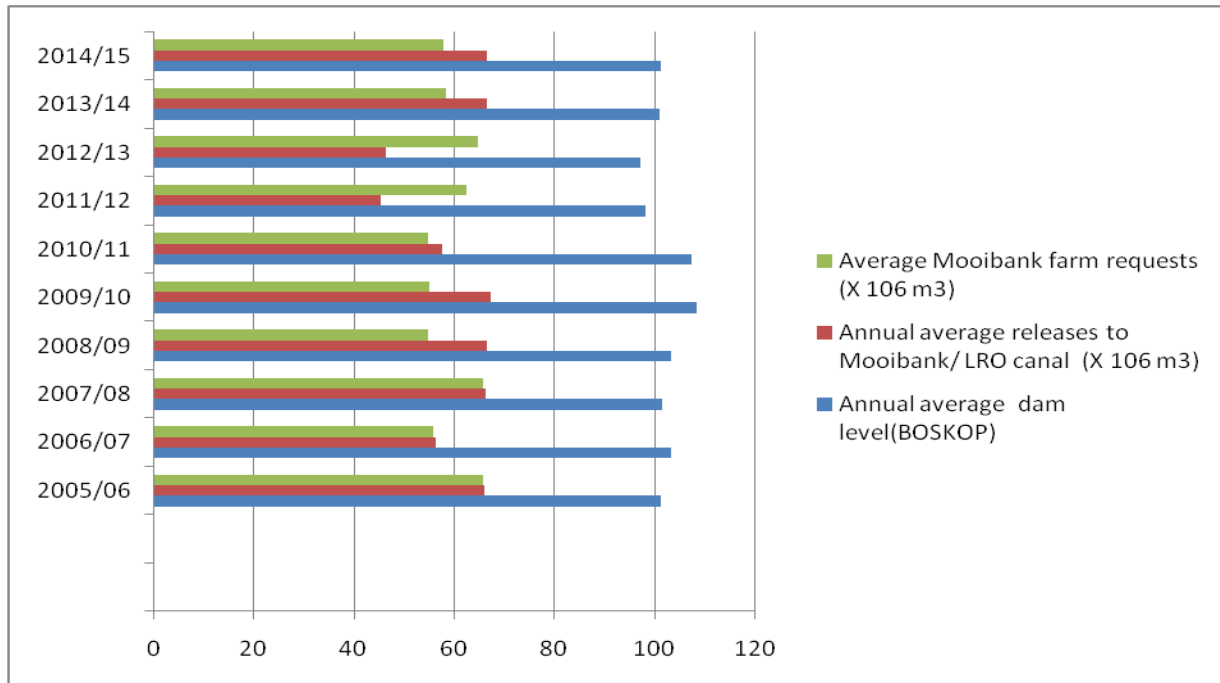


Figure 4.2: Mooi River GWS water volumes Chart

Furthermore, the water volumes data (as indicated in Table 4.1) indicates that, except in 2009/10 and 2010/11, Mooibank farm water requests were exceeded by water releases to LRO from Boskop (see Table 4.2) over the 10 studied financial years. Therefore, this data reveals that 80% of the time in the 2005/6 to 2014/15 period Mooi River GWS could not meet the Mooibank farmers' water demands. Therefore it has applied some strategy in order cater for the irrigation water demands of Mooibank's irrigating farmers in an adequate manner. During the time under investigation the acting area manager of Mooi River GWS (Jaco Conradie) indicated that their water demands were always high; hence the use of the WAS made it easy to allocate irrigation water fairly to the surrounding farms. WAS makes use of MAR for water allocations, as indicated in section 2.5 above.

However, the collected data indicated in Table 4.3 and Figure 4.2 alone could not fully account for the complaints of the first interviewed Mooibank irrigating farmers. Therefore further quantitative data collection and analysis of water distribution in the area of study was required. These components included: the application of WAS, maximum

abstraction rights, canal use and efficiency by Mooi River GWS. The following sections will cover these fundamental concepts of irrigation water and its distribution.

4.5.1(ii) Maximum Abstractions Rights (MAR) and Water Administration System (WAS)

As indicated in 2.4 above, MAR is a scientific method used by WAS in the process of distributing water to the farmers. During the interviews with Mooi River GWS management, they indicated that water-related complains by Mooibank farmers were increasing as a result of water shortages in the area. They further indicated that they were forced to implement MAR as a way of managing and controlling irrigation water usage by all their irrigating farmers (Conradie, pers. comm., 2015, Kemp, per. comm., 2015 & De Ridder, pers. comm., 2015). Therefore, the formula for the calculation of MAR, as indicated in 2.4 above is given as follows:

$$MAR = \frac{T}{A} * (Q - L)$$

Where in,

A = Area of Mooibank farms schedule in hectares (ha)

Q = Discharge of Boskop LRO canal in m³/h,

L =Canal losses (m³/h)see 4.3.1 (a) *calculated under canal efficiency*

During further discussion with Mooi River GWS official Japie de Ridder, he indicated that he was applying the recommended scheme MAR of approximately 314,2m³/ha per water period (week) as listed on their system. However, this was only during summer when there were high irrigation water demands as a result of an increase in temperatures coupled with poor humidity. De Ridder further indicated that MAR varies with dam releases, canal carrying capacity, and canal efficiency. He further indicated that it was impossible to calculate changing MAR constantly, due to the fact that water flow patterns is dynamic by nature (De Ridder pers. comm., 2015). In order to gain a



better understanding of the reasons for the structural water losses indicated by Japie de Ridder during the interviews, the researcher conducted field surveys at Mooibank farms.



Photograph 4: Mooibank canal structural failure (fallen wall), Haaskraal

(Photographer: Victor Morapedi, 2015)



Photograph 5: Mooibank canal (structural failure) with flowing dirty water Haaskraal (Photographer:

Victor Morapedi, 2015)

During this field survey, the potential problem identified in the Mooibank farm area was the deterioration of the canal structures (see *photograph 1 and 2 above*).

4.5.2. Managing the canal (operational uses)

In order to have a better understanding of the actual irrigation water releases to Mooibank farms, the actual quantitative data on the gauging structure is required. The following data were obtained regarding the operational use of the canal by Mooi River GWS and Mooibank farmers. The field data indicates that the carrying capacity of Mooi bank canal (LRO) is 7.950 cubic meters per hour, i.e. 950 mm height in a 1 meter (3 ft.) partial gauging structure (*researcher survey-see photograph 3*). Assuming (theoretically) that all Mooibank irrigating farmers used water at a minimum level of 50 m³/h, the following irrigation data was obtained:

Volume (Q) per hour= Water Orders X Mooibank farm schedule area

$$=50 \times 419$$

$$=\underline{20,950 \text{ m}^3/\text{h}}$$





Photograph 6: Dry Mooibank (LRO) canal with a standing gauge

(Photographer: Phillip Mulovhedzi, 2015)

These limitations (structural) as indicated by the canal gauge plate (920mm, which is equivalent to 12.550m³/hour), render it impossible to deliver water to all Mooibank farmers at the same time, especially to the lower-end farms. The lack of regular irrigating water was also confirmed by visiting the lower-end Mooibank farms. A major commercial (low-end) farmer Henry Potgieter indicated that 75% of the time he was lucky to receive a drop of water from the canal (Potgieter. pers. comm., 2015).



In the course of conducting interviews with sampled Mooibank irrigating farmers, further field surveys (and investigations) were also conducted among the lower-end canal farmers. It became evident that some of the farms in Mooibank were no longer cultivated. The researcher took into consideration the fact that some of the farmers might no longer be interested in farming. However, further interaction with some of the lower-end Mooibank farmers revealed that sometimes it was difficult for them to receive sufficient irrigating water. Andrew Erasmus indicated that the canals in his sections tended to get blocked-up hence it was difficult for him to plant crops on other parts of his farms(Erasmus pers comm 2015)



Photograph 7: Uncultivated farm in Mooibank area

(Photographer: Phillip Mulovhedzi: 2015)

4.5.3. Additional concerns of farmers

Apart from water scarcity in the canals, security is another major socio-economic challenge that is facing farmers (Coetzee, pers. comm., 2015). Most of the farmers interviewed voiced concerns about increasing stock theft and burglaries on their properties. They felt that these conditions posed a serious challenge. According to Andrew Erasmus, a lack of proper fencing along some sections of the Mooi River GWS



canals contributed to stock and household theft. Henry Potgieter said he believed that the lack of security structures, such as fencing along Mooi River's canals, not only increased stock theft but also contributed to a loss of livestock as a result of drowning. He indicated that the carcasses of drowned livestock periodically blocked canal water flows. This type of canal blockage has been posing a serious challenge in recent years (Potgieter & Erasmus. pers. comm, 2015).

Some of the farmers (Coetzee, Potgieter and Erasmus) expressed concerns about the reluctance of government to reform water institutions such as government irrigation schemes. They felt that the creation of water user associations (WUAs) could fast track water demand backlogs such as water licensing and general authorisation (GA). As far as human resources (HR) management in the water service authority is concerned, one of the farmers suggested that government needed to fill vacant posts without considering affirmative action and employment equity policy as it negatively affected water distribution in the area. The farmer further indicated that employing unqualified personnel's in an attempt to comply with the employment quotas might ultimately affect the whole organisation's performance (Coetzee, Potgieter & Erasmus, pers. comm., 2015). The sharing of Boskop LRO canal with Tlokwe Purification water works was also a concern. One of the farmers, Ian Delport, indicated that he struggled to get water as he was situated on one of the lower-end farms. He argued that illegal abstractions and increases in TLM purification water intakes during summer compounded the water shortage problem. He indicated that it would be better if TLM purification water works and Mooi River started engaging the farmers on water shortage issues. As far as he was concerned, the water service institutions were required to serve the people and should not have sense of water entitlement (Delport. Pers. Comm. 2015).

4.5.4. Challenges faced by Mooi River Government Water Scheme (GWS)

With regard to WAS application in the dispensation of irrigation water, Jaco Conradie (Mooi River GWS acting area manager) indicated that they needed to properly train their staff members to enable them to understand and apply all the basic concepts of

WAS. However, he also indicated that the increase in water theft was not a result of poor performance by WAS. He believed that the lack of adequate candidates to fill vacant posts was the main contributing factor to the increase of water theft. He estimated that about 250-300 m³ of water was unlawfully abstracted from the canals on a monthly basis during the previous year. He also raised the issue of ageing canal infrastructure and the accumulation of acid mine drainage (AMD) trace elements as a major challenge. He believes that the accumulation of AMD in the Mooi River catchment could ultimately affect Mooi River's farm production negatively and even the TLM water purification works (Conradie. pers, comm., 2015).



Photograph 8: Mooibank illegal abstractions (Sluice with a broken padlock)

Photographer: Victor Morapedi, 2015

Mooi River GWS water control officer Quinton Kemp also highlighted the problem of human resource. According to Mr Kemp a shortage of personnel to regularly patrol the canals, contributes to the increase in water theft by some of the irrigating farmers. He further indicated that they had sent details of posts for advertisement to the DWS central operations. However, the minister of the DWS had placed a moratorium on the advertisements of new posts; hence they had to wait until the minister gave permission to lift the moratorium. He further indicated that the scheme had only two chief artisans, who were supposed to maintain both Mooi River GWS and its cluster scheme in Ventersdorp. This, according to him was a “mission impossible” because the officials had to service a vast area (Kemp. pers. comm., 2015).

4.5.5. The water use and efficiency (WUE) of Mooibank irrigating canals

Jaco Conradie highlighted several reasons for which Mooi River GWS sometimes failed to supply adequate water to its major stakeholders. He began with the issue of ageing water infrastructure. He estimated that almost a quarter of the water in the canal was lost as a result of leakages, illegal abstractions and spillage. He also estimated that it would cost millions of rand to repair all the infrastructural components of the scheme. He, moreover, indicated that until such time that water savings mechanisms were introduced by other stakeholders such as TLM’s purification water works and irrigating farmers, the problems would persist. He, finally, indicated that they were behind schedule in terms of canal maintenance programmes (Conradie, pers. comm., 2015).

It thus became apparent that water loss is a major challenge. In the researcher’s view, the real gross loss of Mooibank canal (or Boskop LRO) can be determined using standard calculations (*refer to Table 4.1 and 4.2*)

(A)	(i) Actual Volume released from the source (Boskop Dam)	$6.173 \times 10^6 \text{m}^3$
	(ii) Additional volume from Mooi River	$0 \times 10^6 \text{m}^3$
	(iii) Additional volume from Lakeside Dam	$0 \times 10^6 \text{m}^3$
	TOTAL	$6.173 \times 10^6 \text{m}^3$

(B)	Average volume of water requested by:	
(i)	Mooibank irrigators	$6.026 \times 10^6 \text{m}^3$
(ii)	TLM	$1.900 \times 10^6 \text{m}^3$
	TOTAL	$7.926 \times 10^6 \text{m}^3$

(C)	Average volume of water delivered(consumed) to:	
(i)	Mooibank Irrigators	$3.523 \times 10^6 \text{m}^3$
(ii)	TLM	$1.833 \times 10^6 \text{m}^3$
	TOTAL	$5.353 \times 10^6 \text{m}^3$

(D) **Gross Water Losses** = Total released - Total requested

$$= (A) - (B)$$

$$= 6.173 - 7.926 \times 10^6 \text{m}^3$$

$$= \mathbf{1.753 \times 10^6 \text{m}^3}$$

$$\% \text{ Gross Water Loss} = \frac{\text{Gross water loss (see D)}}{\text{Boskop (LRO) canal water release}} \times 100\%$$

$$= \frac{1.753}{6.173} \times 100\%$$

$$= \mathbf{28.39\%}$$

The above calculations confirm Conradie's estimates. It shows clearly that Mooibank GWS canal lost an average of 28.39% per annum from 2005/06 to the 2014/15 financial year. The Mooi River GWS losses of 28.39% as a result of the deterioration of the canal structure and evaporations exceeded the recommended value. According to Muller *et al.* (2012:14), the natural and physical recommended losses, in other words the losses that are classified as unavoidable in an open system such as canals, are required to fluctuate between 9 and 17%. During further engagements, Jaco Conradie indicated that a lack of personnel to conduct proper structural maintenance was the main contributing factor to canal water losses (Conradie. pers, comm., 2015).

4.6. TLOKWE LOCAL MUNICIPALITY PURIFICATION WATER WORKS

As indicated in section 2.10, every human being has the right of access to sufficient water. This basic right is stipulated in the South African Constitution. The following section will explore the data collected by the TLM purification water works and then focus on its analysis. In order to have a full over-view of the TLM purification water works, both historical and existing purification water works data will be explored.

4.6.1. The historical TLM treatment water works data and analysis

During a previous interview with JF Kleinhans, he indicated that during the early 1900s potable water demand in Potchefstroom was as low as 3.4 Mℓ/d. He attributed the low water demand during that time to the low population of Potchefstroom. He even indicated that during the early 1900s, Potchefstroom city council did not even have a water-based sanitation (sewerage) system. When the population started growing in the 1920s the city council decided to get rid of the bucket system (sanitation) and to start construct pipelines, with its first treatment water works. The first treatment water works abstracted water from Potchefstroom dam, now known as Lakeside Dam (Kleinhans. pers. comm., 2013).

Some of the historical numerical (quantitative data) on the history of TLM purification water works was obtained from JF Kleinhans' thesis. During an interview, with TLM water works manager Lance Carson, he indicated that the historical purification water works was constructed to supply Potchefstroom (*referring to Tlokwe*) city residents only. He further indicated that this was before the establishments of Ikageng locations and its extensions in the 1960s. In the interview with Lance Carson, he also touched on the history of TLM purification water works. He indicated that during the 1960s and 1970s Potchefstroom experienced substantial population growth. Consequently the city council upgraded its purification works once every four to eight years (Lance. pers. comm., 2015).

YEAR(Commissioned)	Total capacity (Mℓ/d)	Annual growth(water demand) in %
1924	3.4	Not specified
1924 to 1942	6.8	3.0
1946 to 1951	13.6	4.5
1964 to 1968	25.6	5.5
1976	38.1	5.5
1984 to 1985	38.6	6

Table 4.3: Historical data of TLM water works:

Source: Kleinhans (1985: 1-10)

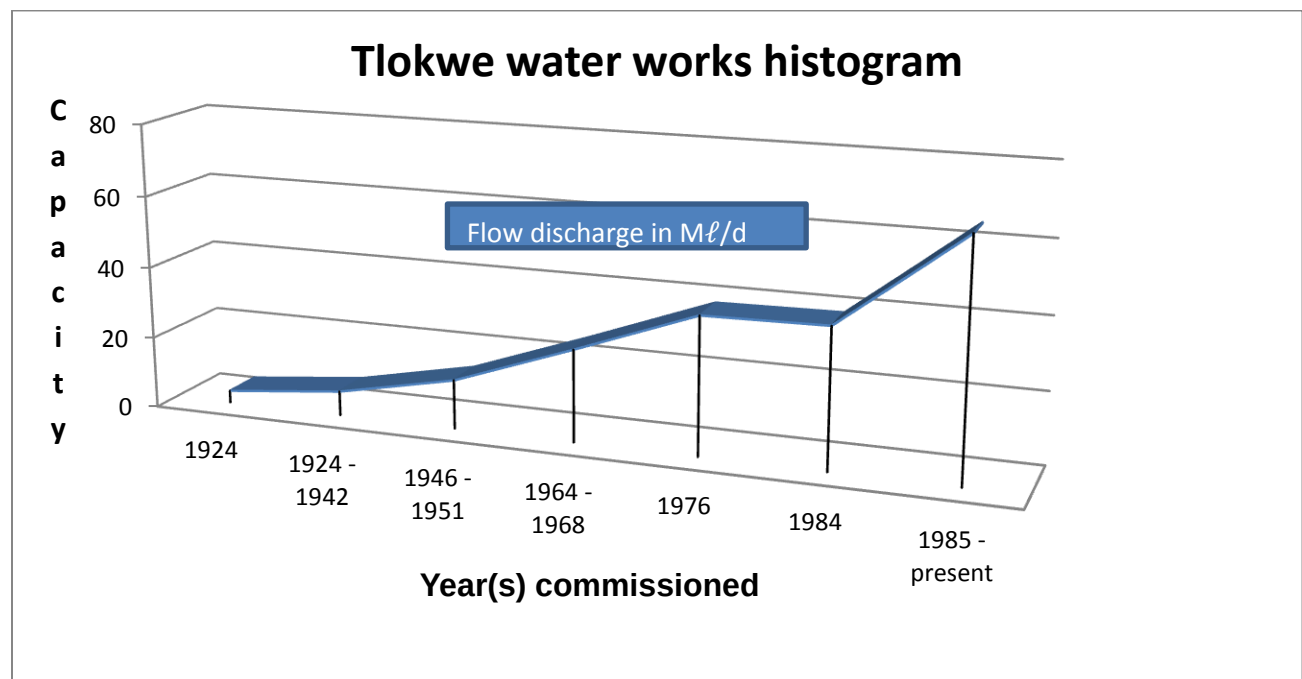


Figure 4.3: Tlokwe Municipality Water Works Histogram

Sources: Kleinhans (1985: 1-10) & TLM (2012/3: 4)

4.6.1(i) Analysis of the historical TLM purification water works data

The original water treatment plant, as indicated in table 4.7, can be explored using the standard calculations of Statistical Package for Social Science Programme (SPSS) to evaluate its compliance with the number of households during the period:

$$\begin{aligned}\text{Water Treatment Discharge (during 1924), } Q &= \frac{\text{Total Plant capacity (v)}}{\text{Time or period (in hours per day)}} \\ &= \frac{3.4 \times 1,000,000 \ell}{24 \text{ h}} \\ &= \mathbf{141,666 \ell/\text{hours}} \\ &\quad (\text{Equivalent to } 3,400,000 \ell/\text{day})\end{aligned}$$

$$\begin{aligned}\therefore \text{Monthly Discharges (year 1924)} &= 3400000 \ell/\text{day} \times 30 \text{ days} \\ &= \mathbf{102,000,000 M\ell /month,}\end{aligned}$$

Ability of original Potchefstroom water treatment works i.e. 1926 to meet the set current water distribution standards

$$\begin{aligned}&= \frac{\text{Monthly discharges}}{\text{Free basic water (FBW) per family}} \\ &= \frac{102,000,000 \ell}{6000 \ell/\text{household}} \\ &= \mathbf{17,000 \text{ households}}\end{aligned}$$

*These figures imply that the original water treatment works was capable of supplying only 17,000 households in accordance with the current Water Services Act (of 1997) standards. However, it must be noted that there was no such Act (WSA) in 1924. Hence it was used as a baseline (benchmark) to give an approximate understanding of what the original plant capability was, in relation to the current approved standards.

4.6.1(ii) Analysis of the current TLM potable water distribution data

Water uses (Potable)	Fraction in % (percentages)	Estimated Volumes in Mℓ
Industrial	26	16.9
Commercial	17	11.05
Domestic	42	27.3
Losses(mechanical)	15	9.75
Total	100%	65

Table 4.4: Potable water distribution in Tlokwe

Source: TLM (2012/13: 14)

Lance Carson (TLM purification plant manager) indicated that the current TLM purification water works structure had a limited capacity, being able to treat only 65 Mℓ/d. He indicated that the current TLM purification water works also needed to be expanded. However, plans have been submitted to Kenneth Kaunda district for an invitation to tender for the water purification works upgrades. He indicated that the upgrade for the existing purification plant will be funded by the municipal infrastructure grant (MIG). Moreover, he believes that the current purification water works is able to meet only the demands of all the connected households in the Tlokwe Local Municipality. He indicated that they should have already connected all households in Tlokwe's townships, but dolomite aquifers limit the municipality ground-water abstractions. Due to the dolomite aquifers, groundwater in Tlokwe cannot be explored until a proper disaster management study has been completed (Lance. pers. comm. 2015).



Dolomites are an anhydrous mineral composed of calcium and magnesium carbonate. The terms “dolomite aquifer” is used to describe a geological formation (conducting groundwater) that is predominantly composed of dolomite mineral (DWS, 2009:15). According to Biswas (1997: 45) the stability of dolomite land largely depends on the geo-hydrological conditions beneath the land surface, further indicating that any over-withdrawal of groundwater in dolomite land can result in a sinkhole. This was also supported by a DWS (2012:15) report, which indicates that allowing the water table to fluctuate (as a result of excessive withdrawal) leads to more rock (dolomite minerals) being dissolved. The presence of dolomite aquifers in Tlokwe (area of study), as indicated by DWS (2012:14) and TLM (2013:6) suggest that proper management of groundwater explorations is required.

Large amounts of calcite or dolomite rocks are usually able to neutralise the acid. However, this is not the case, in the area of study, where there is gold water drainage from the Wonderspruit mining areas DWS (2009:24). According to McCarthy (2009:24) the dolomites rocks (in a natural neutralising processes) are overwhelmed by coal or gold water deposits or drainage, resulting in large quantities of acidic water released into the environment by mining activities, initially into the groundwater and then ultimately into streams and nearby rivers.

Therefore, by taking into consideration the current TLM purification water works capacity (as outlined table 4.2 above); the following analysis can be deduced:

The current TLM water treatment capacity (2015),

$$\begin{aligned}
 Q \text{ (i.e. discharge)} &= \frac{\text{Total Plant capacity (v)}}{\text{Time (hours per day)}} \\
 &= \frac{65 \times 1,000,000 \text{ } \ell}{24 \text{ hours}} \\
 &= \underline{2,708,333 \text{ } \ell/\text{hours}}
 \end{aligned}$$

$$\therefore \text{Monthly Discharges (2015)} = 65,000,000 \text{ } \ell/\text{d} \times 30 \text{ days}$$

$$= \mathbf{1,950 \text{ M}\ell/\text{d per month.}}$$

However, according to Mr Carson, not all treated water is received by households. In addition to the 5-10% lost during back-wash stages, approximately 15% is lost as a result of leakages and bursts in the reticulation network (Carson. pers.comm.2015). One of the TLM officials, Silvia Selegiloe indicated that they usually receive 10-15 complaints per day. According to her, most of these complaints are about burst pipes and leaks. She indicated that residents complained that no one came to fix the burst pipes in their area. However, she indicated that the delay in fixing burst pipes was due to staff shortages at TLM's water and infrastructure office (Selegiloe. pers. comm., 2015).

The compliance of the existing purification water works can be analysed. However, in doing so one must take into consideration the water losses indicated by Lance Carson and Silvia Selegiloe during the interviews. The researcher considered the available TLM potable water usages or consumption outlined in Table 4.7. The compliance of the existing purification water works was then scientifically explored as follows:

$$\begin{aligned} \textbf{TLM Gross Domestic Water Volume} &= \text{Total discharge (Q) X fraction (or 1/100)} \\ &= 1,950,000,000 \times 27,3/100 \\ &= \mathbf{\underline{532,350,000 \text{ } \ell/\text{month}}} \end{aligned}$$

$$\begin{aligned} \textbf{TLM Net Domestic water Volumes} &= \text{Total discharge (Q) X Reticulation loss (in \%)} \\ &= 532,350,000 \text{ } \ell/\text{month} \times 15/100 \\ &= \mathbf{\underline{79,852,500 \text{ } \ell/\text{month}}} \end{aligned}$$

Therefore, the following household data can be deduced in terms of TLM treatment works capacity to comply with current (i.e. year 2014/15) water distribution regulations as stipulated in the WSA 108 of 1997:

$$\begin{aligned}
 \text{TLM Domestic water Compliance rate, of year (2014/15)} &= \frac{\text{Monthly Discharges}}{\text{FBW/family}} \\
 &= \frac{79,852,500 \text{ } \ell}{6000 \text{ } \ell / \text{households}} \\
 &= \underline{13,308 \text{ households}}
 \end{aligned}$$

4.6.1(iii) Analysis of the existing TLM purification water plant

The existing TLM water treatment works is capable of supplying only 13,308 households, as seen in section 4.5.1(ii) above. This analysis was performed in accordance with the current Water Service Act (of 1997) standards. However, it must be noted that the value was calculated in accordance with the free basic water policy of 6,000 ℓ /month. Hence it was used as a baseline (benchmark) to give an approximate understating of what the current plant capability is in terms of meeting approved FBW/MIP standards.

Tlokwe has a total number of 29,212 households (TLM, 2013: 45). However, the current TLM purification water works, as seen in section 4.5.1(ii) above, is only capable of meeting 13,308 households' potable water demands. Therefore, the current TLM water works cannot service all the registered TLM households in terms of the approved and recommended FBW potable water quantity standards.

4.6.2. Systematic Modelling (SM) and its analysis

The analysed data from the Mooi River water distribution system (see Table 4.1 and section 4.5.1) indicates that Boskop (LRO) canal was unable to supply sufficient water to Mooibank irrigating farmers from 2005 to 2014/5 financial years. The water supply for Mooibank irrigating farmers was insufficiently supplied during the specified 10-year periods (the 2005/6 to 2014/15 financial year). The total average Mooibank farms and TLM water purifications requests from 2005/6 to 2014/5 was 7.559 m³/h. However, during the same specified period of study the LRO canal was able to carry a total average of 6.413 m³/h. Therefore, the canal failed to provide an additional water of 1.143 m³/h needed during the stipulated period.

One of the major findings in relation to TLM purification water works is that it took almost 19 years for the municipality (TLM) to plan for the full expansion of the current treatment works. From 1989 to 1995 there were no major upgrades. The existing 65 Mℓ plant was last refurbished in 1995 (Lance. pers. comm., 2015). This indicates a lack of proper strategic planning by TLM. **Planning** is a major component of Systematic Model, as indicated in section 2.1.

Another interesting finding is that not all the water abstracted by TLM treatment water works gets purified; almost 5-10% of backwashed water is diverted into the nearby embankment dam. It is also important to note that the backwashed water is of a high quality (see appendix A). One might suggest that the 5-10% backwashed water should have been diverted into the LRO canal. This could have prevented some of the Mooibank farmers (e.g. Potgieter, Coetzee & Erasmus) from experiencing water shortages.

The finding noted in section 4.4.1 brings us to the second Systematic Model component, which is evaluation. The increase in Mooibank farm's water demands as observed from the collected data (see also table 4.1), should have prompted TLM to evaluate the efficiency of its purification water systems and operations. These findings indicate the existence of a communication gap between TLM, the Mooi River GWS and the Mooibank farmers.

4.6.3. SWOT- analysis

The findings highlighted in section 4.5.2 (Systematic Model analysis) indicate that Mooi River GWS has failed to establish a proper communication mechanism. This has contributed to the increase of water shortages or challenges that seem to be facing mainly Mooibank irrigating farmers in Tlokwe.

However, in order to have a clear understanding of some of these research findings as outlined in section 4.1-4.5.2, SWOT methodology is applied. As indicated in section 3.7, the SWOT-methodology is applied in order to explore private or public institution's strategic plans, operations and management processes. In this study Mooi River GWS is major intermediary between the Mooibank irrigating farmers and TLM purification water works. Therefore a SWOT-analysis of this important role player can be explored as follows (see table 4.5 below)

SWOT	STRENGTH	WEAKNESS	OPPORTUNITY	THREATS
Infrastructural development	-constant supply of TLM purification water work	-ageing of water infrastructure	-scope exists for extensions, positive to meet increasing water demand	- lack of funds for the provision of new bulk water infrastructure -lack of funds for maintenance of existing structures
Vending (on water users)	-enough public funds or revenue	-lack of proper funds collection mechanism	- industrial and agricultural development	- budget deficit
Internal Control	-linking water service delivery with departmental strategic policy	- lack of regular meeting with the main water users i.e. TLM and irrigating farmers	-provide fair allocation of funds for improve service delivery	- leakages, spillages and illegal water abstractions
Personnel	-increase in labour force	- lack of proper implementation with regard to WAS components	-extension on employee hiring -training water control officers in WAS can improve WUE	- increase in number of workers going on pension (increase in vacant posts)
Agricultural development	-efficient in capturing new agricultural (farms) developments in winded.	-lack of water theft and WAS components control measures	-increase of farm productions if proper canal maintenance and operations strategies get implemented	-increase in the congestion of water applications(orders) and possible accumulation of AMD's

Table 4.5 SWOT- ANALYSIS of Mooi River GWS and its farm water distributions

4.6.3.1 In-depth SWOT-exploration (analysis) of Mooi River GWS

SWOT- analyses aims to identify the key internal and external environment factors (as indicated in Table 4.7 above) that are seen as important for achieving the strategic objective of Mooi River GWS. Creswell (2006: 24) indicates that SWOT-analyses groups two key pieces of collected information or data into the following two main categories:

- The internal environment: the internal strengths and weaknesses of the organisation; and
- External factors: the opportunities and threats presented to the organisation by the external environment.

The following section comprises an in-depth analysis of the actual data collected in relation to water distribution by Mooi River GWS using SWOT-methodology.

4.6.3.1(i) The internal environment:

As indicated in Section 1.5 and 4.5.1, the Mooi River GWS use WAS for capturing and distributing water to its irrigating farmers.

-Strengths

During the field visits, Mooi River GWS was able to provide the primary water distribution data over the specified years of study (see Table 4.1). Another important factor that was also identified as advantageous (strength tactical unit) that Mooi River GWS has at its disposal to further achieve effective water distribution was that the WAS's water modules were linked with:

- the administration;
- water order;
- measured data;

- water release;
- accounts, and
- water use efficiency report modules (see section 4.5.1(i-iii))

This in turn had minimised paperwork (manual capturing of water distribution data) in Mooi River GWS. The annual hydrological reports that were manually captured were now generated electronically (see table 4.1). According to Conradie, electronically generated water distribution data resulted in the fair collection of funds from their consumers (see section 4.5.1(ii)).

Furthermore, the data findings shown in Table 4.1 indicate the successive continuation of sufficient bulk water abstractions from Mooi River LRO canal (see section 4.5.1). Hence, it illustrates the strengths (or capabilities) of Mooi River infrastructure, in terms of meeting the requested TLM water purification works volumes. However, that had not been the case with regard to Mooibank irrigating farmers i.e. Mooibank farm water requests (orders) exceeded the supplied volumes during the specified years, 2005/6 to 2014/15 (see Table 4.1 above).

-Weakness

There is a major weakness in terms of fulfilling the personnel functions, i.e. filling vacant positions, by the organisation (Mooi River GWS), as indicated in Section 4.5.2. During field investigations there was still no permission (from the DWS minister) to lift the moratorium on the advertisements of vacant positions which was announced in the year 2014 (see section 4.5.4 above). This weakness had affected the maintenance programmes of Mooi River GWS infrastructure.

Another important tactical unit weakness is that from 2005/6 to the 2014/15 financial year, the Mooi River GWS lost 28.39% of the total water (WT) supplied by Boskop Dam to the Mooibank farm areas as a result of the deterioration of the canal structure (see section 4.5.5).

This can be further explored as follows:

$$\begin{aligned}\text{Total average volume of WL} &= \text{Total average of water quantity supplied (year 2004-2015)} \times \text{WL in \%} \\ &= 6,413 \text{ Mℓ/year} \times 28.39\% \\ &= 1,744 \text{ Mℓ over the specified period (years)}\end{aligned}$$

This is a huge amount of water loss (WL). Hence, it indicates a weakness by Mooi River GWS in terms of proper implementation of the canal's WUE during the specified period (see table 4.1). According to the DWS (2009: 45), WLs should fluctuate between 9-17%.

4.6.3.1(ii) External environment

As indicated in section 4.6.3.1 the external factors imply the opportunities and threats presented to the organisation (i.e. WSA) by the external environment.

-Opportunities

Effective training of water control officers (WCOs) in WAS can improve WUE implementations (see section 4.5.3). Water saved through the proper application of WAS components such as MAR by WCO can be allocated to other industries (sectors) or even supplement the farm water schedule (see section 4.5.5). These in turn could increase farm productions in the area of study (Tlokwe), which might in turn lead to the establishment of new processing or agro industries and even employment.

-Threats

The main threats facing Mooi River GWS water distributions lies with the hydro geological process. As indicated in section 4.5.3 and 4.5.4, upstream mining discharges are contributing to a growing concern relating to AMDs on the Mooi River. Furthermore, the historical data noted in section 4.5.2 and figure 4.2 indicated that water demands by Tlokwe water purification works have been on the rise since 1924. This poses a serious challenge to Mooi River GWS (Boskop LRO), considering that it has a shortage of

personnel for maintaining and upgrading the existing structures. Another threat is illegal water abstractions which also contribute to budget deficit (see also section 4.5.2). Illegal water abstractions in the area of study are not captured on the WAS. According to the DWS (2009:23) consumers can only be billed if their water allocations/orders have been captured by the WAS.

4.7. CONCLUSION

In this chapter the data that was collected was outlined and analysed, with a focus on the various components of WAS and potable water distribution in Tlokwe. The chapter started off with an outline of the data sources, collection and sampling procedures applied in this study. Furthermore, the research methodology applied was then discussed. This was followed by sections of data collection and the analyses thereof. The analysis was further explored (in-depth) using SM and SWOT- analysis tools.

In the next chapter the findings will be outlined and the research questions answered individually. Conclusions will be drawn and recommendations made.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1. INTRODUCTION

In this chapter findings presented in the previous chapter will be discussed. In the first section of this chapter the findings will be used to answer the primary and secondary research questions that were presented in chapter one. The limitations of the study are then noted and recommendations made.

5.2. Discussions of the findings

In this section, the research questions that were set out in chapter 1 will be answered:

5.2.1. Primary research question:

Does the WAS utilised in the Potchefstroom area have any socio-economic impact on the two main water users i.e. agriculture (Mooibank farms) and Tlokwe Local Municipality potable water consumers?

Findings

The implementation of the WAS programme (by Mooi River GWS) and its components which are water scheduling, MAR, irrigation water use and efficiency, do have socio-economic impacts on Tlokwe's major bulk water users, i.e. Mooibank farmers and TLM water purification works. Water for drinking is classified under schedule 1(one) in the NWA of 1998, meaning that it is a human right. Hence a water use licence is not required. This regulation gives TLM the rights of water withdrawal for drinking purposes over irrigation.

The research findings indicate that this legal concept has resulted in TLM demonstrating a sense of water entitlement. Consequently, farmer's complaints are largely ignored. Furthermore, the System Model analysis presented in the section 4.6.2 above indicates that not all abstracted water ends up in the consumers' taps. Almost 5-10% of backwashed water from the TLM purification water works is diverted to the nearby embankment dam and this water infiltrates into the soil. If there was proper communications between Mooibank irrigating farmers and the TLM (purification water works) officials, 5-10 %, of the backwashed water could have been directed into the canals instead of the embankment dam. The primary cause of this problem is that the water supply for TLM purification (potable) was not scheduled in the WAS. Hence, TLM was free to abstract as much as it wanted, even if the abstracted water quantity was sometimes greater than the capacity of the water purification plant's capacity (see Table 4.1). This has caused socio-economic problems in the study area, especially for the lower-end farms, as some of the farms' production and/or cultivations had to be scaled down (or abandoned) due to a lack of sufficient irrigating water. Hence, it may have resulted in the loss of profit. (See *also photograph 4 for a respondent uncultivated farm due to lack of sufficient irrigating water*).

5.2.2. Secondary research questions

5.2.2.1 Does the WAS have any effect on the TLM's water abstractions specifications (i.e. TLM General Authorisations(GA) or water use licence) and also Mooibank farm annual water allocations or quotas?

Findings

As indicated in section 2.4, Mooibank irrigation water has to flow over a long distance through an open canal. On average, as indicated in section 4.6, about 27% of the water supplied to Mooibank irrigation farms is lost due to evaporation, leakages, spillage and incorrect water management. This research shows that the incorrect water management

of WAS components (MAR and WUE) by Mooi River GWS affects water allocations to farmers. This is due to the fact that the actual losses in the canals are greater than those theoretically accounted for in the WAS.

Furthermore, water abstractions for consumption (potable) by TLM are mandatory (schedule 1 of the NWA). Therefore, the WAS components do not apply in this case.

5.2.2.2. Is there any relationship between the management of water infrastructure by the DWA (Potchefstroom) and the WAS's performance?

Findings

The research finding indicated in section 4.5.1 shows that most of the water infrastructure, such as the canals is ageing and requires constant maintenance. Infrastructural problems have resulted in incorrect applications of WAS components, such as MAR, as indicated in section 4.5.2.

5.2.2.3. What are the relevant water resource management systems theories, legislation and policy pertaining to the water resource management programme, including WAS?

Findings

Data was collected and analysed following each of the IWRM principle (i.e. efficiency, equity and sustainability) which falls under Section 2 of the NWA of 1998. This research shows that it is possible to analyse each WAS component. However, the implementation becomes a problem in this case, as indicated in section 4.5. For example, the theoretical values of WUE outlined in section 4.5 indicates that there is a discrepancy between the actual MAR, or water delivered to the consumers, and the figure captured in the WAS components (see section 4.5.1(ii) above). However, the existing legislation (section 3 of the WSA of 1997) requires farmers to pay water

consumption fees irrespective of the discrepancy between real values and theoretical values (MAR and water use data) captured by the WAS.

5.2.2.4. Is there any relationship between the WAS's performance and illegal water abstraction along the Mooi River catchment from Klerkskraal to Mooibank?

Findings

Unfortunately human behaviour is unpredictable. Hence, it cannot be ascertained, whether it is influenced by WAS (its performance) or any other scientific methodology. However, the research findings indicate that there are personnel shortages at the Mooi River GWS. Consequently, the current or existing staff cannot effectively monitor the vast Mooibank farming areas. This could in turn be influencing some of the farmers to occasionally or regularly abstract water illegally.

5.3. SUMMARY OF THE RESEARCH FINDINGS

The findings reveal that there is poor communication between Mooi River GWS and its primary bulk water users i.e. the TLM purification water works and Mooibank irrigating farmers. Furthermore, there is no constant evaluation, implementation or monitoring of water distribution components such as water scheduling, MAR, irrigation water use and efficiency by the Mooi River GWS. The findings reveal that the canal (infrastructure) has been inefficient in the last 10 years (i.e. 2005-2014/5) as outlined in section 4.6. The findings contradicts what Biswas (1997:369) indicated, namely that water distribution programmes build a supportive relationship between the main water authority and water users. The researcher believes that without commitment from the main water authority, scientific water programmes cannot address social relations among water users, no matter how good or highly recommended they might be.

5.4. LIMITATIONS OF THE STUDY

It was difficult to locate all the respondents timeously, especially the Mooibank irrigating farmers. Furthermore, in reviewing and capturing the primary (actual) WAS components, the researcher struggled to cover the whole Mooibank farms sections due to the fact that it is so vast and difficult to access because of its vegetative terrain. However, primary data was obtained through persistence and the co-operation of field worker(s).

5.5. ETHICAL CONSIDERATIONS

Interviews were conducted in such a way that all the volunteering participants were treated with respect, honour and dignity.

5.6. INFORMED CONSENT

According to Bailey (1994:67), informed consent entails making or ensuring that the subject are fully aware of the purpose of the study and, its dangers and the full credentials of the researcher. The researcher made sure that each respondent understood the water distribution concepts and relevant regulations or legislations (section A of WSA of 1997 and NWA of 1998 Act 108).

5.6.1. Voluntary participation

The participants were informed beforehand that their participation was voluntary (free) and they were also offered the possibility of withdrawal if they felt uncomfortable. After the voluntary participation session(s), the respondents were given the contact details of both the supervisor and researcher so that they could contact one of us if they wanted to withdraw their participation.

5.6.2. Confidentiality

The researcher did not ask about the age or marital status of the participants as it might have made them feel uncomfortable. However, the volunteering participants agreed to have their names mentioned for the purpose of the study only.

5.6.3. Harm to participants

The research involved the basic properties of water distribution, which forms part of IWRM; no experiment was conducted on the participants (respondents).

5.7. RECOMMENDATIONS

In light of the research findings a number of recommendations can be made:

5.7.1. WAS and its applications

The water users should know the actual water distribution components, including the ones captured in WAS. This could be done through awareness and an open door policy on the part of the main water users' authorities, i.e. the Mooi River GWS and DWS. The role that WAS can play is to produce valuable information, as well as assisting in the planning of future infrastructural development.

5.7.2. TLM purification water works and its operations

It seems there is a culture of water entitlement at the TLM, due to the fact that it is a public water service provider (institution) classified under Schedule 1 (of the 1998 NWA). This can in itself propagate further bad relations with farmers, especially if

the TLM and its water purification works department are not transparent with respect to potable water distributions and usage. Water conflicts can in future be avoided if TLM (water purifications works) start engaging with farmers and being transparent about its potable water distribution and/or abstractions.

5.7.3. Mooi River GWS

From an environmental perspective, there seems to be a major problem of AMD that poses a significant threat to irrigation farming in the Mooi River irrigation area. Thus, responsible public and proactive environmental management is required to ensure that the situation remains positive with regard to the Mooi River GWS's water supply to its major stakeholders. In terms of water supply, to its stakeholders (Mooibank farmers and TLM purification water works), there is a gap between systematic conservation and the planning of infrastructural development. Most of the water infrastructure, such as canals, are ageing and therefore require immediate maintenance and/or expansion. Furthermore, the Mooi Rivers GWS should start monitoring (regularly) and evaluate the implementation of the WAS's water distribution components such as water scheduling, MAR and irrigation WUE by its officials. One of the most important factors is an effective system of communication. The Mooi River GWS should start creating proper communication platforms or channels that will make it possible for water challenges facing their main water users, namely Mooibank irrigating farmers, TLM purification water works and other interested stakeholders, to be fully addressed on a regular basis.

5.7.4. Recommendations for future researchers

Future research should consider the socio-economic and environmental impacts that could result from the integration of government water schemes (e.g. Mooi River) into water user association(s).

5.8. FINAL CONCLUSION

The proper implementation of WAS (components) will not only benefit the Mooi River GWS. The benefits can also be extended to the surrounding community of Tlokwe and its natural environment. The water that can be saved as a result of the proper application of WAS components can be allocated to other sectors and/or irrigating farmers as well. If irrigating farmers receive additional water, they will be able to extend the cultivation of their fields, which in turn could result in the increase of crop yields, and hence food production and employment in the agricultural sector, and fresh produce for the food markets. Food security is not only a specific location issue, but also a national issue and vital for human health and wellbeing.

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APPENDICES

APPENDIX A: ETHICS CLEARANCE CERTIFICATE



NORTH-WEST UNIVERSITY
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Institutional Research Ethics Regulatory Committee

Tel +27 18 299 4849
Email Ethics@nwu.ac.za

ETHICS APPROVAL CERTIFICATE OF PROJECT

Based on approval by **Research Ethics Committee of the Faculty of Arts**, the North-West University Institutional Research Ethics Regulatory Committee (NWU-IRERC) hereby approves your project as indicated below. This implies that the NWU-IRERC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title: <i>Water distribution and purification of Tlokwe Local Municipality: The case of the Mooibank farms.</i>																															
Project Leader:	Prof Johann Tempelhoff																														
Student:	P. Mulovhedzi																														
Ethics number:	<table border="1"><tr><td>N</td><td>W</td><td>U</td><td>-</td><td>0</td><td>0</td><td>2</td><td>5</td><td>6</td><td>-</td><td>1</td><td>5</td><td>-</td><td>A</td><td>7</td></tr><tr><td colspan="3">Institution</td><td colspan="6">Project Number</td><td colspan="2">Year</td><td colspan="4">Status</td></tr></table> Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation	N	W	U	-	0	0	2	5	6	-	1	5	-	A	7	Institution			Project Number						Year		Status			
N	W	U	-	0	0	2	5	6	-	1	5	-	A	7																	
Institution			Project Number						Year		Status																				
Approval date: 2015-07-14	Expiry date: 2020-07-13																														
Category:	N/A																														

Special conditions of the approval (if any): None

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- The project leader (principle investigator) must report in the prescribed format to the NWU-IRERC:
 - annually (or as otherwise requested) on the progress of the project,
 - without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-IRERC. Would there be deviation from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-IRERC and new approval received before or on the expiry date.
- In the interest of ethical responsibility the NWU-IRERC retains the right to:
 - request access to any information or data at any time during the course or after completion of the project;
 - withdraw or postpone approval if:
 - any unethical principles or practices of the project are revealed or suspected,
 - it becomes apparent that any relevant information was withheld from the NWU-IRERC or that information has been false or misrepresented,
 - the required annual report and reporting of adverse events was not done timely and accurately,
 - new institutional rules, national legislation or international conventions deem it necessary.

The IRERC would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the IRERC for any further enquiries or requests for assistance.

Yours sincerely

Linda du Plessis

Digitally signed by Linda du Plessis
DN: cn=Linda du Plessis, o=NWU,
ou=Vaal Triangle Campus,
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c=ZA
Date: 2015.08.11 13:01:17 +0200

Prof Linda du Plessis

Chair NWU Institutional Research Ethics Regulatory Committee (IRERC)

APPENDIX B: TLM PURIFICATION WATER QUALITY DATA

Analyses performance: Microbiological safety requirements of treated water and bacterial analyses

YEAR 2014/15

DETERMINANT	UNITS	NUMBER OF ANALYSES	SANS 241-1 2011 LIMITS	AVERAGE CONCENTRATIONS
<i>E.coli</i>	Count per 100 mℓ	2945	Not detected	0
Heterotrophic Plate Count	Count per mℓ	2864	≤ 1000	0,415
Total Coliforms	Count per 100 mℓ	2855	≤ 11	0
PERCENTAGE COMPLIANCE = 99,85%				

Source: TLM (2014:23)

Physical organoleptic and chemical requirements of TLM treated water:

Year: (2014/15)

DETERMINANT	UNIT	SANS 241-1 2011 LIMITS	TLOKWE AVERAGE	NUMBER OF SAMPLES	% COMPLIANCE
Colour	Mg/ℓ Pt-Co	≤ 15	2,07	155	100%
Conductivity	mSm	170	59,55	2529	100%
Total Dissolved Solids	Mg/ℓ	≤ 1200	365,0	155	100%
Free Chlorine Cl₂ (DWA)	Mg/ℓ	≤ 5	0,764	1945	99,69%
pH Value at 25°C	pH units	> 5.0 to ≤ 9.7	7,86	2529	100%
Turbidity	NTU	≤ 1	0,642	2529	98,70%
Suspended Solids	Mg/ℓ	No limit	0,57	155	100%
COMPLIANCE IN PERCENTAGES: 99,77%					

Source: TLM (2014:24)

DR MICHELLE COETZEE

(D.Phil. Theology– St Augustine's College, 2014)

AUTHORISED LANGUAGE PRACTITIONER

(English)

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17 September 2015

Dear Phillip Mulovhedzi

Language editing

This is to confirm that I edited your mini-dissertation, *Water distribution and purification of Tlokwe Local Municipality: The case of Mooibank farms* and that I indicated the necessary grammatical corrections.

Although I took all reasonable precautions to ensure that all grammatical and stylistic corrections are indicated, you remain responsible for the final product. Therefore, please check these suggested corrections before applying them and, if possible, again perform a spell check after you have implemented them, in order to eliminate typing errors.

Please contact me if there are any queries or if I can be of further assistance.

Yours sincerely



Michelle Coetzee



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E-Mail: Johann.Tempelhoff@nwu.ac.za

QUESTIONNAIRE CONTENTS

SECTION A: BACKGROUND AND GENERAL INFORMATION (Questions 1-14)

(A) Mooi River Government Water Scheme (GWS) officials;

SECTION B: PRINCIPLE OF EQUITY (Q 12-16)

Tlokwe Local Municipality officials

SECTION C: WATER INFRASTRUCTURE

Mooibank Farmers

IMPORTANT INSTRUCTIONS TO PARTICIPANTS

- (i) Please *complete all the questions asked in section A to C*
- (ii) Some questions only have to be marked with an x in the relevant box
- (iii) Some questions need to be completed in writing
- (iv) Some questions are open-ended and needs an explanation. Some questions are not open-ended

SECTION A: BACKGROUND AND WATER VOLUME (for quantitative data)

1. Questions 1 to 14 to be completed by the Mooi River Government Water Scheme (GWS) Officials
2. Kindly answer questions 1 to 14

Question 1: Background information

Name of Government Water Scheme		
Area Office		
Cluster Office		
Year of Establishment		
Names of Irrigating Farms		
Names of Dam(s)		
Name of Catchment Area		
Contact details for the GWS manager	Name	
	Telephone	
	Fax no	
	Cell phone no	
	E:mail	

Question 2: Water Volume(s)

Annual average dam level(in million cubic meters)									
Financial year	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Cubic meters									

Question 3: Cubic metres water release to Mooi bank farms

Annual average release to Mooibank farms (<i>in million cubic meters</i>)									
Financial year	2005/6	2006/7	2007/8	2008/9	2009/10	2010/1	2011/2	2012/3	2013/4
Cubic meters									

Question 4: Bulk water supply per sector (*in million cubic meters*)

Water usage per user (<i>in million cubic meters</i>)					
Financial years	2009/10	2010/11	2011/12	2012/13	2013/14
Domestic					
Industry					
Agriculture					
Strategic					
Hydro					
Other					

OPERATIONAL USES

Question 5: What are the key scheme problems/challenges that are currently faced by Mooibank farms water users?

Challenge(s)		
A	Ageing water infrastructure	
B	Illegal water abstractions	
C	In adequate human resources	
D	WAS programme implementation	
E	Supply chain problems(long periods in approving infrastructure maintenance costs)	
F	Other	

Any other problems/challenges? (Please specify here)

- (i).....
- (ii).....
- (iii).....

Question 6: According to you, what are the reasons for the scheme problems/challenges that are faced by Mooibank farms water users?

Reason(s)		
A	Lack of financial resources	
B	Harvest failure(poor farm productions)	
C	Insufficient water	
D	Other	

If other reasons exist, list them below:

- (i).....
(ii).....
(iii).....

Question 7: Addressing the key scheme identified problems/challenges

What do you suggest must be done to address the key scheme problems/challenges mentioned in question 5?

- (i).....
(ii).....
(iii).....
(iv).....
(v)(other).....
.....

Question 8: Adequate human resources

Does the scheme have adequate human resources?	Yes	No
--	-----	----

Question 9: If your answer to the above (question 8) is No, kindly complete the table below

	Name the three most important current vacant positions)	How long has this position been vacant?	Why are these positions vacant?
A			

B			
C			

Question 10: Efficiency of water supply to Mooibank water users (farmers)

Does the scheme use WAS efficiently for Mooibank water users(farmers)	Yes	No
--	-----	----

If the answer is No, how does the scheme plan to improve the use of WAS?

- (i).....
(ii).....
(iii).....

Question 11: Meetings held with bulk water users

How often does the scheme hold meetings with the bulk water users (farmers)?

Every 1-2 weeks	Monthly	Quarterly	Every 6 months	Annually
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Question 12: Farming activities of Mooibank farmers

List the major farming activities of your customers, the Mooibank farmers (e.g. crops, cattle and sheep)

Question 13: Suggestions to improve water provisions for agriculture

A:	
B:	
C:	
D:	

Question 14: Any further comments

Please provide any comments(positive or negative) that might be of importance to this study on Mooibank irrigation water supply by your scheme

(i).....
.....
(ii).....
.....
(iii).....
.....
(iv).....
.....

Thank you for your participation and valuable information

SECTION B: QUESTION ON TLOKWE POTABLE WATER DESTRIIBUTION

1. Questions 1 to 7 to be completed by Tlokwe Local Government officials
2. Kindly answer questions 1 to 6
3. The researcher will get the information on question 7 from TLG managers. You can thus leave this question 7 blank

Question 1: Current equitable potable water policies

Which of the currently equitable potable water distribution policies or strategies as prescribed by WSA of 1997 are you complying with?

	Policy	
A	Free basic water(FBW)	
B	Municipal Indigent(MIP)	
C	None	

Question 2: Mechanisms complying with directives to supply potable water to the poor

Indicate which of the following mechanism are you complying with when distributing potable water distribution to the poor communities?

Mechanisms as stipulated in the WSA of 108 1997		
A	1 communal tap of for every 200m radius in shack dwellings	
B	Distance of less than 200 metres of communal tap to households that were/are unconnected to the municipal reticulation systems	
C	Other	

Specific mechanism

- (i).....
- (ii).....
- (iii).....

Question 3: Water interruptions

Do you have any regular or frequent potable water supply interruptions?	Yes	No
---	-----	----

If yes, how long did it take to rectify such interruptions?

.....

.....

Question 4: Mechanism to address prolonged water interruptions

In case of prolonged interruptions caused by leakages, bursting and reticulation network maintenance) as stipulated in the WSA of 1997, what mechanism(s) have you adopted to try and provide potable water to those affected?

Water tanks/trucks	Water shedding	Borehole(s)	None
--------------------	----------------	-------------	------

NB: If the answer above is 'none' please skip question 5

Question 5: Complying with the stipulated WSA of 1998

Was the contingency method efficient in complying with the stipulated regulation Act 108 of WSA of 1998	Yes	No
---	-----	----

If you answered No, please indicate what the causes were for not complying with the provisions as stipulated on the NWA of 1998,

(i).....

.....

(ii).....

.....

Question 6: Future challenges on sustainable potable water distribution

What major challenges are you currently facing that may affect sustainable potable water distribution in the near future?

	Challenge(s)	
A	Treatment water works capacity	
B	Human resource	
C	Financial constrains	
D	Increasing water demands	
E	Water pollution(e.g. AMD),	
F	Other,	

If other, please specify here what other challenges you are confronted with:

(i).....

.....

(ii).....

.....

Question 7: Sharing of the same water resources and water canal

As a manager in TLM and from a managerial perspective, what should be done by TLM if its plant shares the same water resources and canal with Mooibank farms to secure sustainability on sharing this plant and channel?

.....

.....

[END OF QUESTIONAIRES: FOR TLM OFFICIALS AND MANGEMENT]

Thank you for your participation and valuable information

SECTION C: QUESTIONNAIRES FOR MOOIBANK IRRIGATING FARMERS (Q 18-19)

1. Question 1 to 7 to be completed by the Mooibank irrigation farmers
2. Kindly answer question 1 and 2
3. Bothe questions are open-ended

Question 1: current problems that you experience on irrigation water supply by the GWS

What current problems are you experiencing from irrigation water supply by Mooi River GWS?

- (i).....
.....
(ii).....
.....
(iii).....
.....

Question 2: Solutions to these problems

According to you, what are the solutions for the problems identified in question 1 above?

- (i).....
.....
(ii).....
.....

Question 3: Further comments on irrigation water supply by the Mooi River GWS/DWS

Provide any other comments on irrigation water supply service by the Scheme (Mooi River GWS/DWS)

- (i).....
.....
(ii).....
.....

Thank you for your participation and valuable information

Note: Schedule 1 of the National Water Act of 1998 makes it mandatory for the withdrawal of water for drinking (potable water use) purposes. Therefore, farmers were not asked (questioned) on the validity of TLM water works withdrawals. However, they are the main food producers, meaning that their voice need to be heard by water service authority, so that good relationship (*if not existing*) maybe built between all stakeholders in the study area.