# Perceptions of Municipal Water Managers of Limpopo and Luvuvhu-Letaba Water Management Areas on Water Resources, Uses and Restrictions

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## Abstract

*The study was to investigate the perceptions of municipal water managers of Limpopo and Luvuvhu-Letaba Water Management Areas of South Africa on water supply, use and restrictions. Managers in ten municipalities were interviewed to obtain relevant data. Due to lack or resource knowledge, 30% of managers omitted major rivers in their lists while 40% rated some incorrectly based on size. The managers reported non-consumption of water by some basic activities suggesting dearth of knowledge of consumed amounts. Perceived water consumption by major uses was: household>agriculture>industrial>recreation and underestimates agriculture consumption. Managers' perceptions on household consumptions were: washing> agriculture>drinking>cooking>processing food and drinks for sale. Perceptions on agricultural consumption were: irrigation>livestock drinking>dipping. Consumption by industries was perceived larger for food than drink processing. Rainfall occurrence reportedly minimized water restrictions. The perceptions of municipal water managers suggest that they lacked knowledge on water resources and their uses and were better knowledgeable on water restrictions.*

**Keywords:** Water management area, municipality, water resource, water use, water restrictions

## *1. Introduction*

Water demand already exceeds supply in many parts of the world (Vairavamoorthy *et al.*, 2008). Overcoming the world water scarcity and achieving water, food and environmental security simultaneously is one of the most formidable challenges on the road to sustainable development (Alexander, 2002). The scarcity of water in many countries is exacerbated by the nature of the water economy. The water economy in South Africa is characterized by high demand for the resource, intensive competition among use sectors, need for rehabilitation of supply infrastructure and pollution management (Randall, 1981; Backeberg and Groenewald, 1991). Inocencio *et al.* (2003) projected that all countries in Africa will be either physically or economically water scarce by 2025. As for South Africa, various speculations have been made over the last four decades. In 1970 it was projected that water requirements will exceed the maximum yield potential by the year 2000 (CIWA, 1970), and this has not happened.

With the current threat of diminishing water supplies and increasing demands it remains possible for the prediction to be reality, and this could be in 2020 (DWAF, 1986; Weaver, 1990) or some time between 2020 and 2030 (Odendaal, 1992). A contradictory prediction was made that South Africa will not run out of water by 2025 (Muller, 2000; DWAF, 2004). New policy guidelines and institutional arrangements which were being implemented confirmed that the threats of absolute water shortages were diminishing (Saleth and Dinar, 2003). Considering the occurrence of natural phenomena such as global warming and the increasing demand for water to supply communities that were historically excluded the view by Saleth and Dinar (2003) seems disputable. It is a fact that safe water is important for good health (Mwendera, 2006) and survival, but problems of access to portable water remain high (Jimu, 2008) even currently.

Municipal water managers play a critical role in the management of the resource and hence their perceptions on its supply and use in their areas influence the availability of the resource for social and economic development. While supply is influenced by runoff and storage capacity (Tshikolomo *et al.*, 2009), use is influenced by population growth and types of socio-economic activities performed (Molden *et al.*, 2000; Saleth and Dinar, 2003). Water use relates to consumption of water as well as to activities that may affect water quality and the condition of the resource itself. Such activities include abstracting water from a resource, storing it, waste disposal etc. (RSA, 1998; DWAF, 2004). The objective of the study was to investigate the perceptions of municipal water managers of Limpopo and Luvuvhu-Letaba Water Management Areas (WMAs) on water supply, uses and restrictions as the perceptions will, upon translation into municipal programs, influence the management of the water resource and hence the prospects for its availability for socio-economic development.

## *2. Methods*

### 2.1 Description of study area

The study focused on ten municipalities from two WMAs, the Limpopo and the Luvuvhu-Letaba WMAs. The municipalities covered by the study were Makhado, Musina, Lephalale, Polokwane and Aganang for the Limpopo WMA and Letaba, Thulamela, Tzaneen, Giyani, and Mutale for Luvuvhu-Letaba WMA (Figure 1).

### 2.2 Sampling frame and sampling procedure

A sampling frame is a complete list in which each unit of analysis is mentioned only once. Unless a sampling frame is borne in mind, it is impossible to judge the representativeness of the obtained sample properly. The sample should be representative of the sampling frame, which ideally is the same as the population (Welman *et al.*, 2005). In order to ensure proper selection of study units at all levels, multistage sampling was used as described by Leedy and Ormrod (2010) and included primary area selection of WMAs and location selection of municipalities.

The sampling frame for area selection consisted of four WMAs located (fully or partially) in the Limpopo Province of South Africa. The WMAs are Limpopo, Luvuvhu-Letaba, Olifants, and Crocodile West and Marico. For location selection of municipalities, the sampling frame was composed of 14 representative municipalities, nine in the Limpopo WMA and five in the Luvuvhu-Letaba WMA. Of the representative municipalities in the Limpopo WMA, six were fully contained (Musina, Aganang, Lephalale, Blouberg, Mogalakwena and Modimolle) and three shared a larger portion of their land areas with the WMA (Makhado, Polokwane and Molemole). Of the five representative municipalities in the Luvuvhu-Letaba WMA, two were completely located within the WMA (Letaba and Giyani) while three had a greater portion of land in the WMA (Mutale, Thulamela and Tzaneen).

Purposive sampling was used to select both the WMAs and the municipalities. In purposive sampling, study units are chosen, as the name implies, for a particular purpose. The researcher should always provide a rationale explaining why he or she selected the particular sample of study units (Leedy and Ormrod, 2010). The Limpopo and Luvuvhu-Letaba WMAs were chosen because they are managed under the nearby Limpopo Regional Office of the Department of Water Affairs (DWA) that would be easily accessible for information. The five municipalities in each of the WMAs were selected for their readily available information on monthly rainfall and sizes of major rivers flowing through them, all based on a study by Tshikolomo *et al.* (2009). Sampling especially in research covering qualitative issues should consider the units of analysis with the most information about the issues of investigation (Leedy and Ormrod, 2010) and hence the ten municipalities were correctly prioritized.

The municipal information on monthly rainfall was necessary to determine its influence on imposition of water restrictions while the information on sizes of major rivers was necessary to assess the level of knowledge managers had on water resources.

### 2.3 Data collection and analysis

A questionnaire was developed for interviewing the water managers of the municipalities sampled for the study. The questionnaire had two major types of questions, the closed-ended questions that collected quantitative data and the open-ended questions collecting qualitative data (Leedy and Ormrod, 2010). The interviews were more structured when dealing with closed-ended questions and provided limited opportunities for respondents to give more insight on the aspects covered by the questions. As for open-ended questions, the interviews were less structured and probed respondents to give more insight on the aspects covered. The study therefore fit into Hurmerinta-Peltomaki and Nummela (2006)'s description of a mixed research.

The focus of the questionnaire was on a range of water supply and use issues, and these included perceptions on sizes of rivers in the municipalities, water uses for domestic, industrial and agricultural purposes and issues of resource supply restrictions. The researcher conducted the interviews himself and this allowed for clarification of the questions that were not immediately understood by the respondents, ensuring good quality of the data. Quantitative data was captured and analysed using the SAS package (SAS Institute Inc, 2009). The Proc FREQ procedure of SAS was used to generate simple frequency tables of occurrence in each class utilizing one-way tables. The procedure is appropriate to give descriptive statistics about categorical data such as the demographic datasets. The syntax is provided to the SAS software, which automatically calculates the percentage of observations falling within each category of response. The output contains both the actual and the cumulative frequencies. Qualitative data was summarised and analysed using subjective interpretations (Leedy and Ormrod, 2010).

## *3. Results and discussion*

### 3.1 Perceptions on municipal water resources

The perceptions of municipal water managers on water resources have strong influence on how they will manage the resources and as alluded to by Vairavamoorthy *et al.* (2008), determines the extent of availability of water for social and economic uses such as agricultural, industrial, household, recreational and environmental uses. Surface resources such as rivers are major sources of water in the study area and their availability and sizes are easier to assess and were therefore the focus of discussion of the perceptions of water managers. The number and sizes of rivers are influenced by the direction of flow and amount of catchment runoffs described by Schulze (1995) as the water yield from a given catchment that consists of stormflow, baseflow, seepage, normal flow and overflow from any reservoirs within the catchment. The perceptions of municipal water managers on the number and sizes of rivers in their municipal areas are shown in Table 1.

Considering the municipalities in the Limpopo WMA, three rivers were reported by the water manager of Makhado to be flowing through the municipality, namely: Luvuvhu, Mutshedzi and Nzhelele while two were omitted, the Sand and the Klein Letaba River (Table 1). The omitted rivers are major and were accordingly mentioned among the rivers of the study WMAs (Tshikolomo *et al.*, 2009). The Luvuvhu River was perceived to be the largest, followed by Mutshedzi and last Nzhelele. The rating of Mutshedzi River as larger than Nzhelele is incredible because the Mutshedzi River is in fact a tributary of the Nzhelele River and as opposed to the Nzhelele River, is not even mentioned among major rivers in the study WMAs. The incorrect rating of the Mutshedzi River as being larger than the Nzhelele River could have resulted from the former having a well known dam, the Mutshedzi Dam which supplies water for domestic use. The Nzhelele Dam on the Nzhelele River only supplies water for irrigation and is therefore lesser known.

For Musina Municipality, four rivers were mentioned, namely: the Limpopo River perceived the largest followed by Nzhelele which was rated the second largest. The Nwanedi was rated the third largest while the Sand was regarded the smallest river flowing through the municipality. According to DWAF (2004), the mean annual runoff (MAR) of the Nwanedi River is 24.5 million $m^3$ while that of the Sand River is 71.9 million $m^3$, implying that the Sand is larger than the Nwanedi River, and this is contrary to the perception of the municipal water manager. The rating of the Nwanedi River as larger than Sand could have resulted from the former having a large Nwanedi Dam built on it while there was no major dam on the Sand River.

Three rivers were mentioned for Lephalale Municipality, and those were Mokolo rated the largest, Lephalale regarded the second largest and lastly Mogalakwena. Although it is one of the major rivers in the Limpopo WMA (Tshikolomo *et al.,* 2009), the Matlabas was not mentioned. The MAR of Lephalale River is 149.4 million $m^3$ while that of Mogalakwena is 268.8 million $m^3$ (DWAF, 2004), revealing Mogalakwena as larger than Lephalale and is contrary to the perception of the municipal water manager. Polokwane Municipality only has Sand River flowing through it while Aganang Municipality has no major river flowing through it, and these were correctly reported by the water managers.

As for municipalities in the Luvuvhu-Letaba WMA, the water manager for Thulamela mentioned four rivers, the Luvuvhu River rated the largest, Mutshindudi regarded the second largest, Mbwedi perceived the third largest and Nzhelele viewed the smallest, with the Shingwedzi River omitted from the list. The Luvuvhu River has MAR of 362.9 million $m^3$ (DWAF, 2004) and is confirmed the largest. The Mutshindudi and Mbwedi (catchment MAR of 138.1 million $m^3$) were presented as a combined river system forming a tributary of the Luvuvhu River. When the two rivers are considered as a combined river system, they are larger than the Nzhelele River (catchment MAR of 89.4 million $m^3$). If the Mutshindudi and Mbwedi were to be rated as separate rivers however, a different result would likely be reported. The rating of the Mutshindudi River as the second largest was likely influenced by its having a well-known Vondo Dam which supplies water for domestic use to the municipality. The rating of Mbwedi River as larger than Nzhelele is rather inexplicable.

The Tzaneen and Giyani municipalities had two rivers mentioned for each, and those seemed to be correctly rated. The water manager for Mutale Municipality rated the Nwanedi larger than Mutale River. The MAR of the Nwanedi River is 24.5 million $m^3$ while that of the Mutale River is 157.1 million $m^3$ (DWAF, 2004), implying that the Nwanedi is in fact much smaller than Mutale River as opposed to the perception of the water manager.
The omission of major rivers by municipal water managers and the incorrect ratings of the sizes of the rivers imply that the water managers had limited knowledge of the water resources of their areas. Based on these inaccurate perceptions, the water managers are likely to make water management decisions that are not appropriate. Inappropriate water management decisions will negatively influence the availability of the resource for socio-economic development in the study area. It is therefore necessary for the water managers to be equipped with relevant knowledge of water resources for them to make appropriate decisions that will promote resource availability for socio-economic development.

**3.2 Perceptions on municipal water uses**

Water is required for agricultural, industrial, household, recreational and environmental uses (Vairavamoorthy *et al.*, 2008). Growing national, regional and seasonal water scarcities in much of the world pose severe challenges for national governments and international development and environmental communities (Rosegrant *et al.,* 2002). According to Winstanley and Wendland (2007), adequate supplies of clean water are fundamental requirements for human welfare and economic development. Conversely, water shortages and polluted waters limit human and economic growth.

Water is consumed by multiple uses, often referred to as domestic and productive uses. Domestic uses of water refer to water used in the homes for drinking, cooking, personal hygiene and household cleaning, while productive uses highlight the fact that in rural areas people engage in economic activities that are highly dependent on the availability of secure and reliable water supplies (Moriarty *et al.,* 2004). Perez de Mendiguren Castresana (2003) mentioned that specific multiple uses of water in Bushbuckridge in the Mpumalanga province of South Africa include drinking, washing, cooking, irrigation, manufacturing, brick making and beer making.
For municipal water managers to manage this scarce resource well, they should have some knowledge of the major uses of the resource in their areas of jurisdiction. Schreiner and van Koppen (2000) state that poor people's water needs for multiple uses should be the starting point for meaningful management of the resource, confirming the importance of water managers' knowledge of the multiple water uses by the poor.

Seven out of ten (70%) of the water managers claimed they have knowledge of the relative quantities of the water consumed by each of the major uses in their municipalities. The perceptions of municipal water managers on major uses of water according to quantities consumed are shown in Table 2.

According to Table 2, domestic use was perceived to have consumed a very large quantity of water (rating=4.8), followed by agriculture that consumed a large quantity (rating=4.0). The quantities of water consumed for ecological and for industrial purposes was regarded small (rating=2.0) while that used for recreational purposes was reportedly very small (rating=0.9).

The ratings of the major water uses by the respondents differ to some extent from that reported by DWAF (2004) who presented agriculture as the largest consumer of the resource in the study area at 62%. The respondents reported agriculture to be a large consumer of water and to be second after domestic use, and the sector is still highly rated considering the quantity of water consumed. The perception of the managers that agriculture was the second and not the largest consumer of water could have resulted from the fact that they were not involved in supplying the major agricultural sector which received allocations directly from DWA. Municipalities were mainly rural with less industrial and recreational facilities and this could be reason for these sectors being perceived to be small consumers of water.

Three municipalities in the Limpopo WMA (Musina, Polokwane and Aganang) and one in the Luvuvhu-Letaba WMA (Giyani) reported lack of water consumption by some use sectors. The report of non-consumption could be an indication of the water managers' lack of knowledge of the consumed amounts. Each of the five major water use sectors was further discussed to better understand their perceived water consumption.

### 3.2.1 Perceptions on household uses of water

Household use of water is essential for human health and indeed for survival. Water for household use is supplied for domestic and for productive purposes. Domestic water was described as the supply which caters for health and hygiene, covering specific issues such as water for drinking, cooking, sanitation and washing (Soussan *et al.*, 2002; Pollard *et al.,* 2002). Productive water caters for household economic activities.

The 2003 Johannesburg Symposium on Poverty and Water resolved that the quantity of water sufficient for domestic use would typically be between 50 and 150 litres per person per day. Moriarty *et al.* (2004) stated that the benchmark target for South Africa was 25 litres per person per day and this was clearly insufficient, especially if needs for productive activities were considered. The recommended minimum supply of water should be 50 litres per person per day if we were to cater for both domestic and productive uses (Gleick, 1993).

The inclusion of productive uses in household water budgeting is important as it provides opportunities to turn water into cash needed to buy spare parts and to pay for routine maintenance of the water supply infrastructure (Lovell, 2000). As a result, water supply systems that are designed to provide only domestic norms with exclusion of productive uses would most likely fail. The failure would be a result of the water supply system not being able to meet the demand of the water users and this may bring about economic and political instability (Schouten and Moriarity, 2003).

Perez de Mendiguren Castresana (2003) revealed the kind of benefits in monetary values for the various productive uses of water. Ice-block making provided the highest return (R1,70 per liter), followed by beer brewing (R1,05 per liter) and hair saloons (R0,84 per liter). Brick laying was next (R0,30 per liter), followed by livestock rearing (R0,025 per liter) and fruit production (R0,02 per liter). Vegetable production provided the lowest return (R0,013 per liter). Knowledge of household uses of water would therefore be necessary for water managers to make appropriate decisions in investing in the development of the resource and in allocating the resource to different major use sectors.

All the water managers in the study area mentioned drinking, cooking, washing and processing food for sale as important household uses of water. Nine out of ten (90%) of them mentioned processing drinks for sale as an important household use of water. The respondents rated household uses of water according to the quantity consumed as shown in Table 3. Washing was perceived to have consumed a large quantity of water (rating=3.9), followed by agricultural activities (rating=3.4), drinking (rating=3.1) and cooking (rating=2.8) with perceived medium consumptions (Table 3). Very small quantities of water were reportedly consumed by processing of food (rating=1.2) and drinks (rating=0.9) for sale.

The rating of water uses according to the quantity of water consumed suggests that more water was used for domestic activities such as washing, drinking and cooking than the amount of water used for productive activities such as processing food and drinks for sale.

Although agricultural activities are productive, they were reportedly medium consumers of water. This perceived distribution of water where basic domestic activities use more water than their productive counterparts are indicative of short supplies forcing households to allocate more water to basic life activities.The fact that agriculture was perceived to consume the second largest amount of water implied that communities had realized the critical role played by the agricultural sector, both in promoting food security and in earning incomes for the rural households. This result supports Schreiner and Van Koppen (2000) who mentioned that water is vital to increase incomes above one US dollar per day. The reason for agriculture not being regarded the largest consumer of water could be the small scale of practice and the fact that it is not all families that practice agriculture at household level. Two municipalities in the Limpopo WMA reported that there was no water consumption by some use sectors. These were the Polokwane Municipality who reported non-consumption for drink and for food processing and the Aganang Municipality indicating non-consumption for drink processing. The report of non-consumption suggests that the water managers did not have knowledge of the quantities consumed by the sectors.

### 3.2.2 Perceptions on industrial uses of water

Vairavamoorthy *et al.* (2008) indicated that national water policies of many countries place industrial alongside household water needs. The use of water for industrial purposes in a municipality is dependent on the extent to which the municipality has developed industrially. The number and sizes of industries in a municipality determine the quantity of water that is consumed for these industrial purposes. Nine of ten (90%) water managers reported that some water in their municipalities was used by industries. Different types of industries which consumed water were identified. Food processing at industrial level was identified by seven of the ten (70%) municipalities as a user of water. Drink processing and manufacturing was each regarded by half of the municipalities as a user of water. The industries were rated according to the quantities of water consumed as reflected in Table 4.

Food processing was perceived to have consumed a large quantity of water (rating=3.6) and was followed by drink processing whose water use was rated medium (rating=2.6). The water uses for manufacturing (rating=1.3) and mining (rating=0.9) were perceived to be very small while that for power generation (rating=0.4) by the Electricity Supply Commission (Eskom) was regarded almost non-existent (Table 4). The results suggest that more water in the study area was consumed by the processing of food and drinks, often for sale. Food and beverage industries were more common in the study area and this could have been reason for more water being consumed by these industrial activities. Mining and Eskom power generation only occurred in some municipalities and hence the perception of less amount of water being consumed by these activities was not surprising.

All municipalities had some industrial water uses that perceivably did not use water. This report of non-consumption of water by a lot of industrial activities was probably a result of the fact that the study area is rural and has few such industries. It is possible that the managers lacked the knowledge of the water used by some of the industrial activities. In municipalities where food processing industries occurred, they were mostly bakeries, maize mills and abattoirs. With regards to drinks, the major industries involved in the study area included the processing of soft drinks, mainly by Coca-cola, processing juice mostly from fruits, and the processing of beer, both by the South African Breweries and by rural households who brew traditional beer.

### 3.2.3 Perceptions on agricultural water use

Among the various use sectors, agriculture is the world's largest user of water. Rosegrant *et al.* (2002) estimated the consumption of water by agriculture at about 80 percent of global and 86 percent of developing country water use in 1995. The global agricultural water consumption was affirmed by Molden *et al.* (2002) who revealed it to be almost 80 percent of total withdrawals from water sources. Cosgrove and Rijsberman (2000) had estimated the 80 percent consumption to be for irrigated agriculture alone.

To properly understand the quantity of water consumed by agriculture, we need to examine the amount of water we 'eat' compared to what we use for other purposes. A person's food requirement is estimated at 300 kg/year of cereal equivalent which is sufficient to furnish a daily average per capita caloric intake of about 2 900 kcal. Water productivity on the other hand is estimated at one kg/cubic meter, and subsequently 300 cubic meters of water are consumed per year to grow this annual food requirement (Inocencio *et al.*, 2003). As stated by Inocencio *et al.* (2003), the consumption by agriculture is equivalent to about 850 liters per person per day, which is much more than the 50 liters per person per day needed for household use.

Two out of five (40%) of the municipal water managers could estimate the amount of water used for agricultural purposes in their municipalities. All the respondents identified irrigation as a major agricultural water user. Nine out of ten (90%) of the water managers identified animal drinking while four out of five (80%) identified livestock dipping as a major agricultural water use. Table 5 shows the rating of agricultural water uses according to the quantity of water consumed as presented by the municipal water managers.

Irrigation was perceived to have consumed large quantities of water in all the municipalities (Table 5). The amount of water used for animal drinking was perceived to be medium in 90% of municipalities while it was regarded effectively non significant in 10%. Dipping of animals was perceived to have consumed small quantities of water in 80% of the municipalities and 20% reported the quantity used as non-existent. These findings confirmed a statement by Cosgrove and Rijsberman (2000) who reported that irrigated agriculture is the dominant user of water, accounting for about 80 percent of global and 86 percent of developing country water consumption. Also, DWAF (2004) reported that irrigation is the largest user of water in South Africa, accounting for 62% of the total water consumed.

Considering the assertion by Inocencio *et al.* (2003) that the productivity of water for cereal production is estimated at one kg/cubic meter and that a person's food requirement is estimated at 300 kg/year of cereal equivalent, it may be understood why irrigation uses that largest amount of water. The study areas are mainly rural with agriculture being the main economic activity and irrigation being an important agricultural activity.
The quantity of water used for livestock drinking and dipping tends to be influenced by such factors as the number of animals in an area and the proportion of the different types of animals. Areas with more animals use more water for livestock drinking and dipping, and the same occurs where large stock comprises a bigger proportion of the livestock in the study area.

A livestock census revealed that four of the municipalities under study had more than 50 000 cattle, namely: Makhado (64 686), Letaba (53 744), Giyani (83 726), and Lephalale (52 885) municipality (Limpopo Department of Agriculture, unpublished data). Based on the consumption rate of 68 litres/head/day (Lowe *et al.,* 2009), the daily amount of water used for cattle drinking in these municipalities would be 4 398.65 $m^3$ for Makhado, 3 654.59 $m^3$ for Letaba, 5 693.37 $m^3$ for Giyani and 3 596.18 $m^3$ for Lephalale. The other municipalities had fewer cattle each and would accordingly use lesser amounts of water for cattle drinking. For livestock drinking, however, the municipalities used more water than the quantities shown here as other animals would be accounted for, namely donkeys, mules, goats, sheep, pigs etc.

In areas where there are rivers, the animals drink directly from the rivers, and where there are none the water for animal drinking is mostly pumped from boreholes. In some cases the animals drink from the portion of water sourced for household uses. Two municipalities in the Limpopo WMA reported non-consumption of water by agricultural activities of livestock dipping and drinking. These are the Polokwane Municipality that reported non-consumption dipping and drinking and the Aganang Municipality that reported non-consumption for dipping. This report of non-consumption suggests that the water managers had a dearth of knowledge of the amount of water used in these agricultural activities.

The perceptions of municipal water managers that there were activities from various sectors that did not use water suggest that they lacked knowledge of the quantities of water consumed by these activities. This dearth of knowledge was confirmed by the perception that the amount of water used in agriculture is less than that consumed by households contrary to reports that agriculture uses as much as 62% of the water in the study area (DWAF, 2004). The ratings of the amounts of water used by some activities were rather credible. Objective assessment of the correctness of the ratings of water uses by the municipal water managers would, however, require a detailed study of the actual quantities of water consumed between and within each of the different use sectors.

### 3.3 Perceptions on water restrictions

South Africa is a water scarce country (DWAF, 2004) and this situation is very true in the WMAs under study. Due to the problem of water scarcity, different municipalities have to impose restrictions during certain months of the year. Up to 90% of the municipal water managers interviewed experienced water shortages in their municipalities. All the respondents indicated that water restrictions were imposed in their municipalities during certain months of the year. Figure 2 presents the months of the year in which water restrictions were reported to have been imposed by the different municipalities included in the study.

As reported by the managers, no municipality imposed water restrictions in the months of January to April. Some 40% of the municipalities imposed restrictions during May to August and in October and November. Up to 60% of municipalities imposed restrictions in September while 20% had restrictions in December (Figure 2).

According to Tshikolomo *et al.* (2009), the mean monthly rainfall of the municipalities under study are 6.9mm for August, 19.5mm for September, 50.6mm for October, 76.3mm for November, 99.0mm for December, 105.7mm for January, 109.4mm for February, 74.5mm for March, 34.8mm for April, 12.9mm for May, 7.6mm for June and 7.0mm for July. High rainfalls are received in the summer months of November – January with the highest recorded in February and low rainfalls are received in winter months of May – July with the least in August.
The imposition of restrictions by 40% of municipalities during May to August and by 60% of them in September could have resulted from water shortage due to the low rainfall during these months. Although rainfall would generally have picked up, 40% of municipalities retained the restrictions in October and November and 20% did so even in December, and that could suggest delayed rainfall in those municipalities or caution not to lift the restrictions until the rainy season had fully set in. The results suggest that the imposition of water restriction was influenced by the occurrence of rainfall as shown in Figure 3.

There was a moderate correlation ($R^2$=0.4555) between monthly rainfall and the number of municipalities that had imposed water restrictions (Figure 3). The graph reveals that the number of municipalities that imposed restrictions declined when the rainfall increased. Rainfall is the fundamental driving force of hydrological processes (Schulze, 1995) and is therefore important for water supply, which could be reason for its negative relationship with the imposition of water restrictions.

From the above discussion, it appears that some municipalities apply restrictions immediately when the rainy season is ending during May to July, others apply the restrictions at the beginning of the rainy season with yet others applying them at the transition from end of dry season to the beginning of the rainy season. Municipal decisions on when to impose water restrictions could be influenced by such factors as the main sources of water (i.e direct from rivers or from dams or from boreholes), the position of the area of the municipality in the catchment (i.e near sources of rivers or mountains or further down) and the average start of the rainy season.
The impositions of restrictions on water supplies are very necessary in the water scarce areas such as the Limpopo Province. The imposition of restrictions results in smaller supplies of water and lesser socio-economic activities. Non-imposition of restrictions could lead to disastrous consequences as a point could be reached were there would be completely no supply of water in some areas. The municipal water managers seemed to know when to impose restrictions in their specific areas. There is a continued need for research on water restrictions as a way of improving the efficiency of water use during times of scarcity.

## *4. Conclusions*

The perceptions of the water managers on the water resources of their municipal areas revealed a dearth of knowledge of these resources. This lack of knowledge was shown by the water managers omitting major rivers in their enlisting of the water resources and by their incorrect ratings of the mentioned rivers according to size. With this limited knowledge of the water resources, the water managers are likely to make inappropriate water management decisions that will negatively influence the availability of the resource for socio-economic development in the study area. To avoid this situation, the water managers should be equipped with relevant knowledge of the water resources.

With regards to water uses, the managers had perceptions that activities in some sectors did not use the resource in their municipal areas. While the perceptions of non-consumption could be true for some activities, they may not be credible for other activities. For instance, reports by water managers that there was no water consumed by ecological activities and by livestock dipping and drinking sound incredible. The perceptions suggest that the managers could have lacked knowledge of the amounts of water consumed by these uses. The lack of knowledge on various water uses was confirmed by the managers' perceptions that the quantity of water used by the agricultural sector was less than that consumed by household activities. For the municipal water managers to make appropriate decisions in their rendering of water services, it is very important for them to be equipped with requisite knowledge of the water uses. The water managers seemed to know when to impose restrictions in their specific areas. It is necessary to further improve the efficiency of water use in the area, and this requires more research on issues of water restrictions.

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## 6. Figures and Tables

### 6.1 Figures

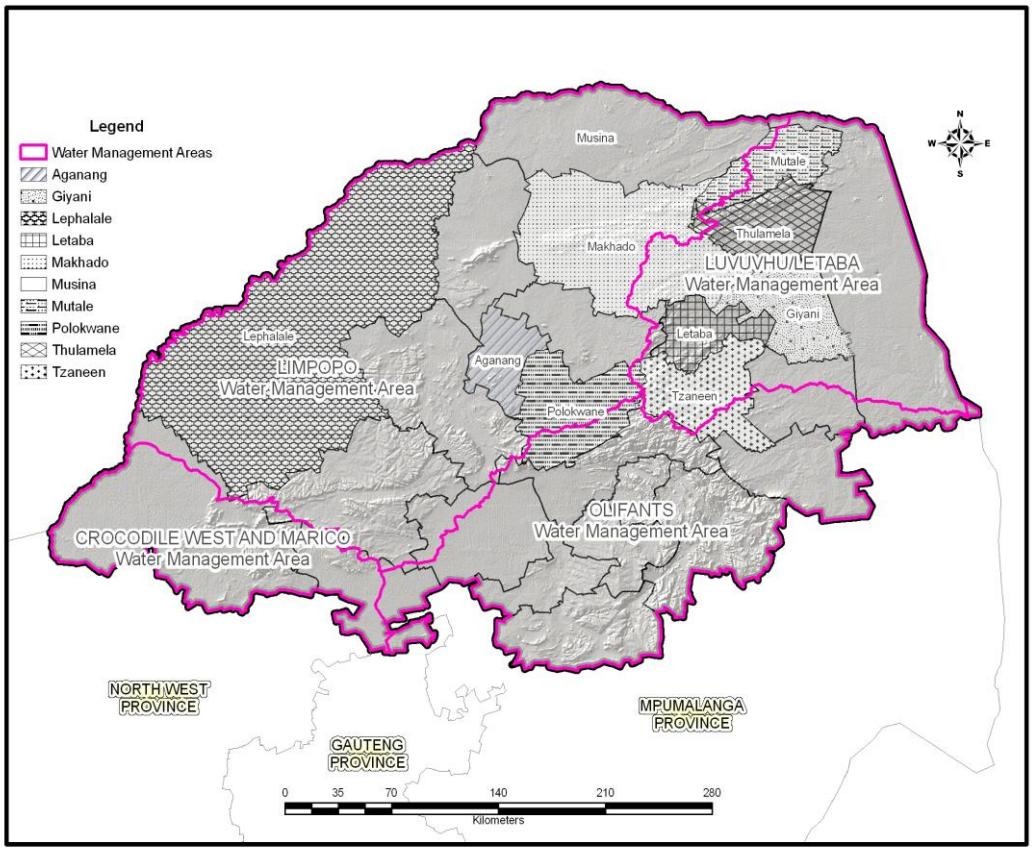


**Figure 1..Map of the Limpopo Province showing Limpopo and Luvuvhu-Leataba WMAs and study municipalities.**

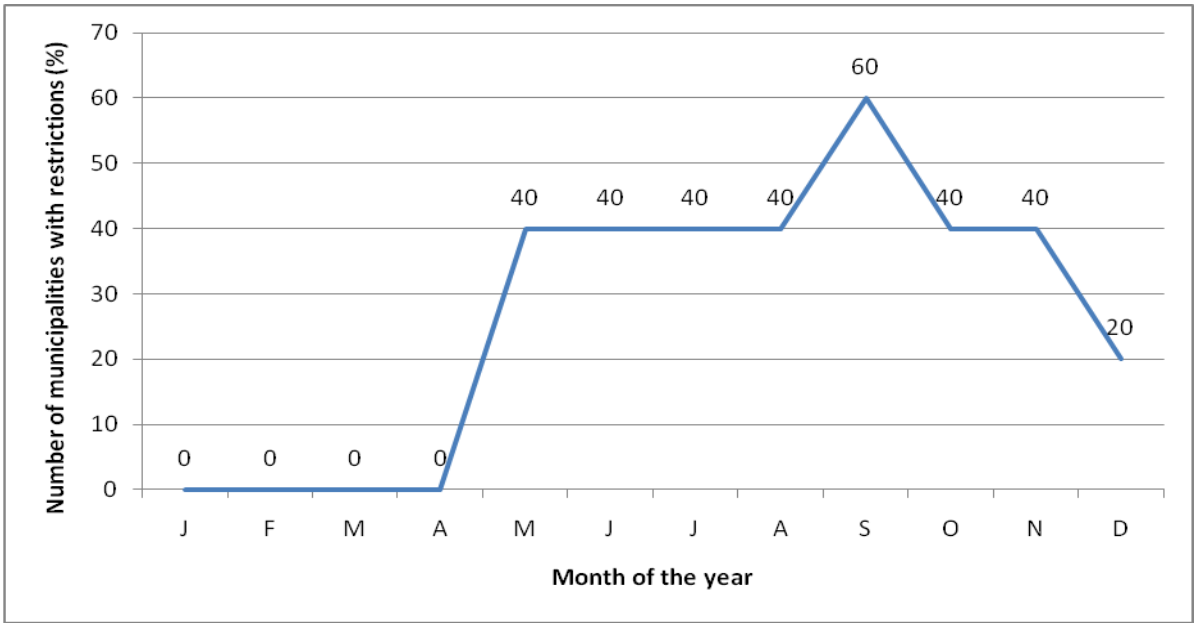


**Figure 2. Perceptions of municipal water managers on water restrictions across the months of the year**

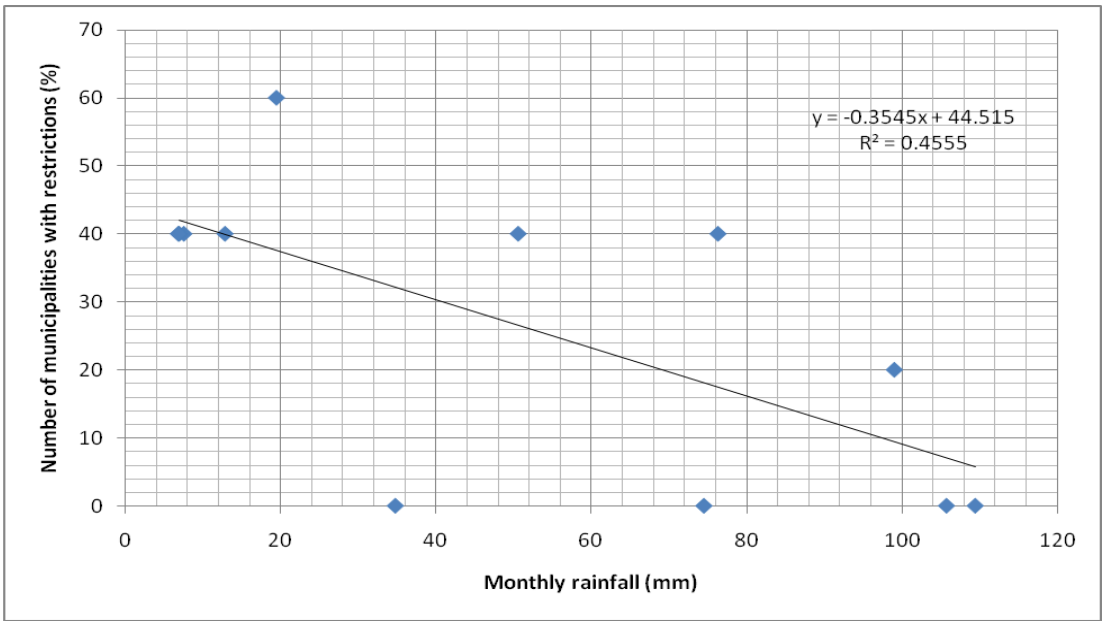


**Figure 3. Influence of monthly rainfall on imposition of water restrictions across municipalities**

### *6.2 Tables*

**Table 1. Perceptions of municipal water managers on number and sizes of rivers flowing through their municipal areas**

| Water Management Area | Municipality | Catchment rating |
|---|---|---|
| Limpopo | Makhado | Luvuvhu > Mutshedzi ک Nzhelele – (Klein Letaba, Sand) |
| | Musina | Limpopo > Nzhelele > Nwanediک Sand |
| | Lephalale | Mokolo > Lephalale ک Mogalakwena – (Matlabas) |
| | Polokwane | Sand |
| | Aganang | - |
| Luvuvhu-Letaba | Letaba | Molototsi |
| | Thulamela | Luvuvhu > Mutshindudi > Mbwedi ? Nzhelele – (Shingwedzi) |
| | Tzaneen | Groot Letaba > Letsitele |
| | Giyani | Klein Letaba > Msami |
| | Mutale | Nwanedi ک Mutale |

Key: > means correctly rated larger than; ک means incorrectly rated larger than; ? means no data to assess rating of larger than; -() means not enlisted

**Table 2. Perceptions of municipal water managers on major uses of the resource according to quantities consumed.**

| Water Management Area | Municipality | Perceived quantity of water consumed | | | | |
|---|---|---|---|---|---|---|
| | | Ecological | Household | Industrial | Agricultural | Recreational |
| **Limpopo** | Makhado | 2 | 5 | 3 | 4 | 1 |
| | Musina | 0 | 5 | 3 | 4 | 0 |
| | Lephalale | 2 | 5 | 1 | 4 | 3 |
| | Polokwane | 0 | 5 | 4 | 3 | 0 |
| | Aganang | 0 | 5 | 0 | 4 | 0 |
| **Luvuvhu-Letaba** | Letaba | 3 | 5 | 2 | 4 | 1 |
| | Thulamela | 3 | 4 | 1 | 5 | 2 |
| | Tzaneen | 3 | 4 | 2 | 5 | 1 |
| | Giyani | 3 | 5 | 2 | 4 | 0 |
| | Mutale | 4 | 5 | 2 | 3 | 1 |
| | **Average** | **2.0** | **4.8** | **2.0** | **4.0** | **0.9** |

Key: 0=None consumed, 1=Very small, 2=Small, 3=Medium, 4=Large, 5=Very large quantity consumed

**Table 3. Perceptions of municipal water managers on household uses of water according to quantities consumed by activity**

| Water Management Area | Municipality | Perceived quantity of water consumed by household activity | | | | | |
|---|---|---|---|---|---|---|---|
| | | Drinking | Cooking | Washing | Agricultural | Process drink | Process food |
| Limpopo | Makhado | 3 | 4 | 5 | 2 | 1 | 1 |
| | Musina | 5 | 3 | 2 | 4 | 1 | 1 |
| | Lephalale | 5 | 3 | 4 | 2 | 1 | 1 |
| | Polokwane | 4 | 3 | 5 | 2 | 0 | 0 |
| | Aganang | 1 | 1 | 2 | 4 | 0 | 3 |
| Luvuvhu-Letaba | Letaba | 2 | 3 | 4 | 5 | 1 | 1 |
| | Thulamela | 3 | 1 | 5 | 4 | 2 | 1 |
| | Tzaneen | 5 | 4 | 3 | 2 | 1 | 1 |
| | Giyani | 1 | 3 | 4 | 5 | 1 | 2 |
| | Mutale | 2 | 3 | 5 | 4 | 1 | 1 |
| | **Average** | **3.1** | **2.8** | **3.9** | **3.4** | **0.9** | **1.2** |

Key: 0=None consumed, 1=Very small, 2=Small, 3=Medium, 4=Large, 5=Very large quantity consumed

**Table 4.Perceptions of municipal water managers on industrial uses of water according to quantity consumed by activity**

| Water Management Area | Municipality | Perceived quantity of water consumed by industrial activity | | | | |
|---|---|---|---|---|---|---|
| | | Process food | Process drinks | Manufacturing | Mining | Eskom |
| **Limpopo** | Makhado | 5 | 3 | 4 | 0 | 0 |
| | Musina | 5 | 0 | 0 | 0 | 0 |
| | Lephalale | 0 | 0 | 0 | 5 | 4 |
| | Polokwane | 3 | 5 | 0 | 4 | 0 |
| | Aganang | 0 | 0 | 0 | 0 | 0 |
| **Luvuvhu-Letaba** | Letaba | 5 | 4 | 3 | 0 | 0 |
| | Thulamela | 5 | 4 | 3 | 0 | 0 |
| | Tzaneen | 4 | 5 | 3 | 0 | 0 |
| | Giyani | 5 | 0 | 0 | 0 | 0 |
| | Mutale | 4 | 5 | 0 | 0 | 0 |
| | **Average** | **3.6** | **2.6** | **1.3** | **0.9** | **0.4** |

Key: 0=None consumed, 1=Very small, 2=Small, 3=Medium, 4=Large, 5=Very large quantity consumed

**Table 5. Perceptions of municipal water managers on agricultural uses of water according to quantity consumed by activity**

| Water Management Area | Municipality | Perceived quantity of water consumed by agricultural activity | | |
|---|---|---|---|---|
| | | Dipping | Drinking | Irrigation |
| **Limpopo** | Makhado | 1 | 2 | 3 |
| | Musina | 1 | 2 | 3 |
| | Lephalale | 1 | 2 | 3 |
| | Polokwane | 0 | 0 | 3 |
| | Aganang | 0 | 2 | 3 |
| **Luvuvhu-Letaba** | Letaba | 1 | 2 | 3 |
| | Thulamela | 1 | 2 | 3 |
| | Tzaneen | 1 | 2 | 3 |
| | Giyani | 1 | 2 | 3 |
| | Mutale | 1 | 2 | 3 |

Key: 0=None consumed, 1=Small, 2=Medium, 3=Large quantity consumed