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SCHOOL OF ENVIRONMENTAL SCIENCES

DEPARTMENT OF HYDROLOGY AND WATER RESOURCES

TOWARDS EFFICIENT WATER UTILISATION IN SOUTH AFRICAN HIGHER EDUCATION INSTITUTIONS: A CASE STUDY OF UNIVERSITY OF VENDA

By

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Declaration

I, Nkuna Zanele with the student number 15008921, hereby declare that this dissertation titled "**Towards efficient water utilization in South African higher education institutions: A case study of University of Venda**" submitted to the Department of Hydrology and Water Resources under the supervision of Prof. Odiyo and Ms. Mathivha is my own work and has not been previously in whole or in part submitted to any University for any degree.

Student's signature Date

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Abstract

Water scarcity has become a constraint for sustainable development in the higher education institutions in South Africa including University of Venda. Water infrastructure is one of the major challenges within higher education institutions, the existing water supply infrastructure is over 20 years old and was not planned for the current population. This study aimed at developing a water management plan for higher education institutions in South Africa using the University of Venda as a case study. A water resource management plan provides a road map for reducing water consumption while encouraging sustainable water utilisation. Evaluation was done within the institution to identify water sources, water resources infrastructure and water utilisation. The study employed questionnaire survey to collect data on water consumption, to evaluate issues of the institutional participation in resolving the water problems within the institution and deduce water wastage.

Water supply data was obtained from meter readings and water invoices obtained from Vhembe District Municipality and University of Venda. The latter were used to determine water consumption within the institution. Based on the sample size, the results indicated the estimated amount of water consumed daily by UNIVEN population is 66 341.9 l/d excluding water utilised at the cafeteria, car wash and auditorium. The average water supplied to UNIVEN in 2017 was 67 642. 25 mega litres/month, this indicates that more water is supplied to the institution since the estimated institutional water demand excluding illegal students in the residence halls ranged between 415 740 l/d and 597 620 l/d of water while the estimated institutional water demand including illegal students varied between 282 2610 l/d and 406 6580 l/d. The latter further indicates that there is water wastage within the institution because the water supplied monthly to the institution was in mega litres as indicated in the invoices, but the results indicated that the amount of water utilised daily within the institution was in litres, this clearly shows that the respondents under estimated the amount of water they utilise.

The average amount of water used by students residing on campus was 271 l/p/d to 735.5 l/p/d while day scholars and university staff use 55 l/p/d to 142.5 l/p/d. The average amount of water used for cleaning ranged between 1 318.5 l/d to 3 909 l/d while gardening usage ranged between 4600 l/d and 8 600 l/d. The School of Agriculture experimental farm uses 9 270.4 l/d and the university laundry was found to utilise 5 186 l/d. The university laboratories were found to utilise 125 l/d to 215 l/d per practical session with 3 to 4 practical sessions conducted per week. The study found that the total water used by construction workers for domestic purposes

is 800 l/d. The utilisation trends showed that during the dry seasons, the university population generally used about twice as much water as compared to wet season because municipal water was supplemented by rain water for watering plants and washing the pavement.

The survey results indicated that students residing in the university residences waste more water by allowing the tap to run while brushing teeth, washing dishes, excessive use of water to rinse clothes while doing laundry, opening showers and leaving the water running while waiting for a desired water temperature. Activities such as watering flowers and lawn in an unmonitored manner and pavement washing in which the hose pipe runs for several hours during watering and pavement washing result in water wastage. The university does not have an environmental or water education projects that encourage students and staff to use water efficiently. Water conservation measures are lacking in the institution because there are no policies and procedures that outline how water should be utilised.

The developed water management plan for University of Venda outline the current water consumption, targets for reduction, drivers for reducing water consumption and water reduction strategies. This study recommends that the University targets to reduce potable water usage by 12% in the next 5 years. The latter has been highlighted in the proposed water management plan. The proposed plan further presents a suite of strategies to reduce water usage, improve institution water resources data and to plan for the future. Water utilisation within the institution has not been efficient due to water not being utilised in a sustainable manner. Sub-metering of each building, water awareness campaign, introduction of water utilisation policies, routine inspection and maintenance of infrastructure and appointing an environmental coordinator or working with water experts in the School of Environmental Sciences will help reduce water consumption within the institution.

Keywords: Policies, Water Management, Water scarcity, water consumption, water demand and water utilisation trends.

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List of abbreviations

CoJ- City of Johannesburg

DEAT- Department of Environmental Affairs and Tourism

DESD- Decade of Education for Sustainable Development

DWA- Department of Water Affairs

DWAF- Department of Water Affairs and Forestry

ERC- Energy Research Centre

GIA- Gross Internal Area

GoK- Government of Karnataka

GWP- Global Water Partnership

HEIs- Higher Education Institutions

ISI- Institutional Sustainability Initiatives

IWRM- Integrated Water Resource Management

LGBER- Local Government Budget and Expenditure Review

LRC- Luvuvhu River Catchment

L/D- Litres per day

L/P/D- Litres per person per day

NGO- Non-Government Organisation

NTU- Nottingham Trent University

PRSP-Poverty Reduction Strategy Papers

RWA- Regional Water Authority

UBC- University of British Columbia

UCSB- University of California Santa Barbara

UCT- University of Cape Town

UJ- University of Johannesburg

UN- United Nations

UNDP- United Nations Development Programme

UNEP- United Nations Environmental Programme

UNESCO- United Nations Education Scientific and Cultural Organisation

UNIVEN- University of Venda

UNISA- University of South Africa

USGS- United States Geological Survey

UWE- University of West England

WITS- University of Witwatersrand

WGDF- Water for Growth and Development Framework

WMP- Water Management plan

WRC- Water Research Commission

CHAPTER 1: INTRODUCTION

1.1 Background

The necessity for water to life and its importance to socio-economic development explains human beings perennial quest to improving water resources management. Arguably, in the wake of the Rio Earth Summit of 1992, the challenge for improved water resources management has been further expanded to include management of water for environmental sustainability. South Africa is classified as a water scarce country (Muller *et al*., 2009), due to its geographical location in a semi-arid area as well as its growing population, increasing water demand, inadequate water management practices and increasing pollution issues (DWA, 2012).

Institutions of Higher Education have the potential to foster sustainable and integrated water management through their education, research, service, and operational activities (Cortese, 2003). The current need for consideration of campus water management is underscored by the development of two parallel programs of the United Nations (UN) and the UN Decade of Education for Sustainable Development (DESD). Both programs were established to draw special attention to the issues of water and sustainability in higher education to meet the Millennium Development Goals, particularly the one of environmental sustainability (UN, 2000).

Gumbo *et al*. (2004) argued that one of the major constraints in managing water demand is the absence of well-structured education and training programmes suitably targeted to stakeholders in the water management chain. Furthermore, this training should move beyond mere transfer of knowledge and skills to actual implementation. Every sector that contributes to a country's economic growth requires water to survive. If water utilisation continues to be inefficient without an integrated approach to manage the scarce resource wisely, it is predicted that freshwater supply will no longer meet the demands of the growing population by 2030 (Seckler *et al*., 1998).

Institutional Sustainability Initiatives (ISI) referred to as campus greening or campus sustainability programs and projects have been established at many universities to plan, develop and manage efforts on campus. These greening initiatives have concentrated on environmental sustainability issues such as green building, recycling, sustainable transportation, energy conservation, water conservation, greenhouse gas emission reductions, green purchasing, and green dining (Patrick *et al*., 2008). Campus sustainability is a rapidly growing priority for university campuses both nationally and internationally. Sustainable management of freshwater resources is a key development priority to meet the growing demand of water.

A reservoir is being built in the existing municipal water network within the institution, which will improve the water supply within the University. The current water reticulation network will be split into two main ring networks (Network A and B). Network A will connect to the current storage facilities (Abeco 1, 2 and 3) and will supply water to the hostels while Network B (newly built reservoir) will supply water to the rest of the university buildings. Thereby increasing the amount of water available within the institution. The supply and demand for water resources in the different sectors need to be addressed. This is because water scarcity becomes a constraint for sustainable development and impacts different sectors with no exception to Higher Education Institutions in South Africa. A water resource management plan provides a road map for reducing water demand and manage consumption. Therefore, it is an adequate response to achieve water security in UNIVEN and its development therefore forms the focus of analysis in this study.

1.2 Statement of research problem

Water infrastructure is one of the major challenges within UNIVEN, the existing water supply system was installed a long time ago and the exact date of installation is not known by the maintenance department. The aging system is deteriorating but the institution does not have any scientific data on it and the quantity of the water demanded or supplied for different uses in the institution. The university operates a bulk metering system for the whole institution without providing meters for sections such as residences and respective faculties. This promotes inefficiency in water utilisation since no one can be held responsible. University cleaners use horse pipe and fire horse reels to wash, flush walkways and pavement. Water leakages are a common phenomenon in the campus, and the Maintenance Department does not respond promptly to such. The latter leads to inefficient water utilisation within the UNIVEN main campus. The fact that the institution does not have a water utilisation plan makes water resources prone to wastage leading to inefficient utilisation as currently happening within the institution.

1.3 Motivation of the study

When the university opened in 1982 it had 360 students, over the years the university has witnessed an increase in the number of students admitted, i.e, in 2010 the university admitted 10 679 students with a staff population of 859 while in 2017, the population was 15 915 students, and 973 staff members. The latter shows an increase student population to be 5 236 with 108 staff over a short period of time. There has been also an increase in infrastructural development. The increasing infrastructure that coupled with the increasing population, has contributed to an increase in water demand and utilisation within the institution. DWAF (2012) acknowledges that the country faces serious challenges in water management despite adequate water management strategies. The implementation of water management strategies remains inadequate. The proposed water management plan must be implemented within the institution so that more water can be saved and the university community will utilise water more efficiently. This has contributed, for example to inability to expand water supply infrastructure as the population increases and new infrastructure development takes place. Inadequate monitoring and management of water supply infrastructure and water use contribute to water loss and uncontrolled use, respectively. Unfortunately, there has not been a water management plan that has been developed for the UNIVEN and therefore there is a need for this study to be conducted. DWAF (2008) projected that the demand for water in South Africa will exceed water supply by 2025. There is therefore a need for UNIVEN to control and manage their water consumption sustainably and contribute to water conservation.

1.4 Main objective

The main objective of the study is to develop a water management plan for the University of Venda (UNIVEN).

1.4.1 Specific Objectives

- To identify water use types at the UNIVEN.
- To evaluate water demand for the UNIVEN.
- To estimate the water consumption in the UNIVEN.
- To evaluate institutional arrangements for resolving water problems.
- To develop water management plan for UNIVEN.

1.4.2 Research questions

- What are the main uses of water in the institution?
- What is the water demand for the UNIVEN?
- What is the actual amount of water used by the University?
- What is the University management doing to resolve the water related problems within the institution?
- How can an institutional water management plan be developed?

1.5 The study area

This study was carried out at the UNIVEN, located in Thohoyandou within the Dzindi River Catchment in the Limpopo province. This area is within Thulamela Local Municipality in Vhembe District. The study area is located between the following geographic grids; Latitude 22°58′38″ S and Longitude 30°26′49″ E. Figure 1.1 shows location of University of Venda within the Dzindi River.

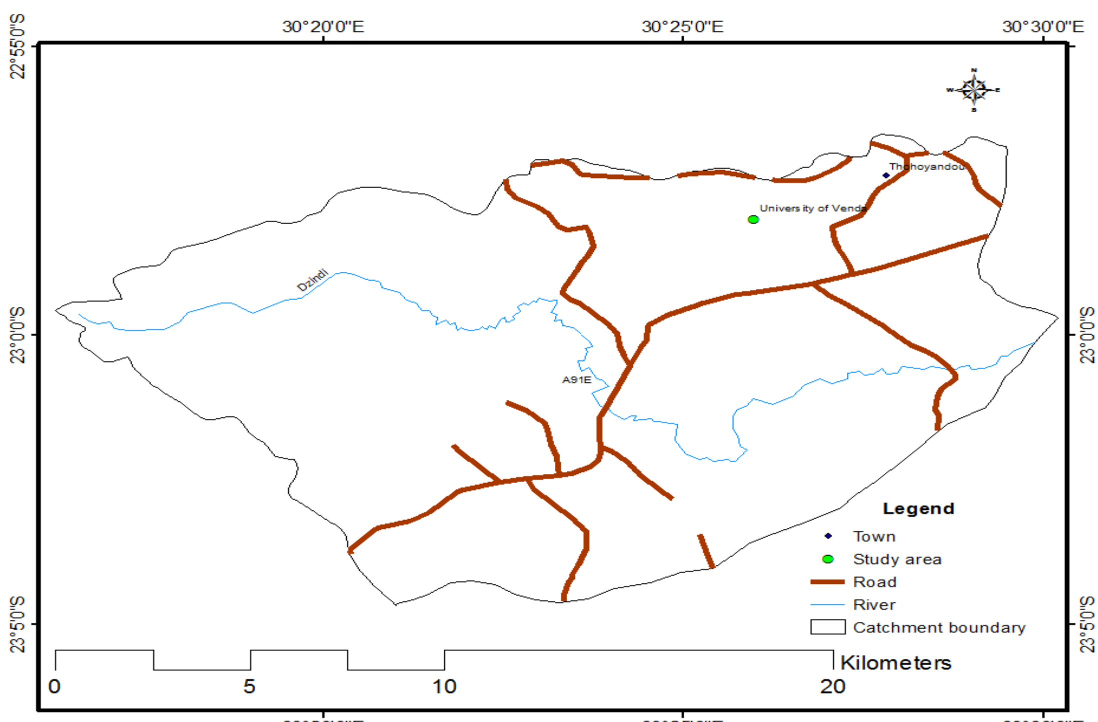

Figure 1.1: The study area

UNIVEN is a South African comprehensive rural based University that was established in 1982 as a branch of the University of the North. The branch became independent on 06 November 1982 when the University of Venda Act (Act 19 of 1982) was passed by the then Venda Parliament. The University of Venda has one main Campus in Thohoyandou. The university population increases every year, with a reported enrolment of 15 537 students for the academic year 2016 (Mulaudzi, 2016). The Campus houses all 8 schools of the institution, namely; Agriculture, Education, Environmental Sciences, Health Sciences, Human and Social Sciences, Management Sciences, Mathematical and Natural Sciences, and Law. The campus also has an experimental farm which is under the School of Agriculture. The campus also houses the Art Gallery, which has a display of carvings, paintings and clay pots made by both students and local community members. Furthermore, the campus has a full-time sports centre that is used for indoor sports as well as other recreational activities such as drama and dance. The main campus further houses nine of the eleven official university student residence halls, namely; Bernard Ncube, Carousel, F3, F4, F5, Lost City Boys, Lost City Girls, Mango Groove, Riverside and Prefab. It is important to note that there are 24 new student residence halls currently being constructed within the university main campus, which will house approximately 7680 students, and this will have implication on water use and the existing non-upgraded water supply system.

Thohoyandou is characterised by high temperature variations depending on the different seasons. The monthly distribution of average daily maximum temperature, the average midday temperature ranges from 22.9^{o} C to 30.3^{o} C in summer and 17^{o} C to 22^{o} C in winter. The region is the coldest during July when the temperature drops to 7.5°C on average during the night. Thohoyandou normally receives about 752 mm of rain per year, with most rainfall occurring mainly during mid-summer. It receives the lowest rainfall (4 mm) in June and the highest (154 mm) in January. The rainfall is seasonal and occurs during summer months from October to March. More than 80% of the rainfall occurs in the summer months and only about 20% occurs in the winter months. (Thohoyandou climate, 2016)

As the temperature increases, evaporation increases as well, and this has a negative impact on water resources (UK Essay, 2013). The major source of water in UNIVEN is Vondo dam, which is located in Phiphidi Village and this supply is augmented by groundwater from UNIVEN boreholes. According to Nematatane (2017), who is a superintendent for all potable water treatment plants under Vhembe District Municipality, some villages around Thohoyandou are now being supplied with water from Nandoni water treatment works. Further to the latter, it is envisaged that the municipal reservoir located adjacent to UNIVEN will be supplied by Nandoni Dam as well.

CHAPTER 2: LITERATURE REVIEW

2.1 Preamble

This chapter reviewed literature on water resources availability in South Africa, water demand, drivers to water management, water management in institutions of higher learning, water resources infrastructure in general and for UNIVEN. The concept of Integrated Water Resources Management (IWRM), concept of sustainability in the context of water, sustainability in higher education institutions and institutional development of Water Management Plan (WMP) were reviewed. The literature reviewed is relevant to the scope of the study because for a successful development of institutional water management plan accurate knowledge of the water availability is required. Water management review assists in planning and managing the optimum use of the resource. IWRM promotes awareness raising, and participatory processes which are essential activities to produce outputs. Sustainability plans are used as tools for conserving water.

2.2 Introduction

Water is a fundamental human need and is required to support all life forms. Access to water also brings benefits and improvement to the standard of living. It is therefore vital that the government efficiently distribute potable water to all citizens. South Africa is a country with marked spatial and temporal variability of rainfall (Griffiths, 1985). With industrialisation, urbanisation and population growth the demand for municipal water services will continue to increase, placing pressure on the ability of the natural systems to provide sufficient quantity and quality of water sustainably. People living in rural areas, generally lack adequate supply of water (Camp, 2000) although water is central to physical survival, household use and development (South Africa, 1994).

Buildings can be classified into five major categories as residential, commercial, public, industrial and agricultural buildings and each type of building has different water consumption levels (Bio Intelligent Service of European Commission, 2009). However, there are primary water use purposes such as toilets, showers, wash basins, kitchens and landscaping that are common to any type of building (Arab Forum for Environment and Development, 2006). Overall, water consumption is greatly influenced by various factors such as building features/infrastructure, geographical location, appliances installed and human activities in the building (Groundfos Commercial Building Services, 2012).

2.3 Water resources availability in South Africa

Water availability is the hydrologic capacity of a water source (surface water body, groundwater, municipal water) to sustain additional water demand after considering other current water uses and water conditions (Tingyi, 2007). Water availability is one of the factors that will affect economic, social and environmental well-being of South Africa over the next decade and its supply is already seriously limited. A study conducted in London by Lalzad (2007) showed that water covers more than 70% of the world's surface. The total amount of water on earth is about 1400 million km^3 (326 million miles) and about 97.5 % of this amount is saltwater with only 2.5% being freshwater (UNEP, 2002). Only about 0.3% of the total amount of freshwater on earth is accessible groundwater or surface water that humans, animals and plants can use (Gleick, 1996). The latter also identified that less water was accessible because water was available where it was not wanted and in other cases, there is too much water in the required places at the wrong time. For instance, about 20% of the global annual rainfall runoff each year occurs in the Amazon basin (Lalzad, 2007), which is inhabited by approximately 10 million people, which is only a fraction of the world's population. Water scarce societies and many countries attempted both to move water from where it occurs in nature to where people wanted it and to store water for future use. The Lesotho Highland Water Project is the largest bi-national infrastructure project between Lesotho and South Africa (International Rivers, 2005). It involved the construction of an intricate network of tunnels and dams to direct water from the mountains of Lesotho to South Africa. It provides water for South Africa and hydroelectricity for Lesotho (International Rivers, 2005).

Water availability in South Africa is relatively low, the country is semi-arid with a highly variable climate with highly constrained freshwater resources (DWAF, 2004). These limited water resources are affected by weather extremes imposed by climate variability and change. Drought, which has devastating consequences in parts of the country, is a recurrent characteristic feature of the country's highly variable climate and weather extremes (WRC, 2015). Rainfall is generally low and irregular with a widespread mean annual precipitation of about 500 mm compared to that of 860 mm of the world average and this makes this country prone to recurrent droughts (Merolla, 2011). As already indicated, rainfall in South Africa is below the world average. The mean annual runoff for South Africa is estimated at some 50 million m^3 a^{-1} and is not distributed evenly throughout the country, with the eastern seaboard having some 80% of the country's runoff, whilst the western regions tend to have low runoff (DEAT, 1999). According to O'keeffe (2003), 92% of rainfall in South Africa returns to the atmosphere through evaporation before even reaching rivers or streams.

According to Local Government Budgets and Expenditure Review (LGBER) groundwater resources are also not abundant, as most of South Africa is made up of hard rock formations that do not contain major groundwater aquifers that can be used on a national scale (LGBER, 2001). South Africa's water resources are comprised of 77 % surface water, 9 % groundwater, and 14% re-use of return flows (LGBER, 2001). Luvuvhu River Catchment (LRC) also supplies other nearby catchments with water. According to DWAF (2005), about 2.4 million m^3 of water is allocated for transfer from Albasini dam to Makhado Municipality in the Sand River Catchment. The population growth and economic development in Makhado Municipality, Thulamela Municipality and other areas which obtain water from LRC also worsen the situation as more water is required to meet the demand.

2.4 Water demand

The United States Geological Survey (USGS) (2014) defines water demand as the amount of water needed for all users. Savenije and Van Zaag (2003) went a step further by incorporating the spatial component and defined water demand as the amount of water required at a certain point. Water demand is influenced by different factors such as population growth, climate, agricultural and economic developments. When population increases so does the water demand, it is estimated that by 2025 approximately 3 billion people will be living in countries experiencing water stress (Majumder, 2015). In the 20th century the world's population has tripled, but the use of water resources has grown 6-fold (Zereini *et al.*, 2009). It is also estimated that in the next 50 years the world's population will grow approximately by 40% and if the current population water use trends continue, the water resource will significantly diminish (UN Population Division, 2007). A study by Gleick (1998) indicated that water availability was affected by anthropogenic factors such as population growth. For example, Katri and Vairavamoorthy (2007) reported that the availability of water sources throughout the world were becoming depleted and this was aggravated by the rate at which populations were increasing, especially in developing countries. An increasing population leads directly to decreasing per capita water availability (Gleick, 1998).

According to Sigenu (2006), some causes of water shortages were human induced, meaning that water shortages were aggravated by human responses. The rapid population growth, particularly during the 1960s, 1970s and 1980s, has caused serious depletion and degradation of water resources in South Africa, and yet demand is constantly increasing (Sigenu, 2006). Otieno and Ochieng (2004) reported that South Africa is currently categorised as a water stressed country because of population growth and it was forecasted to experience physical water scarcity by the year 2025 with an annual water availability of less than 1000 m^3 per capita. With the increasing trends in population, there will be an increased pressure on the available water leading to water shortages. As a result of population growth, the demand for irrigation water has increased in the agricultural sector. According to Earle *et al*. (2005), population growth increases the demand in municipal water services and this places pressure on the ability of a natural system to provide sufficient quantity and quality of water sustainably.

Water demand can also be influenced by the climate. Neale (2006) indicated that climate change increases water demand above those predictions of population growth alone. Water use increases with temperature and diminishes with precipitation (Wilby and Miller, 2009). This means that, water demand is high during scorching summer days while it is low during winter and rainy days. According to Wilby and Miller (2009), future water demand will be affected by climate change. In the agricultural sector, climate-related factors such as changes in the quantity of precipitation, runoff and evapotranspiration rates will increase demand for water (Nicol and Kaur, 2009). As a semi-arid country with a highly variable temperature, it is predicted that there will be a national water crisis in South Africa by 2025 (Gillham and Haynes, 2002).

It is generally recommended that non-domestic water demands should be based on field measurements as it is extremely difficult to estimate them (CSIR, 2003). The City of Johannesburg also recommends in its water supply guidelines that non-domestic demands should be determined where possible from the City Treasurer's records on actual water consumption (City of Johannesburg, 1989). The "Red Book" guideline with regards to non-domestic water demand is summarised in Table 2.1 for developing areas.

Table 2.1: Non-domestic water demand in developed areas (CSIR, 2003)

Non-domestic users	Water demand
Schools: Day Boarding	 15 - 20 litres/pupil/day 90 - 140 litres/pupil/day
Hospitals	220 -300 litres/bed/day
Clinics	5 litres/bed/day -out patients 40 - 60 litres/ bed/ day – in patients
Bus stations	15 litres/user/day for those persons outside the community
Community halls/ Restaurants	65 – 90 litres/seat

2.5 Drivers for water management

2.5.1 Water scarcity

A certain quantity of water is essential for life and maintenance of personal hygiene, the absence of which results in health problems like dehydration and skin diseases (Carter *et al*., 1997). Further, maintenance of a clean environment becomes increasingly difficult with insufficient water creating blockages in sewer systems or spread of sanitary waste on the surface that can increase water, soil and air pollution. Water scarcity or limited availability, particularly during the summer months results in fluctuations, irregularity and reduction in per capita availability (Government of Karnataka, 2000). Fluctuations in water supply can cause unexpected water contamination in the distribution network which is attributed to rustiness developed in pipes due to reduced water flow, which causes health and environmental problems (Hardie and Alasia, 2009).

2.5.2 Poor service delivery

The framework for municipal infrastructure grant has been developed in South Africa with clear policy guiding the use of grant, funding allocations, programme systems, set of structures and procedures from national to local level (Tremolet *et al.,* 2007). Even with these clear procedures the funding allocated to water and sanitation sector is very low, for example the government investment in water and sanitation in South Africa lies between 1% and 2%, innovations in financing happens at municipal level (Mnisi, 2011). In Poverty Reduction Strategy papers (PRSPs) developed over the years, it was noticed that water and sanitation appear at a relatively low ranking of priority (Mnisi, 2011). Factors leading to such low prioritisation of water sector include lack of political support for the sector and these affect poor communities.

According to Sigenu (2006), socio-economic issues such as poverty greatly influence access to water. People with the lowest status and wealth in the social hierarchy, often suffer disproportionately when water supplies are limited. A South African study by Pelser and Redelinghuys (2009) clearly indicated that service delivery in rural areas has always lagged that of urban areas due to a few reasons (lack of infrastructure, geographic barriers and lack of government institutions). Supplying services to remote and geographical spread out population makes infrastructure development and maintenance, as well as ensuring supply of services such as water provision, costly and difficult to maintain. In a detailed article on Water for Growth and Development Framework (WGDF, 2009), it was mentioned that many of the larger villages in South Africa are located on hillsides and generally have unplanned layouts and in these circumstances, to provide even basic water supply to each household is complicated and costly.

Water Supply and Sanitation Policy (1994) pointed out that most existing water schemes in rural areas of South Africa were out of order due to technological failure. According to WGDF (2009), in South Africa a major source of water problem was ageing infrastructure exacerbated by poor operations and maintenance at municipal level. In addition to technological failure, Maluleke *et al.* (2005) conducted an infrastructure assessment. The latter generated the water infrastructure map for New Forest village, and it was from this map that they observed that although the infrastructure is available, the main problem is technological failure. It was reported that there were regular breakdowns of engines and their capacities were insufficient to supply the whole village. In addition to that, it was further reported that the village dam ran dry during dry seasons. The reticulation system was problematic regarding the connection setup between the engines and was a cause of regular breakdown. Less than 50% of the communal standpipes were effectively providing water (Maluleke *et al.*, 2005).

2.5.3 Agriculture

Agriculture sector plays a crucial role in the life of an economy, it is the backbone of the economic system (Schmitt, 1990). Agriculture not only provides food and raw material but also employment opportunities to the country's population. Since agriculture is a crucial sector and a key driver of growth for the rest of the economy in the country, the University of Venda practice farming as well, that involves cultivation of the land for the growing of crops and the rearing of animals to provide food and other products. According to Gleick (2014), agriculture is the greatest water user and consumes 70% of accessible freshwater globally. The latter is more than twice that of industry (25%) and municipal use (8%). Farming can have a positive and negative impact on the environment and the effects can impact on both the air and soil.

2.5.4 Water pricing

Apartheid policies distorted the provision of water supply services and generated a biased approach to water resource management (Nnadozie, 2011). Until recently, users of bulk water in South Africa paid a subsidised price on water that was less than the economic value. Government water policy, and the provision of subsidies including those associated with the provision of irrigation water, made them to pay for the operating costs and they were exempted from paying for the capital costs of water delivery (Hassan *et al*., 2005). The former resulted in considerable advantages to large white commercial farmers at the expense of emerging black farmers and smallholders. The Raw Water Pricing Strategy (1999) aimed to achieve social equity by redressing the imbalances of the past, both with respect to equitable access to water supply services and with respect to direct access to raw water. The following objectives were of equal importance in formulating the new pricing strategy (DWAF, 1998): social equity; ecological sustainability; financial sustainability;

and economic efficiency. Zekri and Dinar (2003) identified price as one of the significant determinant of water demand in rural Tunisia.

2.6 Water resources infrastructure

Water infrastructure consists of man-made structures and facilities used to abstract, retain, treat, convey, and deliver water to users and collect, transport, treat and dispose of waste water (Maluleke *et al.*, 2005). Of the existing domestic water supply schemes in South Africa, many were built during the 1970's or 1980's. Hand-pumps have limited life-spans of generally 15-25 years. These schemes were also designed for a small population and the optimum demand may have been surpassed after just 5 or 10 years, and current levels of use increase the physical pressure upon the systems. It is estimated that around 30% of schemes are malfunctioning (Maluleke *et al.*, 2005). The latter further indicated that majority of these problems will not be considered when levels of water demand and supply are estimated, so that current estimates may be optimistically high.

Mara (2007) indicated that South Africa cannot rely solely on new schemes to solve their water supply problems since the costs of new water projects tend to rise in terms of construction costs per unit of water supplied. This increase is due to the increasing remoteness of sources being tapped, and the need for more complex supply systems. Therefore, it may prove more cost effective in the long run to invest in training and policy measures which help to make water distribution more efficient and equitable (Mara, 2007). At the same time, it is important not to underestimate the need for new water systems, especially in arid or semi-arid areas.

Bredenhann *et al.* (2000) indicated that dry land areas that have minimal opportunities for groundwater exploitation require a combination of systems such as sub-surface dams, and domestic rainwater catchment structures. These tend to be expensive although the remoteness of some areas contributes to high transport costs for materials. Arid areas also require in-depth strategic planning of water resource development because of the impacts of water availability. Water scarcity or limited availability, particularly during the summer months results in fluctuations, irregularity and reduction in per capita availability.

2.6.1 Water infrastructure at UNIVEN

The provision of water services in UNIVEN is the responsibility of Vhembe district municipality. The major source of water for the institution is Vondo Dam which is in Phiphidi Village and falls under Luvhuvhu Letaba Water Management Area. The dam provides water for domestic and industrial uses to the surrounding areas including Thohoyandou, Muledane, Tswinga, Ngovhela and Maugani villages to approximately 70% of the population, it caters for planned settlements only (Nemantatane, 2016). However, institutional capacities to sustain such water systems over extended periods have tended to be limited (Lamola, 2016). By the year 2014, the university had drilled about 6 boreholes to augment the municipal water supply (Lamola, 2016).

Water is supplied from the Vondo dam under gravity to the Vondo water treatment works with a current capacity of 40 million litres per day (Nematatane, 2016). Water supplied undergoes a multistep treatment process, water is disinfected with chlorine, and fluoride is added, along with phosphate to inhibit pipe corrosion. Water is then distributed to a variety of linked reservoirs including the reservoir which is located within UNIVEN. UNIVEN reservoir convey water to UNIVEN by gravity, however, this reservoir also supplies the nearest community residing downside of university campus (Nematatane, 2016). UNIVEN has no other water sources rather than its boreholes and Vondo dam. However, there is a project in place to erect pipeline from Nandoni dam to supplement water to government reservoir, which supplies UNIVEN, but this has not started supplying water from Nandoni dam (Lamola, 2016).

Water is a key resource that supports the staff and students at the institution daily. As University of Venda grows, visible changes are experienced including a substantial proportion of the land surface which is paved or covered with impervious surfaces (e.g. roads and buildings) and these changes impact on water recharge. Vegetation cover reduces the speed of water as it runs down and with more infrastructure developments taking place within UNIVEN, vegetation will be less, and this will result in more storm runoff. With natural ground cover, 25% of rain infiltrates into the aquifer and only 10% ends up as runoff (Eldridge *et al.*, 1993). As imperviousness increases, less water infiltrates and more water run-off. Paving may alter the location of recharge, or replenishment of groundwater supplies, restricting it to the remaining unpaved areas. As deep infiltration decreases, the water table drops reducing groundwater.

There is a storm sewer which is a system designed to carry rainfall runoff and other drainage, it is not designed to carry sewage or accept hazardous wastes. As the storm water runs over the land surface, it picks up pollutants such as leaves, soil and dissolved chemicals and carries them to local waterways. The runoff from the institution is carried in underground pipes and discharges untreated water into Dzindi River (Lamola, 2016). The overall water demand and discharge to the sewer system in the institution can have a significant impact on the local watershed. Effective management of storm water in the institution may reduce potable water used for irrigation and washing the pavements. Storm water management may present opportunities for storing water to be used instead of potable water.

Waste water produced in the institution is managed by the Vhembe District Municipality. University of Venda does not have on-site treatment of wastewater but instead sends all its wastewater to Muledane wastewater treatment plant (Lamola, 2016). The institution relies on significant quantities of high-quality fresh water year-round therefore active water management is not only essential to the long-term planning of the university, but also critical to the Department of Water and Sanitation and Vhembe District Municipality.

2.7 The concept of Integrated Water Resource Management (IWRM)

The most common and cited definition of IWRM is given by the Global Water Partnership (GWP). It is a process which promotes the coordinated development and management of water, land and related resources to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital eco-systems and the environment (GWP, 2009). When addressing increased water scarcity, the principle of economic efficiency emphasises the finite and vulnerable nature of water resources. Therefore, it is critical to use water with the highest possible level of efficiency (Cap-net, 2008) while allocating the resource strategically to all different economic sectors and users (Muller *et al*., 2009). Social equity refers to the basic right of people to have equitable access to safe and sufficient water (Cap-net, 2008), between women and men, rich and poor, across different social and economic groups both within and across countries, which involves issues of entitlement, access and control (Muller *et al*., 2009).

In 2003, the Third World Water Forum was held in Kyoto, where IWRM was confirmed to be the recommendable way to achieve sustainable water resources management (Varis *et al.*, 2008). IWRM was furthermore acknowledged to support the eight UN Millennium Development Goals (UNDP, 2011). At present, many countries have already adopted plans for IWRM. However, past experiences have shown, that implementation of IWRM is a slow process that could take several decades to be fully effective (UNEP, 2012; Xie, 2006). Therefore, Xie (2006) demands for persistent, patient progress on multiple fronts to achieve the goal of water security.

The IWRM concept is founded upon four guiding principles, which were formulated during the International Conference on Water and Environment in Dublin in 1992 (GWP, 2012). Principle 1: Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment. Principle 2: Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels. Principle 3: Women play a central part in the provision, management and safeguarding of water. Principle 4: Water is a public good and has a social and economic value in all its competing uses.

2.7.1 Principle 1

Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment. The first principle links social and economic development with ecological preservation. As the hydrological cycle provides a fixed annual quantity of water that cannot be regulated by human actions, freshwater needs to be acknowledged as finite and a scarce resource. Water is fundamental for all forms of life on earth, providing several ecosystem services for different human purposes, services and functions. Therefore, the maintenance and sustainable management of water resources is essential to sustain life, development and the environment (Cap-net, 2009).

2.7.2 Principle 2

Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels. Water is a resource that concerns and affects everyone. Multiple stakeholders such as water users, planners and policy-makers at all levels and of all social structures must be involved and be part of the participatory decision-making process (GWP, 2013). Water not only brings economic benefits, but also social ones regarding equity, poverty alleviation, the safeguarding of human well-being and environmental protection and security (GWP, 2012; United Nations Educational Scientific and Cultural Organisation, 2009). The participatory approach aims to reach long-term consensus by giving people responsibility in the water sector, to assure effective and sustainable use and development of water resources. Governments should ensure full participation of all stakeholders, with attention to vulnerable groups within the population, such as local communities. According to Xie (2006), all stakeholders must have a strong belief in the value of IWRM and all reforms that are brought by it. Only with total conviction can IWRM be supported and implemented.

2.7.3 Principle 3

Women play a central part in the provision, management and safeguarding of water. Despite being widely accepted that women play a key role in the collection and safeguarding of water resources, particularly for domestic and agricultural purposes, the role of women in water management is usually very small. This disadvantaged role of women is usually linked to cultural and social traditions of societies. Therefore, IWRM demands recognition of the important role that women play in the provision, management and safeguarding of water. Public agencies should involve women and men in social, economic and cultural issues to ensure gender equality and full and effective participation of women at all levels of water management decision making. Giving women and men the same access to information, water related services and equal opportunities for participatory decision-making, represents a key component of IWRM (Cap-net, 2009; GWP, 2012).

2.7.4 Principle 4

Water is a public good and has a social and economic value in all its competing uses. In the past, the economic value of water resources was not adequately recognised, resulting in inefficient water use. As IWRM emphasises economic and financial sustainability, water resources should be managed as an economic good to achieve efficient and equitable use, while also conserving and protecting water resources at the same time (Xie, 2006). Although it is important to recognise access to clean and sufficient water and sanitation at affordable prices as a human right, the scarcity of water resources demands that economic perspectives should not be ignored (Xie, 2006). Furthermore, the management of water resources as an economic good through water pricing greatly contributes to achieving financial sustainability of water service provision that ensures full cost recovery (Xie, 2006). Additionally, water charging contributes to efficient use and water savings, providing incentives to manage demand (Cap-net, 2009; GWP, 2012).

2.8 The sustainability framework in the context of water

Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (UN, 1987). Since the Earth Summit in 1992, the concept of sustainable development has been the leading paradigm by which to alleviate hunger and poverty. Sustainable development has therefore become one of the most frequently cited concepts (Yohe *et al.*, 2007) of sustainability in this generation. That is because sustainable development integrates economic, the ecological and the human/social dimensions.

Sustainability and IWRM Sustainable water management aims to reduce vulnerability and enhance resilience to achieve its overall goal, water security and therefore sustainable development for people and ecosystems. IWRM aims at achieving sustainable water management through economic efficiency, social equity and environmental sustainability (GWP, 2013). One of the major principles that drive IWRM is the involvement of all stakeholders in water management, especially women who are traditionally often disadvantaged. The involvement of local communities is considered to enhance their resilience, for example to deal with the impacts of climate change. To promote participation, decentralisation and capacity building play a vital role to adequately involve local communities (Cap-net, 2009; GWP, 2012). Local community involvement is a key component to achieving sustainable development and the implementation of IWRM.

To meet the water demands for the growing population, changes in consumer behaviour, increasing pollution of water bodies and the impacts and prediction of uncertainties of climate change, sustainable water management is key to achieving sustainable development in the 21st Century. According to GWP (2013), sustainable development can only be achieved with a water secure world. A water secure world reduces poverty and increases living standards, especially for the most vulnerable. Water security is defined as a world where every person has enough safe, affordable water to lead a clean, healthy and productive life it reduces poverty, advances education, and increases living standards (GWP, 2013). It is a world where there is an improved quality of life for all, especially for the most vulnerable who benefit most from good water governance (GWP, 2012).

IWRM is a step towards water sustainability and the solution for good water resources management. Water should not be managed as a separate entity as there are several influencers to water resources. The aim of IWRM is sustainability, taking into account different water users and their behaviours, with respect for the scarce water resources. Therefore, through IWRM public participation is used as a tool to ensure that the available water resources are used in a sustainable manner. An institutional water management plan should emphasise the concept of IWRM. This is because, it involves integrated approaches to water management through action plans incorporating solutions that promote public participation. Thus, planning and decision making takes into consideration public opinion. Rainwater harvesting, reuse of grey water and installing more water meters to check the amount of consumption, contribute to actions on multiple sources of water and effective management of water resources, and hence availability of water resources to meet institutional demand and ecosystem sustenance.

2.9 Sustainability in higher education institutions

The concept of sustainable development was originally introduced at the first Earth Summit in 1972 in Stockholm. During this meeting of government representatives and NGO’s, education was identified as fundamental to the successful achievement of sustainable development, a point that has been reiterated by numerous governments and practitioners in the intervening years. Since then, progress has been variable and generally unsatisfactory. However, a badly needed injection of urgency was administered in 2005, when the UN adopted a Decade of Education for Sustainable Development (DESD) (UNESCO, 2005). The goal of the DESD is to integrate the principles, values, and practices of sustainable development into all aspects of education and learning. The idea being that, such an input will encourage changes in behaviour that will create a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations. Recognising that human behaviour can be altered to limit harmful effects on the environment, sustainable development philosophy has evolved to include more than just recycling and constructing buildings with solar panels but encompasses how individuals and communities behave and interact with the Earth.

UNESCO (2005) identifies two unique opportunities for Higher Education Institutions (HEIs) to engage in sustainable development. First, Universities form a link between knowledge generation and transfer of knowledge to society for their entry into the labour market. Such preparation includes education of teachers, who play the most significant role in providing education at both primary and secondary levels. Second, they actively contribute to the societal development through outreach and service to society. Higher education often plays a critical but often overlooked role in making this vision a reality. It prepares most of the professionals who develop, lead, manage, teach, work in, and influence society's institutions. Thus, HEIs have a critical and tangible role in developing the principles, qualities and awareness not only needed to perpetuate the sustainable development philosophy, but to improve upon its delivery. Few work has been done on universities in terms of sustainability and developing water management plans.

2.9.1 Case studies of how higher education institutions are addressing sustainability

2.9.1.1 University of British Columbia (UBC), Canada

The institution has been in recent years piloting several innovative storm water management systems. In 2005/06, a pilot-test of a new closed-loop storm drain system was installed in Hawthorn Place, a housing project in the Mid Campus neighbourhood (Johnston, 2006). The project was designed to use well water for drought tolerant gardening. The water drains into the aquifer and becomes a large pond of stored water. This, in turn, is used for irrigation and creek generation. The water is returned to the ground by infiltration with the surplus discharging to the storm drain (Johnston, 2006). The closed loop formed by the cistern and well reduces UBC's demand on the regions watershed and stabilizes fluctuations in storm water drainage to UBC's cliffs.

In 2003, the university began to develop a special parking lot at West Mall and Agronomy Road. Hailed the Orchard Lot, it features a permeable surface made of plastic textile, gravel, sand, soil, and grass. The other half is regular blacktop, which mitigates cliff erosion by directing water to underground infiltration chambers (Johnston, 2006). Usually storm water goes directly into a piping system, which empties over UBC's cliffs and causes erosion. This water, however, goes into a trench full of rocks and these allows the water to seep slowly into the ground. This system became a precursor to new work carried out in the following years on peak storm water volume mitigation and regeneration through well pumping (Johnston, 2006).

2.9.1.2 University of Cape Town (UCT)

The institution plans were underway for water-wise planting, and drip irrigation (Critien, 2007). The harvesting of storm water, permeable paving (also called Sustainable Urban Drainage Systems), and grey water management were all part of future development plans. In general, there were short and longer-term interventions that could make a significant difference to UCT's water consumption patterns and practices, many of which were in place or planned (Critien, 2007). In conjunction with Properties and Services, the Energy Research Centre (ERC) at the University of Cape Town embarked on a research project aimed at establishing the University's carbon footprint (ERC Carbon Assessment study EU Internship Programme). Based on the developed work plan for this project, a literature survey on the carbon foot printing field was conducted and various consultations were held with key institutional staff and field experts (Letete *et al*., 2008). The report contains a conceptual framework onto which all components of the carbon footprint were to be presented. An initial first draft of the carbon footprint of the University had been completed and this estimated UCT's direct carbon emissions from liquid fuel use and indirect carbon emissions from electricity use (Letete *et al*., 2008).

With the current drought condition in Cape Town, the sustainability projects in UCT are not operational. A Water Task Team was formulated at UCT to facilitate new water consciousness on campus and drive water-savings activities (UCT, 2018). UCT Libraries has embraced the university's water-saving campaign by installing metered bathroom taps with adjustable low flow, encouraging staff to bring their own water to work and turning off their instant-boiling-water systems (Swingler, 2018).

The team has a complete record of nearly all water use across the UCT campuses from 2015 to 2017. These includes calculating the volume and the cost per capita use which assists to generate evidence to ensure that UCT complies with the Level 6B water restrictions (UCT, 2018). The capture of seepage water on lower campus will be used for irrigation of essential services. Water campaign is being rolled out and every department is asked to take their own initiative to bring awareness to the seriousness of the current drought and water sustainability into the future. From, the end of February all UCT residences have been having shower buckets. Students were requested to capture shower water and use it to flush toilets. A total of 13 smart digital water meters have been installed on upper campus. This was the first effort to build a robust network of real-time digital meters on campus, together with a visible water dashboard that will improve the measurement and management of water. These are just some of the ways that UCT is seeking to save water at an institutional level and during this drought period the institution targets 50% saving of water (UCT, 2018)

2.9.1.3 University of Johannesburg (UJ)

Water consumption at the University was closely linked to its electricity consumption and serves as another measure of how efficiently the university uses natural resources. Average water usage per campus increased marginally by 2% from 693 078 kl in 2014 to 706 765 kl in 2015 (UJ, 2015). All buildings have been supplied with quality water and an increase in usage has been observed over time. Elimination of water wastage has become a crucial focus area for UJ. During 2015, UJ continued to experience problems with the City of Johannesburg (CoJ) regarding the accurate and correct measurement of water consumption when comparing 2013 and 2014 figures to that of 2015 (UJ, 2015). Hence water consumption measurement systems have become a necessity as it was found that the institution could not rely solely on water measurement from the CoJ municipality. Billing problems coupled with inadequate water meters at key points have resulted in inaccurate consumption being recorded.

Considerable effort was put into rectifying water consumption during 2015. A water metering project was initiated to determine accurate water consumption figures. UJ made use of an external company to monitor water consumption at all its points of consumption and to develop an accurate baseline against which future progress can be measured (UJ, 2015). Readings are taken monthly and UJ will continue to focus on its water measurement system in the future. This was set to continue during 2016. The target was to achieve a usage reduction of 6% by 2017. The Unit focuses on reducing the percentage of unaccounted for water delivery to achieve targeted levels. Togo (2009) mentioned that it is important for higher education to redefine sustainability locally because sustainable development problems crucial to developing countries are different from those of developed nations. Sustainability initiatives from the institution's side should therefore provide students with the knowledge, attitudes, and skills to become better citizens in their own communities.

2.9.2 Lesson learned

The case studies presented in the above sections demonstrate the process to which sustainability was put into practice at international and national universities. Key conclusions could be drawn from these case studies that sustainability is significant and therefore other institutions of higher learning effectively manage storm water through harvesting it and using the water for irrigation and this reduces the use of potable water for irrigation. Permeable pavements are used within the institutions and this increases the water recharge and grey water management is part of their plans. Water wise awareness takes place within the institutions. Sustainability promotes avoidance of depletion of natural resources therefore through efficient water utilisation the water needs of the present will be met without depleting water resources for the future. Lack of public information within UNIVEN cause students and staff not to have clear understanding of local water and the challenges faced. Lack of proper knowledge promotes careless behaviour or attitude on water utilisation therefore there is need for sustainability initiatives within the institution so that water can be utilised and managed efficiently.

2.10 Institutional development of water management strategy (WMS)

2.10.1 University of California, Santa Barbara (UCSB)

The University of California Santa Barbara has taken proactive steps to reduce water consumption. The campus developed a Water Management Strategy (WMS) that can be used as guidelines to decrease overall water use while meeting the demands of its current and future uses (Cole *et al*., 2013). Below are the steps that were taken into consideration while developing the WMS;

Step 1: Perform data collection, Compilation and Analysis

- UCSB's historical and current water use was evaluated to gain a physical understanding of UCSB water systems and aggregate available data on UC-system water use (Cole *et al*., 2013).

Step 2: Identify and evaluate strategies for water reduction suitable for the UCBS campus

- This step included a review of formal literature and existing studies, identified technically feasible, site-specific water management strategies for reduced consumption and quantity of water saving and economic costs of alternative strategies (Cole *et al*., 2013).

Step 3: Identify education and outreach opportunities pertinent to on-campus water conservation

- Here behavioural areas of improvements for on-campus residents (e.g. undergraduates and on-campus faculty) to reduce water consumption were identified and integrated educational solutions to reduce water use on- campus into existing on-campus action groups and UCSB public resources (Cole *et al*., 2013).

Step 4: Compose guidance documents

- WMS for the UCSB campus was developed and simplified to create water management template transferable to University of California (Cole *et al*., 2013).

2.10.2 University of Oxford

A measure to reduce the environmental impact of the University of Oxford was to develop a WMS to reduce the amount of potable water the University uses. The main elements included, surveys of the University's top 10 water using buildings, email survey of all building managers, opportunity identification which included repairing, maintaining and fitting meters on the university's rainwater harvesting systems, fitting top flow rate restrictions and urinal control devices and target setting. The trajectory of the university's water uses over the past five years did not follow that of its Gross Internal Area (GIA) (Pike, 2011). Since 2004/05, the University's GIA increased by 10% and its energy use increased by 23%, whereas its water use decreased by 20% (Pike, 2011). There was evidence of improved (increased) water efficiency of the University's sanitary fittings due to replacements or renovations, with 13% of the taps for which evidence was provided having aerators fitted to reduce the flow rate.

The university's water use decreased by an average of 2.2% per year for the past 10 years (Pike, 2011). It was considered that, as a minimum, the target for water management should be to maintain the trajectory for the next five years. That required focussed effort to reduce water use, as the scale of opportunities for water use reduction were likely to be greatly reduced. Therefore, the target for the university's water use was for water use to decrease by 11% by 2014/15 against 2009/10 levels (347,364 m^3), meaning that absolute potable water purchased in 2014/15 was expected be no more than 310,000 m^3 (Pike, 2011).

2.10.3 Yale University

Yale University Water Management Plan 2013–2016 included four distinct strategies towards the university's immediate water conservation goal and longer-term vision for active and adaptive water management (Yale University, 2013). These strategies were intended to build on the water management approaches and analyses to date and to provide a coherent and flexible framework for future activities as follows:

- **Maintain commitment to water metering and analysis**

Maintain existing meters and install new meters as required for new construction. Commit resources as needed to ensure sub-meters are operational. Maintain existing quarterly data collection and quality control processes. Establish and maintain review with Regional Water Authority (RWA) to ensure that the most accurate numbers possible are provided on quarterly bills. Analyse and publish data at the building level on an annual basis (Yale University, 2013).

- **Align design standards and planning documents with water management goals**

Update sections of Division 15 of Yale Design Standards for Capital Projects to reflect requirements for water-efficient plumbing fixtures, water metering, and water sub-metering within buildings. Internal resources and guidelines to inform the design were prepared, installed and operated to reclaim water systems and irrigation systems on campus (Yale University, 2013).

- **Implement water conservation projects and activities**

Projects were developed and implemented to increase the water efficiency of existing campus fixtures and systems to conserve approximately 20 million gallons of potable water (Yale University, 2013). Develop and implement projects to provide non-potable water demands with alternative sources of water to conserve approximately 3 million gallons of potable water. Activities were implemented to minimise chilled water demand during peak cooling months to avoid the use of approximately 5 million gallons of potable water used as cooling tower makeup (Yale University, 2013). Educational initiatives with Yale Office of Sustainability, Sustainability Service Corps, and other relevant groups on campus were coordinated to raise awareness about water use and influence behaviour towards water conservation and longer-term projects for future development were formulated and implemented focusing on both water conservation and storm water runoff reduction.

- **Adapt management plan goals**

Best practice methodology for evaluating representative water use given that data quality was established, and thermal conditions varied annually. Preliminary costs and benefits for water conservation projects were formulated and activities prior to goal-setting, so that goals and respective tactics were appropriately defined (Yale University, 2013). Yale committed staff time and resources to project formulation and goal setting within Utilities and Engineering and built on the successes and lessons learned to date moving forward. University of Yale was committed to reducing its potable water usage by 5% over the next three years, from 2013 to 2016 (Yale University, 2013). With active and adaptive management, Yale had the opportunity to serve as a leader in sharing water data and water conservation initiatives with the broader public (Yale University, 2013). This plan presented a suite of strategies to reduce water, improve water use data, collaborated further with RWA and Water Pollution Control Authority, and plan for the future. In recognising the value of water beyond its utility costs, Yale strived to position the campus well for long-term resiliency (Yale University, 2013).

2.11 The case studies of South African Universities

Universities in South Africa have been applying water efficient measures to respond to the national request to save water and reduce consumption (UNISA, 2009). For instance, in Stellenbosch University a water meter was fitted at the back of the toilets and readings were taken for a period of fourteen days. Following this, existing standard symphonic flushing in 12 litre cisterns was replaced with demand flush systems (Monareng, 2010). Although, the university's main concern was a maintenance issue, it was reported that there were less maintenance issues with the demand flush system than standard toilet system (Monareng, 2010).

A pilot study was undertaken on a back of four toilets at one of the female residences at the University of Stellenbosch. A water meter was fitted to the back of toilets and read for a period of fourteen days and following this, the existing standard symphonic flushing systems in 12 litre cisterns were replaced with Demand Flush Systems (Stone, 2007). Water consumption was measured for another 14 days to determine the water savings and the amount of water saved was just over a thousand litres per day or around 250 litres per toilet per day (Stone, 2007), see Table 2.2.

Table 2.2: Water savings made on a bank of 4 toilets over 14 days (Lydia Hostel, Stellenbosch University)

	Standard flush (*l*)	**Multi-flush (*l*)**	**Water saved (*l*)**	**% saved**
Volume used	24093	9807	14286	59.3%

(Source: Stone D, Aqua Smart Water Management, 2007)

Six residences at the University of Cape Town (UCT) installed Hippo Bags into the cisterns of all suitable toilets. The Hippo Bags were given to the University by the City of Cape Town and can save between 2.5 and 3.5 litres per flush (Monday Paper, 2005). According to Handler *et al.* (2003), University of Cape Town installed a demand flush toilet system and has made a significant contribution to water saving in the residences. Also, the university was satisfied with waterless urinal and was to begin a roll out process, retrofitting all the urinals on campus (Handler *et al.*, 2003). North-West University introduced water efficient shower roses in only two hostels. The showerheads were found to be water efficient, acceptable to the students and required less maintenance than standard shower roses (Still *et al.,* 2008). This resulted in the university taking a decision to install the shower roses throughout the campus's six hostels and the university was also considering the installation of waterless urinals (Still *et al.*, 2008).

The University of the Witwatersrand (Wits) introduced waterless urinals. The motivation for retrofitting the men's toilet facilities in some of the residences and the head office building was to save money (by reducing water consumption) and respond to the national request to save water and reduce water consumption (Still *et al.,* 2008). After continuous complaints from users about odour problems, the suppliers upgraded the waterless and odourless urinals to the Eco-Smell-stop urinal and in addition, the cleaning staff were also given demonstrations and received training on the correct cleaning procedure (Still *et al.,* 2008).

2.12. Water reduction in other universities

2.12.1 Nottingham Trent University

Nottingham Trent University (NTU) was awarded the green university for the year 2009, for its excellent environmental performance. To achieve this status, NTU had incorporated an effective environmental policy, targets and improved awareness. The university has a vibrant environmental team, constituting an environmental manager, a go green group and eco champions, who all work together to implement environmental management programmes and policies such as sustainable awareness. Most of the guidance the university provides is related to good housekeeping, for example the use of signage around university to encourage water efficiency and also aims to impact on the wider community, by advertising information on good practices while at home (Ward *et al.*, 2010). Moreover, NTU is part of the Eco-Campus scheme which is an Environmental Management System and award scheme that particularly aims to assist universities in the progression towards environmentally sustainable practices (Ward *et al*., 2010). So far, the university's environmental team has achieved Silver Level accreditation.

2.12.2 University of Gloucestershire

The university aimed to commit to sustainability by embedding it in all aspects. It is independently verified and registered to the international environmental management standard BS ISO 14001 (Ward *et al*., 2010). In addition to this, the university has an environmental policy and an environmental team, which implements the policies. The university undertakes energy reviews regularly, to identify effective management techniques for utilities (including water). From this, updates the Universities Utilities Strategy which acts as a guide for responsible management of utilities. In terms of water, a yearly reduction target in volume of water discharged is set with detailed action plan on how it could be achieved. Within 2008/2009, water consumption was observed to reduce from 35 091 m^3 to 32 621 m^3, an overall reduction of 7.0% (Ward *et al*., 2010).

Whilst the operational components are specifically University facilities staff responsibility, inputs from all staff and students are required to satisfactorily deliver the strategy, Gloucestershire University recognises this and invests in awareness raising programmes. A sustainability visibility project campaign was launched within the university campuses for this purpose, using posters and leaflets to encourage the participation of students and staff in saving energy and water during daily activities (Ward *et al*., 2010).

2.12.3 University of West England, Bristol

The University of West England (UWE), Bristol has its own environmental and sustainability policy with the corresponding action plans put into practice by the University's Energy and Environmental Management Unit (Ward *et al*., 2010). The University is in the process of implementing the BS 8 555 and acorn scheme as its Environmental Management System. In 2008/2009, UWE consumed approximately 427 088 tonnes of water, which was significantly less than 476,300 tonnes in the previous year (2007/2008) (Ward *et al*., 2010). This reduction was reportedly achieved by a combination of implementing of various awareness programmes, improving infrastructure and by incorporating sustainability as an integral part for decision making.

In terms of education and awareness, the university encourages good housekeeping by creating awareness raising events such as an environmental week and the provision of information through induction programmes, poster campaigns, newsletter articles, presentations particularly to university departments. It has also published a guide towards green living for students and staff to learn ways they can improve the environment within and outside the university. Staff are given environmental inductions, which cover environmental policy, utilities management and so on (Ward *et al*., 2010). The University of Bristol equates that approximately £360 000 per year spent on utilities may perhaps be better spent on teaching, research and facilities (Ward *et al*., 2010).

For the management of energy and water consumption in over 300 buildings, the university uses a sophisticated software package which enables the monitoring of utility consumption within buildings. Currently, there is an ongoing installation of supplementary sub metering to facilitate thorough monitoring of water consumption and other utilities within university buildings (Ward *et al*., 2010). Furthermore, Bristol University recognises that buildings occupants and departments have a better knowledge of the buildings activities and so have launched an energy (including water) saving ideas competition whereby different ideas are proposed. There are also regular external water audits and surveys carried out within the university buildings to identify opportunities for improving performance which have thus far identified potential savings of £60,700 (Ward *et al*., 2010). Water reduction in South African universities have been covered under sustainability.

2.13 Possible methods that have been applied in other studies

2.13.1 Building Research Establishment Environmental Assessment Method (BREEAM)

BREEAM provides criteria for establishing sustainability of institutional approach to water use (Pike, 2011). BREEAM is a sustainability assessment method that covers a range of environmental issues and could serve as an environmental credential and its categories evaluate energy and water use, health and wellbeing, pollution, transport, materials, waste, ecology and management processes (Ebert *et al*., 2011). Based on BREEAM, a series of building audits of the University of Oxford 10 top water using buildings was undertaken and email survey of the University's Building Managers and Departmental Administrators was performed (Pike, 2011). Over the past 10 years, different plumbing systems that reduce potable water consumption within new buildings and renovations at Yale University were installed. Many of these installations contributed to earning Water Efficiency and Innovation in Design credits toward Leadership in Energy and Environmental Design (LEED) certification (Yale University, 2013). According to Grace and Macfayden (2006) the benefits of BREEAM is that it is a robust process for the sustainability check, detailed, easy to specify, has independent existence and the qualifiers are tailor made of each building. While the disadvantages of BREEAM is that it is complicated, inflexible, poorly understand and it is expensive. BREEAM indicates if the institution has sustainability in the agenda or not and again it provides environmental benefits such as pollution reduction, water use reduction and construction waste reduction for the reason that it also promotes awareness. BREEAM is relevant to this type of study and was mostly used in studies conducted abroad and it was one of the method which was not used in this study.

2.13.2 Case studies

In a study conducted by Cole *et al*. (2013) the future water conservation strategies were deduced from accessible literature and case studies and the deduced strategies underwent a preliminary feasibility investigation to determine if they would be useful and practical for the UCSB Campus. For all water saving strategies, annual water savings were calculated, and an economic assessment was conducted, which accounted for initial capital investments, operation and maintenance over time, and utilities cost savings attributable to water reductions (Cole *et al*., 2013).

One of the benefits of case study methods is their ability to capture lived reality and are likely when applied successfully, to maintain more of the noise of real life than many other types of research (Hodkinson and Hodkinson, 2001). Zainal (2007) mentioned that the detailed qualitative accounts often produced in case studies not only help to explore or describe the data in real-life environment, but also help to explain the complexities of real-life situations which may not be captured through experimental or research survey.

An ordinary criticism of case study method is its dependency on a single case exploration making it difficult to reach a conclusion (Tellis, 1997). Yin (1994) examined case methodology microscopic, because of the limited sampling cases. Davies and Beaumont (2011), also indicated that case studies involve analysis of small data sets, therefore conventional empirical techniques cannot be used, or where they are used, they may have limited application as there may not be enough data to meet requirements for statistical significance. Case studies include trend studies that examine different samples from a population surveyed at different times and brought an understanding of complex issues such as how other institutions save potable water and reduce consumption through sustainability and applying water efficient measures and extended experience or added strength to what is already known through previous research.

2.13.3 Meter readings

In the study conducted by Ward *et al*. (2010), water consumption was defined per building rather than per department as is the case in some of the water metering data and in order to identify and investigate the buildings with high consumption, water billing information was used to rank buildings according to their yearly consumption. Yale University also maintains several dozen submeters in order to understand water use within their central utility plants, dining halls, and selected building systems (Yale University, 2013). Metering data sometimes is not truly meaningful or reliable and does not indicate water consumption levels and trends if the required meter data is incomplete. The latter is mostly the case in developing countries as metering is mostly not done in individualised buildings. When the metering data is complete and up to date, this method makes it simple to determine water consumption. Correct and complete meter data also assist in identifying water wastage. Meter readings are used to obtain the changes in levels of water consumption within the institution throughout the year, considering that from the water meter the previous reading and current reading was provided, therefore, meter readings were useful to the study.

2.13.4 Questionnaires, observation and interviews

The method used in the study carried out by Oruko and Sojo (2015) was questionnaires and observations, respectively. The latter was done to answer questions concerning other potential sources of water, water wastage, conservations measures and overall quality of water supplied to Mombasa polytechnic in Kenya. Ward *et al.* (2010) interviewed building managers to better understand the facilities, the operation of facilities, and to assess the general level of water awareness within the buildings and laboratories, and questionnaires were also distributed to the college staff and students at Imperial College in London. According to Mathiyazhagan and Nandan (2010), if observation is done correctly, subjective bias is eliminated, and the information obtained under this method relates to what is currently taking place. Therefore, the past behaviour or future intentions do not complicate the method. Unfortunately, unforeseen factors can interfere during observation and information gathered or observed can be limited and where large samples are concerned this method is not applicable.

Questionnaire survey has the ability to collect data from a large number of respondents and advanced statistical techniques can be used to analyse survey data so that the validity and reliability can be determined (DeFranzo, 2012). Debois (2016), mentioned that questionnaires encourage anonymity and provide freedom to the respondents and ensuring uniformity in responses. Regrettably, respondents may not feel encouraged to provide accurate honest answers and also this method cannot be applied in situations where unprompted responses are needed.

During interviews, more data can be collected and misinterpreted questions by the interviewee can be managed by the interviewer but Nayab (2011) indicated that it is difficult to get the selected sample respondents to be interviewed and the presence of the interviewer on the spot may over inspire the respondents. Through a questionnaires survey, significant amount of data is collected from a large population size and due to its openness, analysing the data becomes simple. Interviews are a way of involving participants to talk about their views while gaining more knowledge from individuals about the availability of water resources, different water uses and how they cope when there is water shortage within the institution. Observations are also relevant to the study because it helped qualify and corroborate facts from the survey findings and ongoing population behaviours. For instance, water wastage and water resources supply infrastructure within the institution.

CHAPTER 3: METHODOLOGY

3.1 Preamble

This chapter presents the data collected and the sources of data. The data analysis methods that were applied to the collected data to achieve the objectives of the study are also presented. The sequential methodological framework is clearly outlined while the framework for the development of the WMP is also discussed.

3.2 Data requirements and sources

Data requirements for this study included institution population data, provided by the University of Venda, water consumption data obtained from the students and staff and the meter readings obtained from Vhembe District Municipality and the University of Venda. Figure 3.1 is the google satellite image of the University of Venda.

Figure 3.1: University of Venda

The methodological framework which shows the sequence of data analysis for this study is presented in Figure 3.2. The obtained population data was used to determine the water usage in terms of the water demand and consumption and water wastage. A review of institutional water management plan was carried out which gave rise to the University of Venda Water Management Plan.

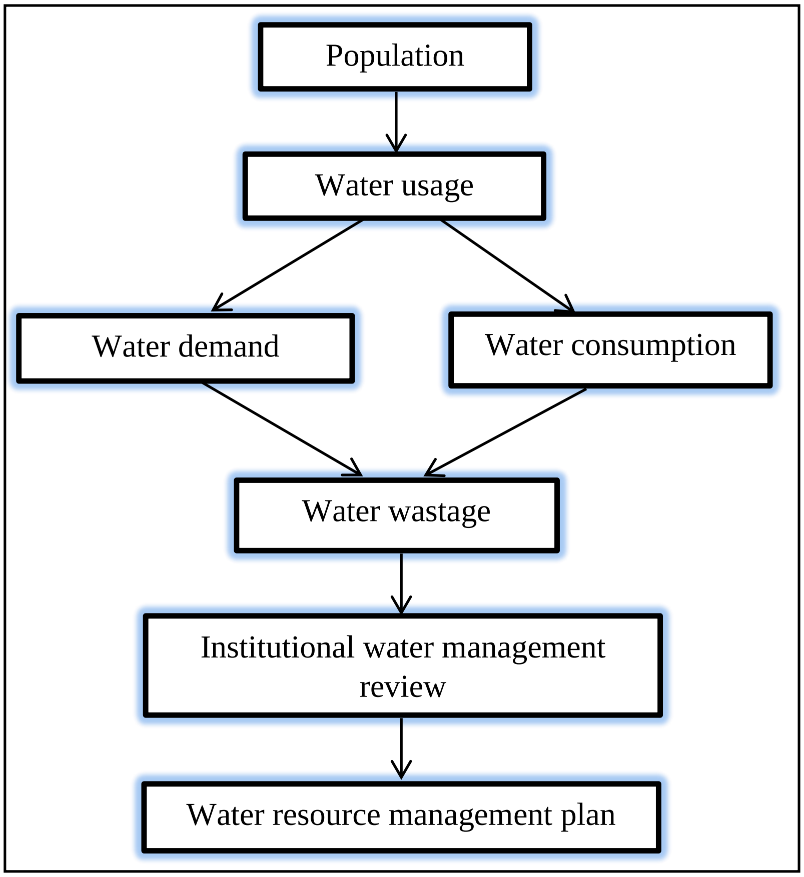

Figure 3.2: Methodological framework

3.3 Site Observation

Field observation data was collected in a form of pictures to present visual evidence of the water sources, water resources infrastructure and water utilisation within the institution. Informal interviews were conducted with the students and staff members concerning the status of water resources infrastructure and water services from the university.

3.4 Evaluation of institutional water demand

Water demand is the volume of water required by users to satisfy their needs. The minimum and maximum water demand standards for schools was obtained from the non-domestic water demand in developing areas guidelines by CSIR (2003), presented in Table 2.1 under the water demand section. Therefore, the institutional population water demand was determined by multiplying the standards as stated in the CSIR (2003) with the population of the institution.

Institutional water demand = Standard by CSIR × Population.................. (1)

3.5 Estimation of institutional water consumption

The study employed the use of questionnaires (Appendix A) to collect data on water consumption. From the questionnaires, users within the institution were asked how much water they utilise daily for their common uses. Water supply data was obtained from meter readings located within the institution behind the university library. The water utilisation trend is of significance since it highlights how water use fluctuates throughout the year. Due to the service provider and the system changing, water invoices for the University of Venda from January 2017 to December 2017 were collected as the service provider only had the records and no historical invoices. The invoices from the institution were correlated with the data from the local municipality, the amount of litres of water which was supplied each month was compared over a period of 12 months. This was done to determine the 2017 monthly water utilisation trends in the university.

3.6 Water wastage

Water wastage is measured as the difference between the actual water supply and the actual water consumption. Questionnaires (Appendix B) were used to deduce water wastage caused by students within the institution and through site observation water wastage caused by university staff was deduced.

3.7 Evaluating issues of the institutional participation in resolving the water problem

The study used questionnaires (Appendix C) to evaluate the issues of the institutional participation in resolving water problems within the institution. The questionnaire consisted of a set of questions that were presented to the students and staff members. It should be noted that the selection of gender was not an issue because the unit of analysis in this study is not for individuals, but the institution. Age was also not considered.

3.8 Water management plan

In order to develop the water management plan that the university can adopt; policy statements, financial resources, current water uses and costs, which were obtained from municipal documents, staff and students from the University of Venda were utilised to develop the WMP. The proposed WMP framework is shown in Figure 3.3 below.

Step 1: Assess current water uses and costs

- This step involves collecting water consumption and cost data and determining a baseline that will be used to calculate cost savings.

Step 2: Set an overarching policy and goals

- Identify existing written policy statement that ties water efficiency to the long-term operating objective of the institution.
- Set goals for equipment maintenance, efficient water use and water use reduction projects.

Step 3: Assess water efficiency opportunities and economics

- The next step is to find ways to increase water efficiency and reduce water use

Step 4: Develop an implementation plan

- The implementation plan will predict if water goals are met by implementing cost-effective and water efficiency measures.
- The plan will also include education and outreach efforts for the institution's population to help reduce water use.

Step 5: Measure progress

- Monitoring, evaluation and regularly reviewing the strategic plan to make sure measures are implemented and goals are realistic and accomplished.

Step 6: Plan for contingencies

- Water emergency and drought emergency plan that describe how water needs during emergency, drought or other water shortages will be met

Figure 3.3: WMP framework

3.9 Analysis of data

The questionnaires were pretested with 40 participants, to identify errors and limitations of the survey tool. Raosoft social scientific sampling software (2015) was applied to predetermine the sample size needed to achieve an error rate of 5% from research data. Data confidence levels were predetermined at 95% with the total sample size of 16 888 for the University. Student enrollment data was obtained from the university registrar, the number of staff was obtained from the Human Resource and the number of students staying on campus was obtained from the student Housing Department. Furthermore, after adjustments, the questionnaires were administered to a total of 420 participants. The participants included the students residing on campus, off campus students, University employees (gardeners and cleaners), staff, laboratory technicians, laundry, students undertaking practicals and School of Agriculture experimental farm. The data acquired from the field study were analysed with the aid of IBM Statistical Package for Social Sciences (SPSS) software version 23. The descriptive statistics analysis was conducted to evaluate the frequencies and percentage of the data retrieved.

3.10 Estimation of water utilised

Water used by both cleaners and gardeners was estimated by timing the minutes it takes to fill up a 25 litres bucket. The respondents indicated the number of times they go to the toilet and that number was multiplied by the maximum amount of litres of water used per flush. The number of toilet flush was multiplied by 26.5 litres which is the amount of water utilised per flush.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Preamble

This chapter presents the findings of the study and the discussion thereof. The discussion in this chapter includes the water sources and storage for the institution, municipal water supply, institutional population, common water uses and the frequency of water use, water demand and consumption, water wastage, awareness of water resources on campus and institutional arrangement in resolving water issues.

4.2. Water sources in University of Venda

Observation design was employed to help corroborate the findings from the survey method. From the key informant (maintenance department), the domestic water sources for University of Venda were identified as municipal water supply and borehole within the institution. The municipal water supply is treated as the main source of water for the university since the entire university receives water from this source. Since 1994 water supply schemes have been managed by DWAF, but minor improvements have been made to improve the water supply infrastructure within the country. Efforts to improve water services have been limited mainly because water supply infrastructure were aged and the costs for maintenance and operation are high. The water supply sources statistics are shown in Figure 4.1 below.

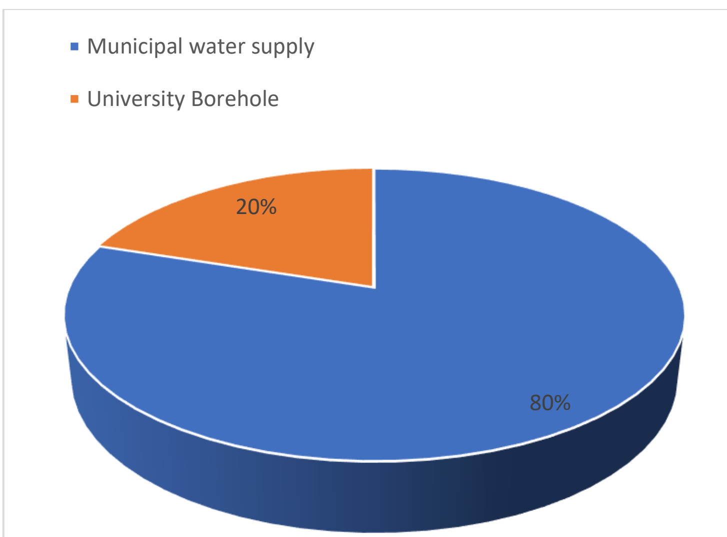

Figure 4.1: Water sources in University of Venda

The survey results show that the University of Venda is connected to the municipal water supply system but also uses alternative source of water as well because the University does not get water from the main source every day. 80% of the university population rely on municipal water supply as their main source of supply and the students store enough water in containers but also use water from boreholes when municipal water is not supplied. The remaining 20% use water from the boreholes and of this 20%, 10% is used at the School of Agriculture while the other 10% is used by the rest of the university population to supplement municipal water supply, respectively. In 2017, majority of the buildings including residences on campus had a borehole to supplement municipal water whenever there are breakdowns or supply problems with the main source. Two boreholes located near School of Agriculture are only used occasionally during construction, during replacement of boreholes pump from mostly used boreholes or during high water demand which mostly occur in the morning and particularly when there is municipal water supply cut within the institution.

Water supplied by the municipality is stored in a reservoir (Figure 4.2), however, this reservoir also supplies water to the nearest villages (Nghovela and Maungani) around the university campus. The university uses abeco steel tanks located within the University campus to store water from the municipality. The municipal reservoir stores 54 mega litres and the abeco steel tank stores 5 mega litres while each borehole tank stores 10 000 litres of water as shown in Table 4.1.

Figure 4.2: Storage reservoir storing water from Phiphidi water treatment

Table 4.1: University of Venda water storage

Water storage type	**Litres**
Municipal reservoir	54 000 000 litres
Abeco steel tank	5 000 000 litres
Borehole	10 000 litres

Abeco storage tanks (Figure 4.3) have design periods of 20 years, they receive water from the municipal reservoir which receives water from Phiphidi water treatment plant. Another tank was built on high elevation to create enough pressure so that water can reach all the buildings regardless of how far they are located from the tank. The water is then pumped from the pump house through outflow pipe to the elevated storage tank. After water has been pumped to the elevated tank there is enough pressure to distribute water to each building by gravitational force through the outlet pipe in the distribution system. Water is then transported to the reserve storage tank located at the School of Agriculture (Figure 4.4). Each building has a gate valve in case increased pressure is required or for repair purposes in each individual building.

Figure 4.3: Abeco steel tank carring water from the muincipal reservoir

Figure 4.4: Reserve storage tanks located at the School of Agriculture

The municipal water supplied to UNIVEN is mostly sufficient and students residing on campus mentioned that they receive water the entire day unless there is a pipe burst. Poor water supply infrastructure influences pipes burst mainly due to high pressure and water distribution in the institution become unstable, which is a major problem. When there is a pipe burst the Maintenance Department within the institution close water for some buildings including residences within the institution depending on the location of the burst pipe.

4.3 Population analysis

The population size for UNIVEN students for the academic year 2017 was 15 915 and 973 staff members, resulting in the overall university population of 16 888. The obtained data was used to determine population of students staying off campus. The population of student and staff in the institution for the years 2010 to 2017 are provided in Figure 4.5.

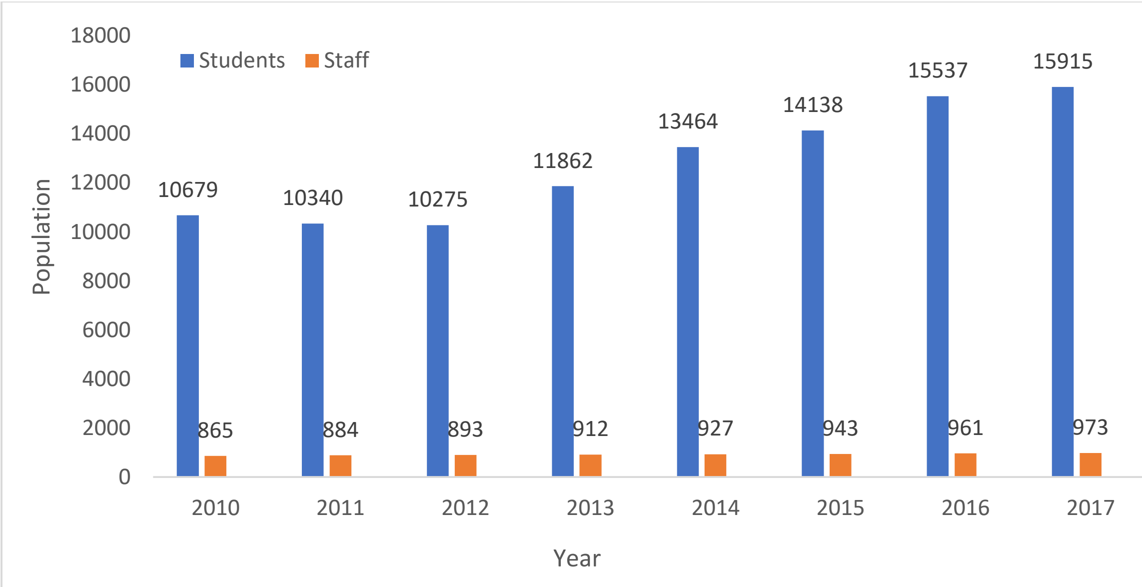

Figure 4.5: Population of University of Venda

Population growth strains the existing water supply infrastructure since water consumption and demand increases as well and water is the utility resource that is likely to be constrained most.
The number of students accommodated in the student residences exceeds the number of rooms on campus and the demand for rooms is very high, therefore there is possibility that students are illegally housed on campus to a point where the rooms are congested. Officially, 2 165 students were accommodated within the university residences in the year 2017. The latter however, excludes students staying in university residences which are located outside of the campus. While conducting the survey, a room which accommodates two students, was found to house three to five students. According to Sunday Times (2017), there is lack of accommodation for almost 10 000 students, indicating the possibility of up to seven students sharing room meant for two students. This therefore presents a challenge while determining the number of students who are housed illegally within the student residences. To obtain the number of students residing off campus and the number of day scholars, the total number of students legally residing on campus was subtracted from the overall number of students. The total number of students residing off campus was estimated as 13 753 which includes students who are housed illegally on campus.

4.4 Water demand for UNIVEN

Institutional water demand is based on the population size and different water uses in the respective institution. According to the University of Venda report on existing and proposed future water infrastructure at UNIVEN (2008), the water demand for the University of Venda was determined in accordance with the Guidelines of Human Settlement Planning and Design as complied by the CSIR Building, Construction Technology and RDP Rural Water Supply Design Criteria Guidelines as published by DWAF. According to CSIR (2003), the water demand for day scholars varied between 15 l/p/d and 20 l/p/d while the variation in water demand for students residing within the campus varied between 90 l/p/d and 140 l/p/d.

For this study, the university staff adopted the day scholar's water demand (15 – 20 l/p/d) because they are on campus for only a certain period in a day. The institutional water demand for UNIVEN which takes into account the day scholars, students residing on campus, university staff and the students residing on campus illegally as already mentioned in section 4.3. Determination of student residence water demand for this study took into account three scenarios; scenario 1 only considered the legal students residing in the campus residences, scenario 2 considered a single room with one illegal student while scenario 3 was the extreme case which considered a single room with 3 illegal occupants. The probable maximum number of illegal occupants is not as concluded by the Sunday Times (2017) because there are off campus student residences and there are also students that reside at home as they reside within close proximity to the university. Table 4.2 and Table 4.3 depicts UNIVEN water demand estimations excluding the illegal student scenario and including the illegal student scenarios respectively.

4.2 Institutional water demand excluding illegal students

Population		**Institutional water demand (l/p/d)**		**Institutional population water demand (l/d)**	
		Minimum	**Maximum**	**Minimum**	**Maximum**
Students residing on campus	2165	90	140	194 850	303 100
Day scholars	13 753	15	20	206 295	275 060
University staff	973	15	20	14 595	19 460
Total	**16 891**	**120**	**180**	**415 740**	**597 620**

4.3 Institutional water demand including illegal students

Population			**Institutional water demand (l/p/d)**		**Institutional population water demand (l/d)**	
			Minimum	**Maximum**	**Minimum**	**Maximum**
Students residing on campus	Legal occupant	2 165	90	140	194 850	303 100
	1 illegal student occupant	4330	90	140	389 700	606 200
	3 illegal students occupants	8 660	90	140	584 550	909 300
Day scholars	No illegal student occupant	13 753	15	20	206 295	275 060
	1 illegal student occupant	11 588	15	20	173 820	231 760
	3 illegal students occupants	7 258	15	20	108 870	145 160
University staff		973	15	20	14 595	19 460
Total		**49 366**	**330**	**500**	**1 672 680**	**2 490 040**

The analysis for 2 165 students legally residing on campus showed that water demand varied between 194 850 l/d and 303 100 l/d while the analysis for day scholars showed varied between 206 295 l/d and 275 060 l/d. The university staff daily water demand varied between 14 595 l/d and 19 460 l/d. Therefore, the minimum institutional water demand was 415 740 l/d while maximum institutional water demand was 597 620 l/d. Water demand taking into account scenario 2 (1 illegal student) was 389 700 l/d to 606 200 l/d while scenario 3 (3 illegal students occupants) was 584 550 l/d to 909 300 l/d. Scenario 2 and 3 significantly affected the institutional water demanded. The latter not only stressed the water demand, the water supply infrastructure within the students halls also gets affected as it was not designed to accommodate the illegal students occupants. When there is 1 illegal day scholar water demand varied between 173 820 l/d and 231 760 l/d while 108 870 l/d and 145 160 l/d was for 3 illegal day scholars. Therefore, the minimum institutional water demand including illegal students was 1 672 680 l/d while the maximum institutional water demand including illegal students was 2 490 040 l/d, if this situation does not change this is what it will look like for the university. Water demand within the institution increases because of lack of more efficient plumbing fixture not connected to the new student residential dwelling as well as the university set-up changing. The latter results in a higher water demand as compared to the period when the university was least developed (Lamola, 2016). The climate of the area causes water demand to increase as well due to high temperatures, so the university population tend to use more water for maintaining their outdoor landscape. A study conducted by Kruger (2006) over the period 1910 – 2004 reported significant decreases in annual precipitation in the northern regions of the Limpopo Province, which is where the UNIVEN is located.

4.5 Common water uses in the institution

Major water uses areas were found to be School of Agriculture experimental farm, the university laundry, cafeteria, student hostels and the different Schools in general. Water was used for cooking, drinking, washing, bathing, cleaning of rooms, cleaning and flushing of toilets, cleaning offices, cleaning lecture halls, washing pavements, agricultural purposes, gardening and washing apparatus in laboratories, Figure 4.6 shows the common water uses in the University of Venda.

Figure 4.6: Common water uses in the institution

4.5.1 Water utilisation by students in the residences

While conducting survey, it was found that there is a high number of students who are housed illegally in the student's residences. The water supply infrastructure within the University of Venda is designed to cater for a certain number of people. With the population growing and the addition of illegal students in student's residences, the water consumption increases which then increases the pressure on the existing water supply infrastructure. Students who are housed legally on university residences are billed for services such as water in their resident's fees, but the illegal students are not billed for such services. As a result, it becomes the responsibility of the university to cover the service cost of the illegal students.

Understanding water use is an important first step towards developing conservation of the resource (Anderson, 2008). Questions directed to students were framed to better understand students' knowledge of water consumption, water utilisation habits and willingness to incorporate more sustainable practices. The survey showed that 100% of the students residing on campus use water for drinking, cooking, cleaning, bathing, laundry and flushing toilets. According to World Health Organisation (2013) small quantities of water are needed for drinking and cooking and large amount of water is used for bathing, cleaning and washing. Analysis of survey results showed that the largest consumptive behaviour of UNIVEN students, was letting the shower water run while waiting for it to reach the desired temperature. From the survey, 52% of the students wait for one to three minutes, 28% wait for three to five minutes, 16% wait for five to seven minutes while 4% wait for seven to ten minutes as shown in Figure 4.7.

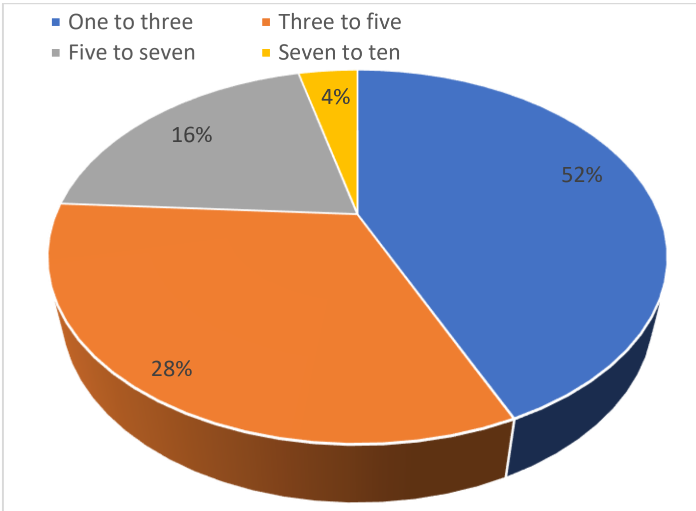

Figure 4.7: Amount of time (minutes) students run water taps while waiting for desired temperature

The lowest consumptive behaviour was cleaning the rooms. Drinking water is often neglected when considering water use. When students were asked how much water they required for drinking, 26% mentioned that they never drink water from the tap without the use of a container. Thirty percent (30%) of the respondents mentioned that they drink water from the tap once per day. While 25% of the students drink water from the tap twice per day and the remaining 19% of the students drink water from the tap thrice per day as shown in Figure 4.8. The respondents indicated that the amount of water they drink per day was influenced by weather. When day temperatures are high, they tend to drink more water as compared to cooler days.

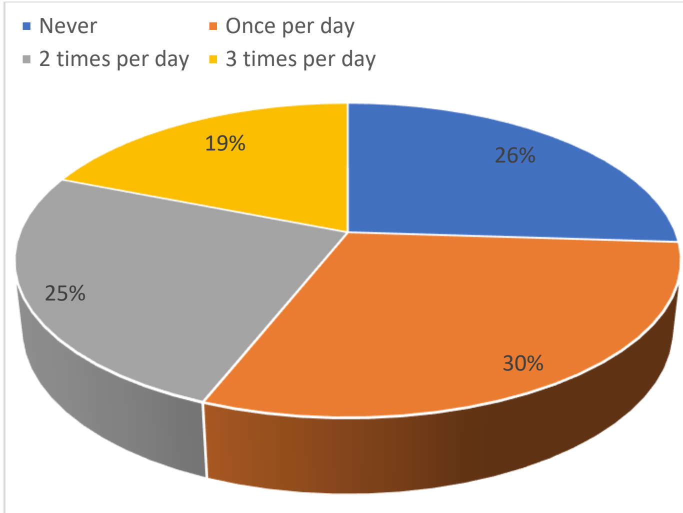

Figure 4.8: How often student drink water from the tap

About 85% of students cooked their own meals in the rooms, while the remaining 15% bought prepared meals from the cafeteria or outside the university campus. 46% of the respondents cooked once per day, 33% cooked twice a day while 21% cooked three times in a day. Fifty six percent of the students used running water to wash dishes while 44% washed dishes in a bowl. There is a laundry on campus, but majority of the students preferred to wash their own clothes.70% of the students residing on campus wash their own clothes at their residences. 10% of the students who do their own laundry mentioned that they sometimes take their clothes to the laundry while 30% always took their clothes to the laundry. Twenty two percent (22%) of the respondents did their laundry four times a month, 40% did it twice a month while 27% did it three times a month and only 11% of the students did their laundry once a month. Forty percent (40%) of the students said that they go to the toilet seven times per day, 21% go to the toilet six times per day while 20% go to the toilet five times per day and the remaining 19% go to the toilet four times per day. The study revealed that students have the tendency of flushing the toilet before using it. All students indicated that they clean their rooms, 15% of the students indicated that they clean every day, 45% clean their rooms three times a week and the remaining 40% clean their rooms on weekends only.

About 60% of the students residing in the university student's residences use showers, while 37% use both showers and buckets alternatively to bath and only 3% use buckets to bath. The results of the survey revealed that the gender of the students does influence the duration and how many times a student bathed per day. Female students tend to bath more and took longer showers compared to male students. Additionally, respondents mentioned that the times of the day when shower is taken more is in the morning before classes and later in the evening before they go to bed. The survey also showed that there is a difference in the time taken to shower during week days and weekends because some of the students are not around during weekends. Fifty five percent of the students showered twice a day, of which 45% are female students and 10% are male students. 23% of the students showered three times a day, of which 19% are female students and 4% are male students and the remaining 22% showered once a day and are all male students. About 29% of the students took 15 to 30 minutes in the shower, while 48% took 10 to 15 minutes and the remaining 23% took 5 to 10 minutes.

Seventy six percent of the students mentioned that they keep the shower running while applying soap or shower gel and 24% said they rarely keep shower running. DWA (2012), states that to reduce the amount of water used during showering, a person must shower for 5 minutes and the shower must be turned off while applying soap. About 85% of the students used running water to brush their teeth while the remaining 15% used a glass. 55% of the respondents keep the tap running while brushing their teeth and 45% of the respondents mentioned that they rarely keep the tap running. According to DWA (2012), taps must be turned off while brushing teeth. Some student's habits regarding keeping the tap running while washing dishes, showering and brushing teeth are shown in the Figure 4.9.

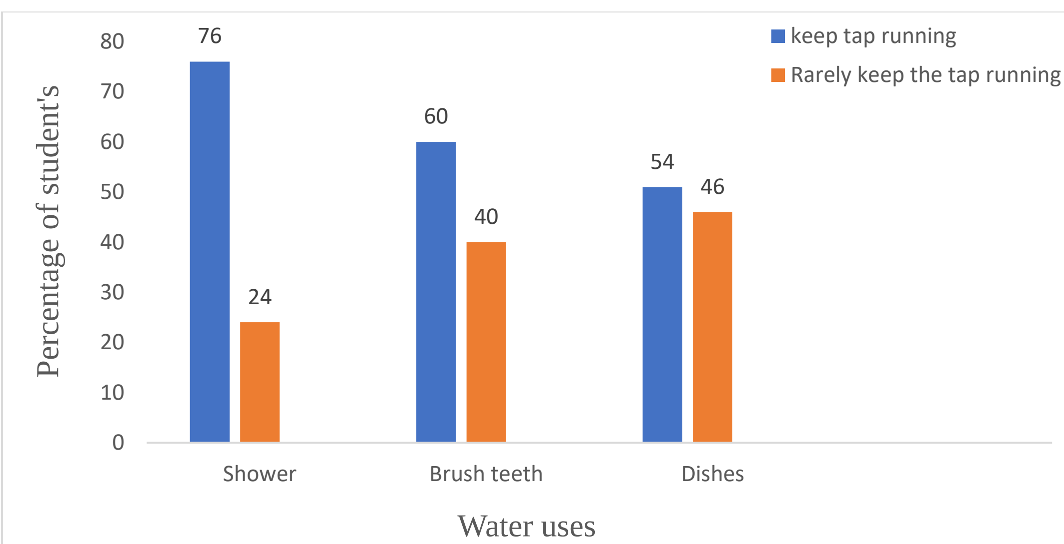

Figure 4.9: Student's habits regarding keeping the tap running while using water

The survey results show that students do not understand the use of grey water, 72% of the respondents mentioned that they do not use grey water at all, while 28% of the respondents use grey water. They indicated that water used for rinsing the dishes is reused for mopping the floor. The university maintenance department close water for some buildings while fixing the burst pipe. The latter compels the students to store water in their rooms since they are not informed about the turnaround time for fixing the bursts. About 50% of the respondents, store water in their rooms using 20 litres buckets, while 32% use 10 litres buckets of water. The remaining 18% of the respondents mentioned that they use 5 litres buckets of water but they do not collect water every day. The overall amount of water consumed by students residing on campus for drinking was 2 to 15 litres, for preparing food was 10 to 25 litres and for cleaning was 3 to 10 litres. Water used for laundry was 100 to 300 litres, for flushing the toilet was 106 to 185.5 litres and for bathing was 50 to 200 litres as shown in Table 4.4.

Table 4.4: Estimated water consumption by students residing on campus

Water uses	**Water consumption (l/p/d)**
Drinking	2 – 15
Preparing food	10 – 25
Cleaning the room	3 – 10
Laundry	100 – 300
Flushing the toilet	106 – 185.5
Bathing	50 – 200
Total	271 – 735.5

Seventy percent (70%) of the surveyed students residing on campus mentioned that they use 2 to 5 litres of water for drinking either at the academic side or their residences, 24% indicated that they use 6 to 10 litres while 6% use 11 to 15 litres. Seventy two percent (72%) mentioned that they use 10 to 15 litres of water to prepare food in a day, 17% use 16 to 20 litres and 11% use 21 to 25 litres. Sixty two percent (62%) said that they use 3 to 5 litres for cleaning the room while 38% use 6 to 10 litres. Twenty three percent (23%) indicated that they use 100 to 150 litres of water for laundry in their residences per week, while 15% use 160 to 200 litres, and 62% use 210 to 300 litres. Forty percent (40%) said that they use 185.5 litres for flushing the toilet, 21% use 159 litres, 20% use 132.5 litres and 19% use 106 litres. Nineteen percent (19%) indicated that they use less than 30 litres of water for bathing in their rooms per day while 26% use 50 to 100 litres at the showers per day, 38% use 110 to 150 litres and 17% use 160 to 200 litres.

The water utilisation by the students in the residences is inefficient. The water consumed on a daily basis by the students residing in the university residences is higher than the water recommended by the CSIR (2003). The latter indicated that sustainable water use was not practiced because students do not measure the amount of water required for a particular purpose. More water is wasted while using the shower, brushing teeth and washing the dishes and clothes. Taking a five-minute shower a day, instead of a bath, saves up to 400 litres of water a week and showering can use up to 20 litres of water per minute (DWA, 2012). Cutting shower time by one minute could save up to 6 813.6 litres of water a year (University of California, 2018). Brushing teeth with the tap running is one of the most common ways of wasting water, with about six litres used per minute (O' F'atharta, 2013). By turning off the tap when brushing teeth, a person can save up to 11.36 to 18.93 litres of water every minute (University of California, 2018).

4.5.2 Water utilisation by day scholars and university staff

Seventy eight percent (78%) of the interviewed day scholars indicated that they use water for drinking and flushing the toilets. Of the 78% of students, 58% of the respondents mentioned that they do not drink more than 2 litres per day while they are on campus and the remaining 20% mentioned that they drink 2 litres or more while on campus. 22% of the interviewed day scholars indicated that they use water for flushing the toilets and washing hands only, they use bottled water for drinking.

Thirty six percent (36%) of the day scholars mentioned that they go to the toilet five times per day while they are on campus, 31% go to the toilet four times per day, while 22% go to the toilet three times per day and the remaining 11% mentioned that they go to the toilet two times per day. It was found that about 39% of students residing off campus but close to campus, use the showers in the residences to bath and sometimes wash their clothes on campus, but the water used is counted under students who are legally residing on campus. The amount of water consumed by day scholars is less than the amount of water used by students residing on campus. Figure 4.10 shows the water uses by day scholars on campus.

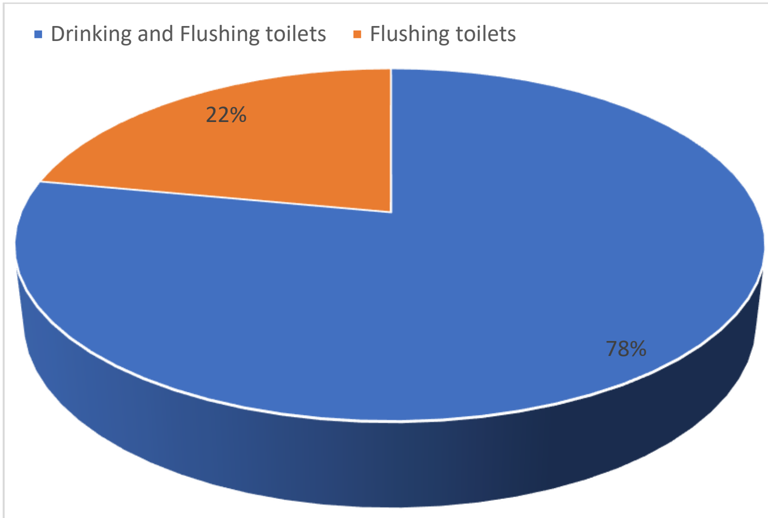

Figure 4.10: Water uses by day scholars

The university staff were also interviewed, and the survey shows that the staff use water for drinking and flushing the toilets. About 48% of the staff mentioned that they do not drink tap water but preferred bottled water because they consider the potential contamination of the tap water. 31% of the respondents said they do drink tap water, while 21% drink both tap water and bottled water, the respondents also indicated that they use water sparingly. About 69% of the respondents mentioned that when making tea or coffee they heat more water than required and the water left in the kettle is poured out but they ensure that the tap is properly closed after use. 31% of the respondents mentioned that they share the office therefore when the water is heated for making coffee or tea it is shared, and they ensure that the tap is closed properly after use.

Thirty six percent (36%) of the university staff indicated that they go to the toilet five times per day while they are on campus, 31% go to the toilet four times per day, 22% go to the toilet three times per day while 11% go to the toilet two times per day. Day scholars use less water compared to staff members and these can be mainly because students spend less hours on campus while staff members spend almost the whole day. Day scholars mainly uses water for drinking and flushing toilet only while staff members even boil water for coffee or tea.

It was found that there were few offices with pot plants, as they were found in the corridors and were watered everyday by the university cleaners. 72% of the respondents indicated that they were interested in water issues and also read articles and watched programs about water but do not know the quantity and quality of water within the university and its neighbourhood. A study conducted by Nare (2015) showed that most of the communities in the LRC where the University is situated have no knowledge on the states of water quality within the Catchment. Therefore, they are prone to the risks of contracting waterborne disease. The study further revealed that the treatment efficiencies calculated from the treatment plants showed that communities were vulnerable to diseases due to accessing inadequate amounts of water and poor quality of water. University staff interest in environmental issues correlated positively with their ability to track environmental information. 73% know where to seek water information and also think that water conservation is important but do not know how much the university spends on water bills per annum. 27% of the respondents do not know where to seek water information and thinks that water conservation is important, however, they do not know how much the university spends on water bills. Water consumed by university staff and day scholars was comparable. Water for drinking including making tea was 2 to 10 litres and for flushing the toilet was 53 to 132.5 litres as shown in Table 4.5.

Table 4.5: Estimated water consumption by day scholars and university staff

Water uses	**Water consumption (l/p/d)**
Drinking	2 – 10
Flushing the toilet	53 – 132.5
Total	55 – 142.5

Seventy one percent (71%) of both day scholars and university staff indicated that they use 2 to 5 litres of water for drinking per day and 29% use 6 to 10 litres of water while on campus. Thirty six percent (36%) mentioned that they use 132.5 litres of water for flushing the toilet while 31% use 106 l/d, 22% used 79.5 l/d and the remaining 11% used 53 l/d. A study conducted by Oruko and Sojo (2015) in Mombasa polytechnic college in Kenya, showed that the amount of water utilised by staff and day scholar at a developing institution was 37 litres per staff or day scholar per day.

The latter highlighted that the present water supply was not enough, the supply lasted for 12 hours in the lower hostels while upper hostels received 9 hours supply daily, and also indicated that this can be mitigated by exploring alternative water sources such as addition of boreholes and installation of two lines of water supply from Mzima spring. The results of the survey indicated that 55 to 142.5 litres of water per staff or day scholar was utilised per day in UNIVEN, this is more than what staff and day scholars utilised at a developing institution. Water utilisation by day scholars and university staff was found to be inefficient. More water can be wasted by flushing the toilets because old toilets are used in the institution and can use 13.25 litres to 26.5 litres per flush, compared to new toilets that can only use up to between 6.1 litres per flush (Regional Water Provider Consortium, 2018). Using more water than needed when preparing the tea increases water consumption. In order to estimate the amount of water used for drinking day scholars and staff indicated that they preferred drinking water with bottles than cups.

4.5.3 Water utilisation by cleaners

Due to increased infrastructure development within the institution, there has been an increase of impervious surface (i.e. roads, pavements and buildings) and while washing these impervious surfaces additional amount of water was utilised. Interviews were conducted with cleaners and supervisors. The cleaners manager was also interviewed to verify the information given by the cleaners. The respondents indicated that the water used by university cleaners is from the main source and borehole water was only used when municipal water is not supplied. It was found that cleaners are also responsible for watering flowers found in the corridors in different buildings and in the offices every day as shown in Figure 4.11.

Figure 4.11: Examples of flowers watered by cleaners

The respondents mentioned that buckets are used to water flowers, and about 56% use 5 litres buckets to water flowers, while 33% use 2 litres and the remaining 11% use 10 litres to water flowers as shown in Figure 4.12. According to the cleaners the size of the flower pot determines the amount of water used to water the plant. The respondents also indicated that the bigger the flower pot the more water was used.

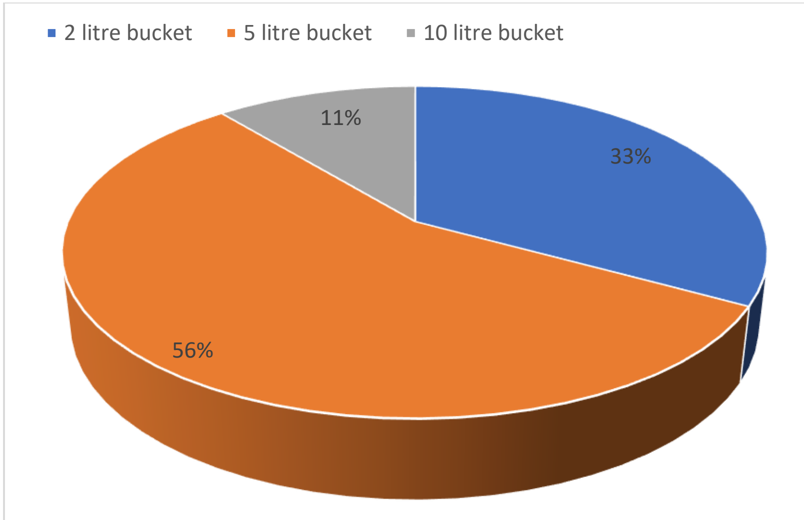

Figure 4.12: Percentage of cleaning respondents using different bucket sizes to water flowers

When municipal water was not supplied, water for cleaning the toilets is available but not for flushing. Therefore, toilets are locked to avoid them being utilised and mobile toilets are made available. The respondents mentioned that the pavements are washed daily, every morning an instruction is given to the cleaners of which part of the university pavements should be washed. During the process of pavement washing, the hose runs for several hours, thus leading to water wastage. The respondents mentioned that all the toilets on campus including the toilets in residences, lecture halls and the corridors at residences are cleaned daily. University cleaners are not responsible for cleaning the student rooms. The respondents also indicated that the water is enough for all the uses. According to the respondents, grey water is dirty water which is not suitable for cleaning.

The study revealed that it takes 1 minute to fill up a 25 litres bucket therefore, in order to estimate the amount of water used for washing the pavement, time taken to wash the pavement was multiplied by 25 litres. The supervisor indicated that it takes 32 to 40 minutes to wash the smallest pavement (60 m^2) and 44 to 60 minutes to wash the biggest pavement (120 m^2) within the university. According to the university cleaners, a 25 litres bucket was used while cleaning the toilets and residences, it should be noted that each toilet was flushed after washing and 26.5 litres of water was used per flush. Therefore, 26.5 litres of water for each toilet tank was added with the amount of water used for cleaning. Cleaners indicated that 2 buckets of water were used for cleaning a restroom which have 5 to 6 toilets while 3 25 litres buckets of water were used for cleaning a restroom which have 7 to 8 toilets. The study revealed that the biggest residences within the institution have 8 to12 toilets per floor and 6 25 litres buckets of water were used to clean each floor of the four-story residences while the smallest residences have 6 to 8 toilets and 5 25 litres buckets of water were used for cleaning. Water for cleaning the lecture halls was estimated through adding the number of buckets used per day for cleaning and the survey showed that 2 to 5 buckets of water are used for cleaning smaller lecture halls and 6 to 9 buckets are used for cleaning the biggest lecture halls.

The amount of water consumed by university cleaners for washing pavement was 800 to 1400 litres depending on the size of the pavement section, for cleaning the toilets was 156 to 310 litres per toilet block and for cleaning the small residences was 284 to 362 litres per residence floor, water consumed for the four-story residences which are the biggest in the institution was 1872 to 2297 litres per residence. Water used for cleaning lecture halls was 50 to 125 litres for the small lecture halls and 150 to 225 litres for the big lecture halls and water for watering the flowers was 2 to 25 litres per building as shown in Table 4.6.

Table 4.6: Estimated water consumption by cleaners

Water uses	**Water consumption (l/d)**
Washing pavement	800 – 1500
Cleaning the toilets	182.5 – 287
Cleaning the residences	284 – 1872
Cleaning lecture halls	50 – 225
Watering flowers	2 – 25
Total	1 318.5 – 3 909

Fifty two percent (52%) of the cleaners mentioned that 800 to 1000 litres of water is used for washing pavement and 48% uses 1100 to 1500 litres of water daily per pavement. The results of the study revealed that 68% of the cleaners use 182.5 to 209 litres of water for cleaning the toilet and 32% uses 260.5 to 287 litres. Forty eight percent (48%) of the cleaners indicated that 284 to 337 litres of water was use for cleaning residences and 52% indicated that they use 1448 to 1872 litres. Sixty seven (67%) of the cleaners indicated that they use 50 to 75 litres of water for cleaning the small lecture halls and 33% of the cleaners indicated 100 to 125 litres while 52% of the cleaners used 150 to 175 litres of water for cleaning bigger lecture halls and 48% used 200 to 225 litres. About 75% of the cleaners indicated that they use 2 to 15 litres of water to water the flowers while 25% of the cleaners said that they use 16 to 25 to water the flowers daily.

Water utilisation by cleaners was found to be inefficient. The results of the survey indicated that cleaners do not use water in a sustainable manner and more water wasted during washing of pavements, cleaning the residences and the toilets. Further to the latter, the water used was not measured as cleaners make estimates of the amount of water they use. Rain water and grey water is not used for these non-drinking purposes. According to Zabala *et al*. (2016) the use of rain water and grey water as a water source for non-potable uses, must be conditioned or treated to meet the quality criteria set by local standards or regulations.

4.5.4 Water utilisation by gardeners

Irrigation water includes water that is applied by an irrigation system to sustain plant growth in all agricultural and horticultural practices and includes water that is used for pre-irrigation, frost protection, field preparation and weed control (Maupin *et al*., 2014). After interviewing the gardeners, supervisors and the manager, it was found that water used by this section is from the main source and borehole water is not used as an alternative source of water when municipal water is not supplied.

The respondents mentioned that the garden including the lawn at the university stadium is watered everyday excluding Sundays, a horse pipe is used when watering the garden as shown in Figure 4.13. The supervisor mentioned that the duration of watering depends on the size of land watered but gardeners are given sections of different sizes to water every day until the shift ends. Buckets are not used when watering the garden including watering the flowers. The amount of water required for gardening is not enough to water the entire garden within the university (Nethengwe, 2017).

Figure 4.13: The irrigation system used for watering the garden within the institution

Environmental knowledge is also important because some of the plants within the campus garden consume a lot water. The survey showed that the respondents do not know whether the plants on campus garden, are indigenous or alien plants. Further to this, the crop water requirements for these garden plants/ trees/ grass/ flowers are not known. Grey water is not used at the campus garden because the perception is that the water is dirty and contains chemicals which can be harmful to the plants.

According to the supervisor time taken for watering the stadium lawn was 60 to 120 minutes, and for watering the lawn in other parts of the university was 48 to 88 minutes and for watering the soccer field was 60 to 100 minutes while for watering the flowers was 16 to 36 minutes. The gardeners working at the stadium the estimated amount of water used for watering the stadium lawn everyday was 1 500 to 3 000 litres of water. Eighty three percent (83%) of the university gardeners indicated that the estimated amount of water used for watering the lawn was 1 200 to 1 800 litres of water while 17% indicated that 1 900 to 2 200 litres was used. The gardeners further mentioned that the estimated amount of water used for watering the soccer field was 1 500 to 2 500 litres. It should be noted that the gardeners do not always use the sprinklers system for watering the lawn, they sometimes use a horse pipe and this lead to uneven distribution of water on the lawn since the water continues to flow in a channel. Fifty seven percent (57%) indicated that the estimated amount of water used for watering the flowers was 400 to 700 litres while 43% of the gardeners indicated that 800 to 900 litres was used as shown in the Table 4.7.

Table 4.7: Estimated water consumption by university gardeners

Water uses	Water consumption (l/d)
Watering the stadium lawn	1500 – 3000
Watering the lawn in the other parts of the university	1200 – 2200
Watering the soccer field	1500 – 2500
Watering the flowers	400 – 900
Total	4600 – 8600

Water utilisation by the gardeners was also found to be inefficient, the results of the survey show that gardeners do not use water sustainably. Gardeners water certain sections with different sizes of the lawn until the shift ends. According to DWA (2012), garden should be watered early in the morning or in the evening, when temperatures are cool, as one can lose up to 90% of water to evaporation. Invasive alien plants should always be removed (DWA, 2012), unfortunately the study revealed that gardeners lack knowledge about the type of plants in the institution, therefore more water was used even on plants which do not require much water since different plants have different water needs. Water use was not efficient, as mentioned above, the gardeners do not use sprinklers at all times, more water is wasted while using the horse pipe since the water is unevenly distributed on the lawn.

4.5.5 Water utilisation in School of Agriculture experimental farm

The School of Agriculture within UNIVEN cultivates land for the growing of crops and rearing of animals such as pigs, chickens, goats, cows and sheep in their experimental farm. The farm manager and workers were interviewed. They indicated that the sources of water used in the experimental farm are from both the municipality and the university boreholes. Municipal water is connected to a tank which continuously supply more than 2000 litres of water to animals for drinking on a daily basis while 7270.4 litres/ 4 hours/ 16 segments/ day of borehole water is used to water the crops Table 4.8.

Table 4.8: Estimated water consumption by School of Agriculture experimental farm

Activity	**Duration**	**Experimental farm segments**	**Water used *(l)***	**Total water used *(l)***
Watering plants	4 hours per day	16	113.6	7270.4
Drinking	-	-	-	2000

The respondents further indicated that the only day which crops are not watered is when it is raining. In the event of inadequate rainfall, crops are watered but not for the same duration compared to days that there was no rain. The experimental farm has 16 segments and normally crops are watered every day from 8H00 to 12H00 making use of 113.6 litres of water per hour on average. The latter water in litres is prescribed by the irrigation system used at the experimental farm (Restuccia, 2016). Respondents further indicated that water is only conserved through the type of irrigation method being used at the experimental farm. The perception of the respondents about using grey water or recycled water is that the grey water might contain chemicals which can be harmful to the livestock and crops, therefore grey water is not used in the farm. A study conducted by Travis *et al*. (2005), suggest that oil and grease from grey water can accumulate in soils and affect the ability of the soils to absorb water, essentially making it water repellent. According to the respondents, irrigation with treated grey water can mitigate the utilisation of natural water resources but it may also result in environmental problems such as increase of salinity in soil and this can reduce production. Therefore, using treated grey water at the experimental farm is not considered.

Farms are major users of water and the water utilisation at the School of Agriculture experimental farm was high. This is comparable to agricultural water users as they use 62% of all the water used in South Africa and in many instances, the use is highly inefficient (DWAF, 2004). There were 62 cows on the farm during the study period, the average drinking water per cow is 91.1 litres per day (Kraub *et al.*, 2016). The duration of irrigation scheduled at the experimental farm is improper even though crops are watered early in the morning to avoid evaporation loses. Since the soil is already moist, and the plants will not require the same amount of water hence good irrigation is about managing the soil moisture level so that the plant is maintained in the desired condition. According to Connellan (2002), the timing of irrigation needs to meet the changing water demands of the plants and moisture level of the soil. The micro irrigation system used promotes efficient water use because the systems can efficiently water crops in a controllable way through delivering water directly to the stem, but more water is wasted as a result of over irrigating. Over irrigation occurs because of lack of technical experts in the farm, competent management and maintenance of an irrigation system requires reasonable level of skill and expertise.

4.5.6 Water utilisation at the laundry

The respondent managing the laundry mentioned that the water used for washing the clothes is from the main water source (municipal water) and when the municipal water is cut off, borehole water is used. About 15 baskets of clothes, are washed per day during the 5 working days of the week and approximately 23 baskets of clothes are washed over the weekends. The respondent also indicated that water used for washing one basket of clothes is not used to wash another basket of clothes. When rinsing the clothes, two times the amount of water for washing is used. The respondent further indicated that, the amount of water used for rinsing is as a result of the type of soap used in washing. The water used for rinsing the clothes is not used for washing although it appears clean for washing another load of clothes. The average amount of water consumed by University laundry for washing and rinsing the clothes is approximately 22 500 litres/ weekday for 75 baskets and 13 800 litres/ weekend for 46 baskets of clothes as shown in Table 4.9.

Table 4.9: Estimated water consumption by university laundry

Week days						Weekends			
		No. of baskets / day	**Average water use / load (l)**	**Water used / day (l)**	**Weekday water use (l)**	**No. of baskets / day**	**Average water use / load (l)**	**Water used / day**	**Weekend water use (l)**
Water use type	Washing	15	100	1 500	7 500	23	100	2 300	4 600
	Rinsing	15	200	3 000	15 000	23	200	4 600	9 200
	Total				**22 500**				**13 800**

Water utilisation at the laundry was inefficient and this was mainly caused by not washing a full load of clothes, since the clothes cannot be combined and also the use of two times the amount of washing water for rinsing. Every time the machine is used, water is being consumed so not consolidating the washing was not efficient. Dickinson (2018) recommended average water use for washing per load of clothes as 56.8 to 113.6 litres and the washing machine typically run for 15 minutes. Taking into account the latter recommendation, the University laundry uses more water for their laundry operations.

4.5.7 Water utilisation in laboratories

Laboratories are fundamental part of the institutional activities. For a better understanding on water consuming activities in the laboratories interviews were conducted with laboratory technicians from the following Departments; Chemistry, Biochemistry, Botany, Horticulture, Hydrology and Water Resources, Microbiology, Plant production and Zoology. The other Departments were selected because they all make use of water while conducting students' practical's experiments and for research purposes. About 60% said that they use tap water at the laboratories most of the time, which is water from the main municipal source and borehole water is not used while forty percent (40%) uses distilled water and indicated that it is being supplied to them. The remaining 20% filter their own water for use at the laboratory and mostly filter more than the required amount, but they indicated that they make sure that they keep the remaining water in the containers.

The survey shows that laboratory technicians use water for scientific experiments, washing equipment's (graduated cylinders), rinsing laboratory dishes (test tubes and beakers) and washing hands only when the need arises, for example to ensure no contamination of samples. The respondents further indicated that they do not have any other uses beside the ones mentioned above. Water consumed at the University laboratories for washing equipment was 25 to 40 litres per practical session and for rinsing laboratory dishes (Burette and pipettes) was 40 to 80 litres per practical session. Water consumed for scientific experiments was 20 to 35 litres per practical session and for washing hands was 40 to 60 litres of water as shown in Table 4.10.

Table 4.10: Estimated water consumed at laboratories per practical session

Water uses	Water consumption (litres/practical session)
Washing equipment	25 – 40
Rinsing laboratory dishes	40 – 80
Scientific experiments	20 – 35
Washing hands	40 – 60
Total	125 – 215

Respondents indicated that they wash the equipment before and after use and 60% mentioned that they use 25 to 30 litres for washing equipment, and 20% indicated that they use 30 to 35 litres and 20% use 35 to 40 litres of water. Seventy percent (70%) said that they use 40 to 50 litres of water for rinsing laboratory dishes while 30% use 50 to 80 litres. The survey revealed that water used for scientific experiments varies depending on the practical undertaken, twenty percent (20%) mentioned that they use less than 20 to 25 litres of water for scientific experiments while 30% use 25 to 30 litres and 50% use 30 to 35 litres. Eighty percent (80%) indicated that they use 40 to 50 litres of water for washing hands after performing practical work while 20% said that they use 50 to 60 litres of water.

Thirty percent (30%) of the respondents indicated that they store water in containers for back up in case of water cuts, while 50% of the respondents always made sure that there is distilled water which is available for use and the remaining 20% said that when water cuts occur they do not perform practicals. Sixty percent (60%) of the respondents mentioned that they conduct four practicals sessions per week and assist 60 to 85 students per practical session in the laboratory and 30% of the respondents conduct three practical session per week and assist 40 to 50 students while the remaining 10% mentioned that the practical sessions that they conduct per week is not structured and the number of students fluctuate from 20 to 40.

The respondents mentioned that their departments do not have any documentation encouraging water conservation but they all think that water conservation is important. The respondents indicated that they sometimes provide advice to students on efficient water utilisation before performing their practicals. Some equipment used at the laboratory discharge water; therefore, water cannot be reused in the same or other processes and students are not allowed to reuse water while performing practicals because this might alter the final results and interfere with the quality of the output.

4.5.8 Other water uses within the university

The institution supports grade 12 learners through a winter school program which takes place on campus during the winter break (3 weeks). During the program learners are housed on campus at the student residences and they utilise water for their domestic purposes for that period. These learners are only charged for lessons and accommodation and not for services like water and electricity. Therefore, the University is responsible for the bill of water utilised by the learners. The water consumption is high during this period as depicted from the water invoices from the water service provider. The University pays twice the amount in winter as compared to the other months when the students are not in recess.

The University management allows people to hire the university auditorium for events which are not academically related such as funerals and weddings. Some events take place during the week while some on weekends and during the events, water is utilised either for drinking or flushing of the toilets. People who hired the auditorium are not responsible for paying for water consumed during the events because the amount of water consumed is unknown and not included in the money which is charged for hiring the auditorium, therefore the University must also pay for the water which was utilised during such events. Therefore, this leads to inefficient water utilisation. Water is also used at the University cafeteria and in a student car wash in front of the University sports hall, though it does not operate on a daily basis.

Increase in student population within the University of Venda led to increase in infrastructural development and this has contributed tremendously to increase in water utilisation. During the construction phase water consumption is broken down into two categories of requirements, sanitation and construction processes (Chakane, 2014). Water used on site for construction processes such as tool washing, brickworks, concreting, plastering and dust suppression is not measured or recorded. Water used for construction within the institution is from the main source of water. An example is the newly constructed building next to the Art Gallery. The duration of the construction of the building was from September 2014 to 2017. The United Nations (UN) suggests that a person needs in this kind of region is 20 – 50 litres of water a day to ensure that their basic needs for drinking, bathing and cooking (UN-Water) are met and during the peak of the construction period the average number of construction workers on site per day was approximately 36. The following calculations in Table 4.11 assume 50 litres/worker/day with the assumption that portable chemical toilets were used at the construction site.

Table 4.11: Estimated water consumption by construction workers

September 2014 – 2016				**2017**			
Consumption (l/w/d)	Construction duration (days)	Number of workers on site	Total consumption (l/w/t)	Consumption (l/w/d)	Construction duration (days)	Number of workers on site	Total consumption (l/w/t)
50	854	36	1 537 200	50	365	16	292 000

*l/w/d – litres/worker/day

*l/w/d – litres/worker/total construction duration

4.6 Water utilisation trends within UNIVEN

Water utilisation depends upon several factors such as climate, availability of water resource and water pricing structures. The required data to determine the university monthly water utilisation trends were obtained from the invoices which shows how many litres of water was supplied to the university on a monthly basis and the amount of water charged by the municipality. The institution does not use a prepaid water meter which shows the credit and the amount of water available in litres. The university is billed monthly according to the number of litres of water that was supplied, which in this study is concluded to be the total amount of water consumed by the university community.

Climate was found to be important in explaining water utilisation trend. During summer seasons the area receives most of its rainfall and water supplied is low as shown in Figure 4.14. The latter is because of the student recess in summer season with reduced water use in the University. In addition, the municipal water supply is supplemented with rainwater for washing pavements and flushing walkways. The municipal water supply usage decreases with rainfall days as there is no need for watering the garden or lawn during such days.

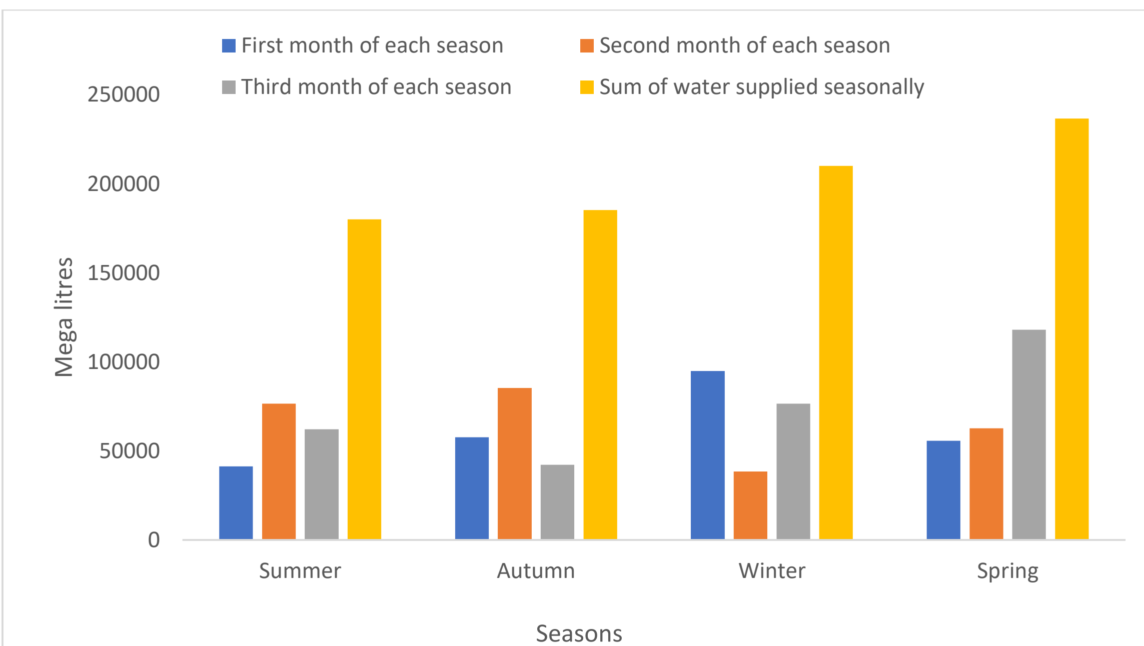

Figure 4.14: Seasonal water supply for University of Venda

During autumn seasons water supplied to the University was higher than the amount of water supplied in summer seasons. During winter seasons the institution was supplied with more water compared to the wet seasons. During dry seasons the university population generally uses more water as compared to the wet season. Winter school within the institution during which high school students mostly allow showers to run for desired temperature, contribute to the water supply increment. During spring season water supplied to the institution was very high compared to all the seasons. When it is warmer the university population tend to consume more water since they do more of the activities that use water such as watering the garden, filling the swimming pool and having extra showers.

4.7 Water wastage

The survey results indicated that students tend to open and not close the taps when there is no water and when the water starts flowing the taps run unattended. These happen when brushing teeth, washing dishes, and rinsing clothes (see Figure 4.15). After using the water, students leave taps unfastened when they find them dry and opening showers and leaving the water running before bathing all lead to water wastage within the institution. Frequent bathing by students (morning, afternoon and evening) also lead to water wastage, therefore, water wastage and misuse in UNIVEN is mainly caused by students.

Figure 4.15: Water wastage at students residences

Water wastage attributed to university staff were cases like overflowing water while watering the flowers and lawn in an unmonitored manner and during the process of pavement washing the hose runs for several hours, thus leading to loss of water. Overflow of the storage tanks in the residences, academics departments and School of Agriculture. Figures 4.16 and 4.17 below indicate the common water leakage and spill at School of Agriculture experimental farm. Due to lack of collection point of runoff and roof rain water harvesting during rainy seasons, the uncollected water is lost to the Dzindi River.

Figure 4.16: Water leakage at the reserve storage located at School of Agriculture

Figure 4.17: Water spill at the School of Agriculture

Cases of pipes that burst are due to the aging water supply infrastructure, while leaks are also common as there is a general lack of regular maintenance. Slow response by the maintenance department to reported faulty cases leads to more water loss. The study shows that behaviour is a major source of water loss. According to laboratory technicians, students are mostly inconsiderate towards water consumption. This is demonstrated by leaving taps running and not turning them off after completing their practicals. The laboratory technicians indicated that they constantly remind students of the importance of turning the taps off or adjusting the flows, but this did not seem to greatly change the situation. They still had to constantly turn the taps off themselves throughout the laboratories before leaving. Another case of water losses caused by students is more water utilisation for rinsing laboratory dishes. Here again, the amount of water used could greatly exceed the amount of water required. Figure 4.18 shows a University of Venda student rinsing laboratory dish during experiments at the laboratory.

Figure 4.18: Student rinsing laboratory dish at the laboratories

Water losses experienced by the university through pipe bursts are reported at maintenance department. 70% of the students residing on campus do not report pipe bursts directly to the maintenance department, they indicated that they mostly report pipe bursts to floor representative, and cleaners for onward transmission to the maintenance department, while 30% of the respondents reported to the maintenance department directly. After reporting the bursts, 77% observed that the maintenance department took weeks and at times months to fix the pipes burst while the remaining 23% observed that the maintenance department took a few days before fixing the pipes burst. According to the maintenance department, broken pipes are not recorded but more broken pipes are at the school of agriculture, followed by student residences.

About 92% of the day scholars said that they have seen running or leaking taps within the institution but did not know where to report and for this reason they do not take any action when they come across broken taps. The remaining 8% said that they act when they come across a pipe burst or broken tap, and they also indicated that they report the matter at the maintenance department, cleaners or student affairs, but they do not follow up on the matter.

In case there is a broken tap in the building the University management said that they report the matter directly to the maintenance department and the respondents declared that the maintenance department takes a few hours or days to respond to the matter. In case there is a pipe burst at the university farm, the matter is reported to the farm manager and the manager reports to the maintenance department but if the manager is not around the workers report directly to the maintenance department. The respondents mentioned that the maintenance department does not take time to attend to the matter, within a few hours after reporting, and mostly the matter would be dealt with on the next day.

Cleaners and gardeners declared that when they come across a broken tap or a pipe burst, they report the matter to the supervisor and the supervisor reports to the maintenance department, but sometimes they personally report the matter directly to the maintenance department. About 36% of the cleaners and gardeners mentioned that the maintenance department takes a few hours to attend to the matter. While 64% mentioned that maintenance department attend to the matter after a few days and only if you follow up on the matter. The laboratory technicians indicated that they do have a situation where the taps break or pipes burst within the laboratory. However, old pipes are corroded within their respective departments, resulting in leaks, often with rusty water. Seventy percent (70%) of the laboratory technicians indicated that the maintenance department responds to the matter after a few days but only if they follow up on the reported matter, while 20% said the maintenance department responds after a few weeks and 10% mentioned that the maintenance department never responds to the reported matter.

4.8 Awareness of water resources within the institution

The students residing on campus indicated that the university had never provided education regarding water use or encouraged the students to reduce their water consumption. About 64% of the respondents strongly disagree that they had received education regarding water use, 31% of the students mostly disagree while 3% strongly agree and the remaining 2% mostly agree, the responses from students are shown in Figure 4.19. In addition, postgraduate students mentioned that they have been with the same institution for years but have never seen an awareness day about water.

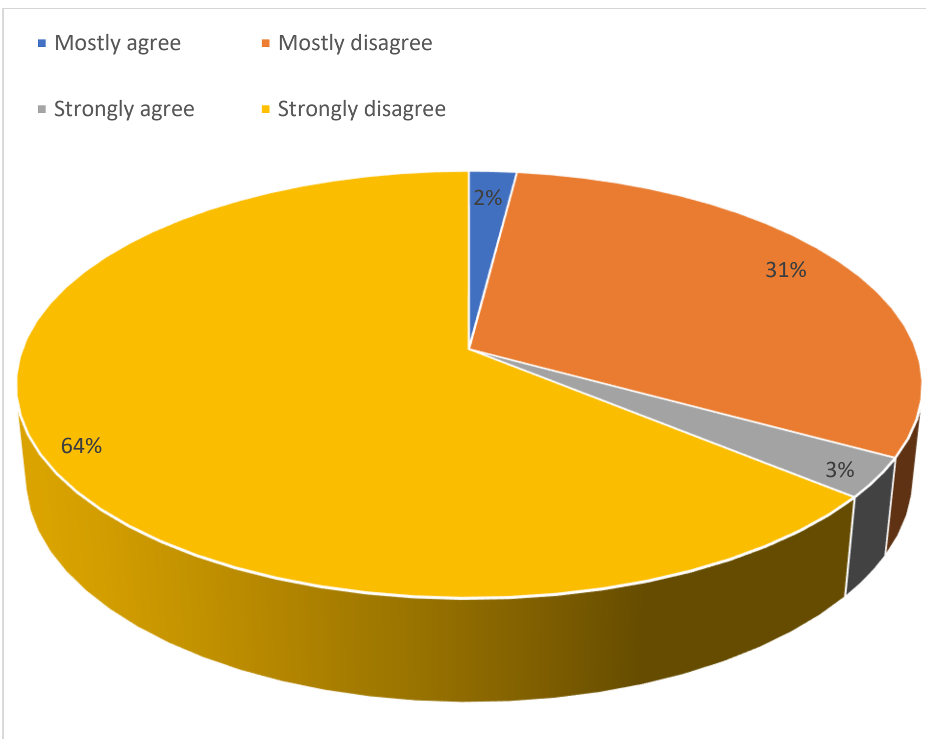

Figure 4.19: Education provided by the university

The highest percentage of day scholars declared that the university does not provide any education regarding water use, 97% of the students said that they have not received any education while 3%

of the students which are under the school of Environmental Sciences in the Department of Hydrology and Water Resources said that they have received some information on water conservation during their lectures.

Gardeners are not aware of the concept of water wise and they even declared that they had never undergone a water wise training, but the supervisor mentioned that they are advised not to allow the water run by the street while watering the garden. At the university laundry the respondent said that there is no one from the management or maintenance who has discussed with them about water utilisation and efficiency. According to the respondents at the School of Agriculture and university cleaners there is no policy that guides UNIVEN water users on how water should be conserved. The large percentage of students and staff do not feel encouraged by the university to reduce their water consumption.

While conducting the study a staff member stated that the UNIVEN neither encourages nor cares much about water as there has been leaks for years and nothing has been done about them. Despite not feeling encouraged both students and staff agree that the university should view water conservation and demand management as important issues to ensure sustainability of the limited water resource for use within the institution. The university staff appeared to be more concerned about water and water related issues but among them they were those who were not interested in water issues. It is evident that the university provides no education or adequate education regarding water consumption and issues to its staff and students.

4.8.1 Institutional water wise knowledge

About 12% of the cleaners do not know anything about water wise and 88% know that water wise is all about using water sparingly. The cleaners and supervisors mentioned that they have never undergone any water wise training, but the supervisors indicated that they are aware of the things which need to be done to save water. Closing the shower while scrubbing the wall and not letting the tap run while washing the basin and this knowledge is shared with the cleaners. Lack of water awareness campaigns within the institution led to only 16% of the students with water wise knowledge and the remaining 84% know nothing about water wise. Students with water wise knowledge reported that they do not waste water.

Fourteen percent (14%) of the gardeners do have adequate knowledge on the water use and they mentioned that they avoid over watering while 86% of the gardeners have inadequate knowledge on water use as they have also never undergone water wise training. The study revealed that all laboratory technicians never participated in any water wise training since they joined the institution and only 19% of laboratory technicians have water wise knowledge while 89% lack the water wise knowledge. 21% of the university staff have water wise knowledge and they mentioned that water issues are more relevant, and they take it seriously while 79% of the respondents have shortage of water wise knowledge. Nineteen percent (19%) of the respondents in School of Agriculture experimental farm does have knowledge on water wise and for this reason they time everyday how long they should water their crops and the remaining 81% lack water wise knowledge as shown in Figure 20.

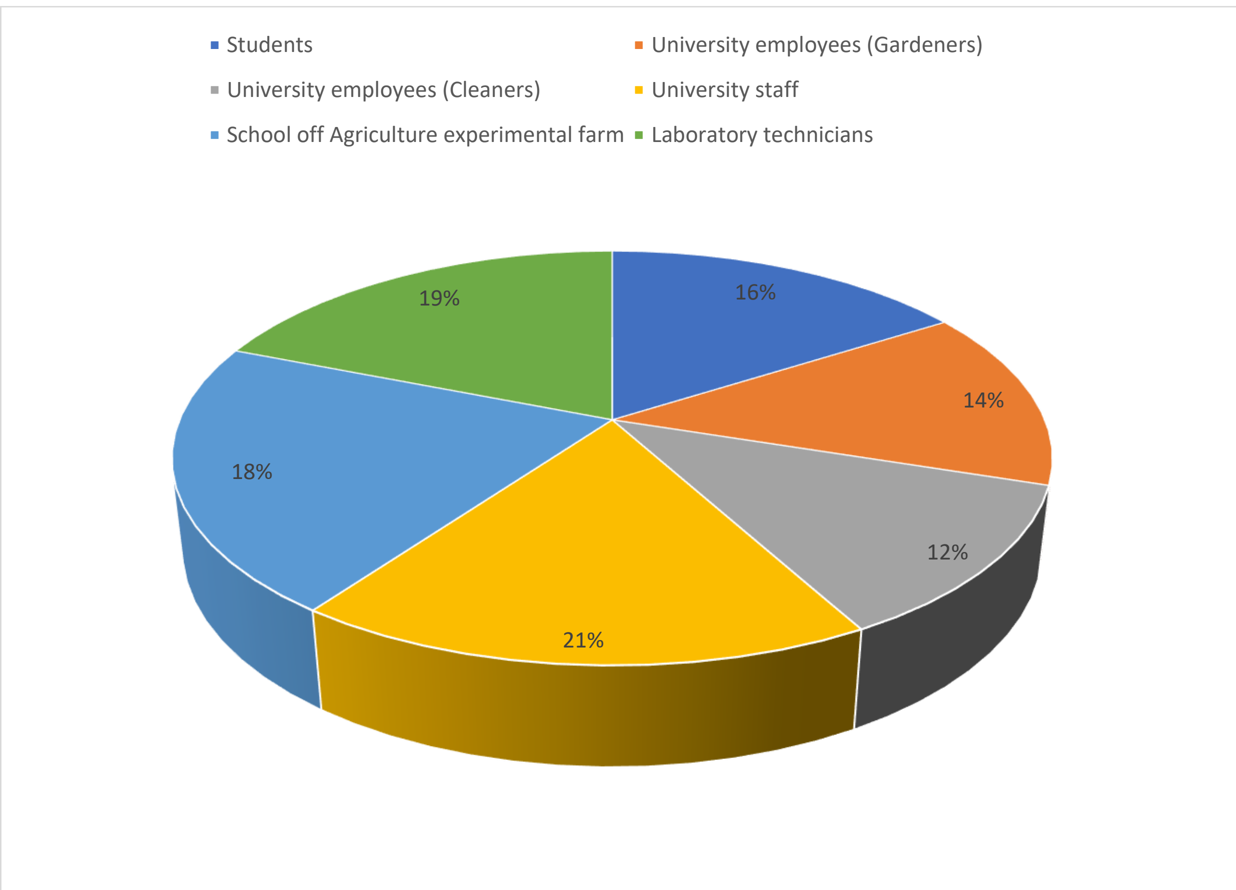

Figure 4.20: Institutional water wise knowledge

4.9 Institutional arrangements in resolving water problems

The survey revealed that water conservation and demand management measures were lacking in the institution as there are no water rationing policy, no public awareness and sensitisation to the students and the staff members on the efficient utilisation of water on campus. The facilities management indicated that the institution has documentation encouraging water conservation, however, students and staff have never accessed this document because the facilities management does not communicate with the students and staff. Further to that, the institution does not assign a person to work on water wise programs or water conservation and demand management issues within the institution. This contributes to misusing water or water losses because students and staff are not encouraged or committed to conserving water.

During the study, there was an observed lack of communication and transparency regarding data relating to water consumption between facilities management, university staff and the students. The facilities management are aware of issues and factors affecting water resources within the institution but there was little direct cooperation in investigating and finding solutions. Water meter data was not available over a period of time and in addition, there is one functional water meter located in the institution behind the university library.

4.9.1 The challenges encountered within the institution with water resources

- Lack of communication between the director of facilities (who is responsible for water resource management within the institution) and university water users.
- Unavailability of water use awareness projects.
- Absence of water resources posters or slogans within the institution to encourage efficient water utilisation which is another form of awareness about the importance of water conservation.
- Lack of proper security system, there is poor access control this might result in overexploitation of water resources because people who are not part of the university might be collecting water from the university illegally, as well as coming into the university and take showers. This might be a result of the fact that UNIVEN is part of a rural community

where they believe that everyone has access of right to the university or lack of resources to install the proper security system.

- There is no proper metering system, there are two meters within the institution however only one meter is operational. This is bulk metering which records the bulk amount of water from the source and not for individualised buildings.
- Laboratories within the institution does not use upgraded or innovative equipment's which conserve water.
- Improper management of the water storage, the original water supply system was planned long time ago for a certain population and the population has increased and this might create competition and conflicts among users.
- Shortage of qualified personnel to deal with water management within the institution that result in insufficient scientific data, for example, currently there is no one at the maintenance department who knows when the water supply system was planned and for the number of people it was planned to cater. Again, the institution does not have the invoices for the past years.

4.9.2 The suggested solutions towards efficient water utilisation.

- Change in human behavior is crucial in eliminating water waste, therefore, the facility management should create water education programmes because, if the programmes are applied appropriately and effectively, the available water can be utilized in a sustainable manner. Available evidence shows that performing educative campaigns and providing feedback on such campaigns can positively sway individuals' behaviours from wasteful to more sustainable (Peterson *et al*., 2007).
- The university water management office should ensure that visitors using the university auditorium and university guests are also involved in water conservation efforts through water posters and slogans around the campus.
- Proper relationship between the university water users and the university water resource management office, and there should be an establishment of a sustainability office to promote water conservation since the managers will ensure that workers do not waste water.

- The institution should move towards having a proper security system that ensures that only students who are allocated rooms should access their rooms to avoid overuse of water. Students and staff in the University of Pretoria access to the campus, laboratories and buildings on campus through access cards and Department of security and services maintains highly important tasks such as daily unlocking of doors in 530 building on 7 campuses (University of Pretoria, 2018). The department is also responsible for taking preventive action to safeguard against water leaks and electrical faults (University of Pretoria, 2018). The University of Witwatersrand has a 24 hour CCTV coverage and a card swipe system to assist in controlling access and the university has currently embarked as part of the institution integrated security system on a project to enhance safety security through the implementation of a new biometrics system (University of Witwatersrand, 2018).
- Installation of individual meters for the purpose of monitoring water use in a building and this can help the management monitor water consumption patterns and detect any abnormalities in water consumption easily. Meters and all associated communications and analysis equipment must be maintained to ensure that the accuracy of recorded data is maintained within acceptable limits.
- The management should consider replacing the old laboratory equipment's with water saving equipment's and this ensures that the management is mindful of the natural resources supporting that research and conservation should be a priority in proper laboratory technique.
- For improvement of campus water infrastructure, the management should consider enlarging the water storage within the institution or replacement of old water fixtures to low water flow fixtures so that the available water can be saved.
- The water challenges in UNIVEN exceeds the abilities of the current workers on campus as they lack capacity and as a result promote mismanagement of water resources. Therefore, the management should hire experts to fill the gaps and their experience can also save money by assisting the employees with training and change can be implemented. To reduce the water inefficiencies on campus there should be a specific way of monitoring and measuring water used. The management should improve in keeping all scientific records, which will be used for future reference.

CHAPTER 5: UNIVEN WATER MANAGEMENT PLAN

5.1 Preamble

This chapter presents the water management plan for UNIVEN which highlights the current water consumption in the institution, institution targets, drivers for reducing water consumption, recommended actions to reduce consumption and the contingency plan for the institution.

5.2 Water Management Plan (WMP) for University of Venda

This document considers how the University utilises water, outlines the approach to managing water utilisation and sets targets for water use reduction. The WMP has been developed to support sustainability of water resources in higher education institution through reduction of water consumption and finding alternative sources of water. The UNIVEN WMP outlines:

- ❖ Current consumption
- ❖ Institutional targets
- ❖ Drivers for reducing water consumption
- ❖ Water reduction projects
- ❖ Monitoring, Evaluation and Reporting

5.3 Current water consumption in the institution

In 2017, the University utilised 811 707 mega litres of water and Figure 5.1 indicates the water supplied to the University monthly. This consumption data was extracted from the municipal invoices billed to the University, as the service provider.

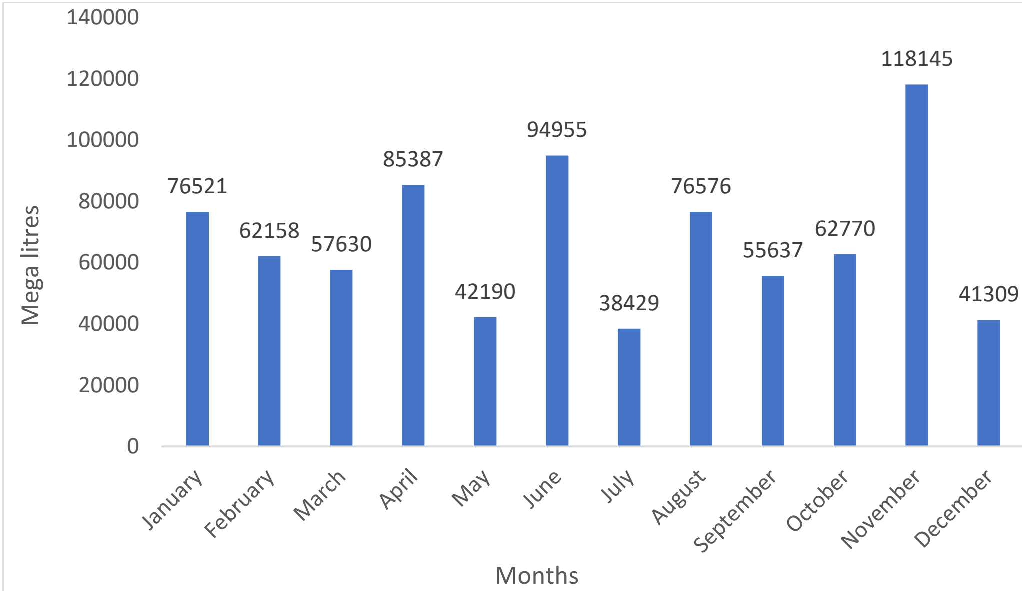

Figure 5.1: Water supply for University of Venda in mega litres

The monthly water consumption within the institution varies from month to month. The latter may be due to seasonal variation and different activities that happen within the institution. The meter data from the old meter has not been included because currently it is not working, and the University is not doing anything to resolve the issue. Recently constructed or refurbished buildings are not water efficient because water efficient appliances and fixtures are not installed in them, therefore water consumption will ultimately increase.

Table 5.1 indicates the amount of water utilised by the university population daily, water utilised at the cafeteria, car wash and auditorium are excluded because respondents refused to participate in the survey and they indicated that water utilisation data there was not metered to measure their water usage. According to Schnauber and Daschman (2008), few studies that are available point out that reasons for refusals may be serious answers by respondents and not just general excuses. Additionally, reasons for refusals are concomitants of refusal as behaviour. Refusal is not always a trait (stable personal behaviour), but rather involves spontaneous reactions which are highly dependent on situational factors.

Table 5.1: Estimated daily water consumption in UNIVEN

Water users	Water used in litres per day
Students residing on campus	1006.5
Day scholars and university staff	197.5
University cleaners	5227.5
University gardeners	13 200
School of Agriculture experimental farm	9270.4
University laundry	36 300
Laboratory technicians	340
Construction workers	800
Total	66 341.9

Based on the sample size, the results of the study revealed that approximately 66 341.9 litres of water was consumed within the institution daily. Taking into account the amount of water utilised per month, obtained from the invoices and the daily consumption from the questionnaire survey, the institution is not utilising water efficiently that is because of the large consumption noted. The results obtained are not accurate because there is a weakness in the way the management is managing the accommodation, there is a high number of squatters within the institution and as a result it was challenging to estimate the total amount of water consumed by students within the institution.

Data presented is with low reliability as values were from rough estimates given by the university cleaners, gardeners and those working at the experimental farm, as much as given an indication that there is overuse of water in some cases. Therefore, due to inefficiencies there is no certainty in the results. The results show that water consumption in UNIVEN is typical in a university sector, but some universities of a similar size and profile are achieving lower water consumption per person. According to Cole *et al*. (2013) the University of California Santa Barbara faces distinct water challenges due to arid climate, local water sources and the growing campus population and these are similar water challenges faced by UNIVEN. Therefore, the water use behaviour in the UCSB was compared with how UNIVEN population utilise their water resources, the annual water use was 811 707 mega-litres which was far more than the annual water use of an institution with similar parameters, where the water use was 218.5 million gallons (0.2927 mega-litres).

5.4 Institution targets

It is considered that, as a minimum, the target for water management should be to maintain the direction of the water management plan for the next five years. This will require focused effort to reduce water use. Herrmann and Schmida (2000), indicated that 30 – 60% of potable water could be saved annually depending on the catchment area, and Rahman *et al*. (2014), indicated that rainwater harvesting system is cost effective technology. Therefore, if 30% of rainwater is harvested, 30% of the money used for potable water can be decreased. The annual potable water use for UNIVEN in 2017/18 is the baseline while water use by 2020/22 is the benchmark. The most suitable percentage that the institution can set as a target to achieve the recommended target by the University of California Santa Barbara (2013) should not be substantially smaller than the percentage mandated. Therefore, the target for the UNIVEN water use should be for water use to decrease by at least 12% by 2020/22 against 2017 levels (which were 811 707 mega-litres), i.e. the absolute potable water purchased in 2020/21 should be no more than 774 343 mega-litres.

The University of California, Office of the President mandated an all university system-wide reduction in potable water use by 20% by 2020 (Cole *et al.*, 2013). Since UNIVEN has never implemented any water conservation strategies, achieving at least half of the mandated percentage should be the goal. Therefore, the following should be the university goals for the next 5 years;

- Improved maintenance and metering of the water coming from the municipal reservoirs adjacent to the University
- The individual metering of each building which will account for water going into the respective buildings within the institution
- Proper monitoring of the groundwater resources within the institution, as this is an alternative water source and can also assist in reducing the water bill the university pays the water services provider
- Improved pipe burst repair turnaround time within the university campus
- Reduce water consumption by 12%
- Reduce the university water bill by 30%

5.5 Drivers for reducing water consumption

Since the University of Venda shares water from the main source with the nearby villages, the university has the responsibility to minimise the use of this scarce resource. Due to water shortage and high water demand, the University drilled boreholes behind the majority of the buildings on campus. Growing water scarcity increases the need for more efficient water consumption and this starts with consciousness at the individual and institutional level. Water use efficiency can be achieved through better education, behavioural changes and technical efficiency. Behavioural, attitude change, and continued student and staff engagement is important in driving water reduction because it provides a mechanism for continuous improvement. Through behavioural and attitude changes the institutional population will be minimising harm to the environment through adaptation to the implemented plan by the institution therefore economic efficiency, social equity, social development and environmental protection will be met. The University also need to engage the hydrological experts from the Department of Hydrology and Water Resources and Consumption Management.

Water consumption for the University of Worcester for the year 2011/12 was 42 733 m^3 and for the year 2012/13 was 37 547 m^3 and the percentage change between those years was 11% decrease in water consumption (University of Worcester, 2014). Water consumption can also be reduced by water restrictions to a point where penalties apply when rules are not followed, therefore the university population will be aware of the formal restrictions and adopt water-wise habits as part of daily activities. Decreasing water consumption will have an additional financial benefit through reductions in water bills. In the 2017 academic year, the university spent R38 238 920 on water only. If the water consumption is reduced, a portion of that amount can be diverted to departments to ensure proper running of the academic calendar. There is currently no budget for measures to reduce the amount of water that the university purchases.

5.6 Recommended actions to reduce consumption

5.6.1 Rainwater harvesting infrastructure

Rainwater harvesting systems collect a proportion of the water from rainfall onto a building; this water is usually filtered and fed into a tank from where it is used in sanitary fittings and urinals. Water quality of rainwater harvested is an important issue and Gobel *et al*. (2007), assumed that the water harvested is of suitable quality although some microbiological contamination can be present. Odiyo *et al*. (2009) found that in Siloam Village, rainwater was of good quality for domestic uses. Therefore, the quality can be controlled by making sure that the rooftops where rainwater infrastructure is equipped are clean and using screens to protect the water from debris. Rainwater harvesting can be used as a strategy to adapt to climate change and Steffen *et al*. (2013) concluded from their results that rainwater harvesting can reduce storm water runoff volume up to 20% in semiarid regions, and less in regions receiving more rainfall.

The University has no rainwater harvesting systems. Rainwater harvesting can provide a reliable, cheap and good quality alternative water source. Rainwater harvesting also complements groundwater. If each building within the institution was equipped with rainwater harvesting infrastructure 30% of the money used on water can be saved. The Manor Road Building has a system that has been estimated to have the potential of providing approximately 750 m^3 of water per year, representing a saving in water costs of approximately £1 000.

5.6.2 Grey water recycling

Grey water is wastewater generated from activities such as laundry, dishwashing, and bathing, which can be recycled for uses including flushing urinals. Water can be recycled by putting a bowl in a sink while washing hands and vegetables. While showering students can use a bucket to capture the water. A pipe can be connected to a sink and a storage tank so that water used for washing dishes can be stored in a tank.

Swimming pools have filters that must be rinsed periodically, this rinsing process uses a large volume of water that is discharged to drain. However, this water is generally of sufficient quality to be recycled for flushing urinals, and such systems are becoming more and more common in sports Centres. It is estimated that approximately 550 m^3 of rinsing water is generated at the Iffley Road Sports Centre each year, representing a potential saving of £800 per year if this water were recycled (Pike, 2011). Increases in water use efficiency, water infrastructure improvements and significant replacement of potable water with recycled water earned UCSB substantial reductions in potable water use from the Baseline average of annual use of 292.7 million gallons (1996/97) to (1998/99) to the Benchmark average annual use of 218.5 million gallons (2008/09) to (2010/11), (UCSB, 2013).

5.6.3 Introduction of individual building metering

Installation of meters in each building allows the understanding of how a building uses water at each time of the day (this is as opposed to standard meters that can only tell you how much water has been used since the last time the meter was read). Such meters are particularly useful in identifying leaks, as they make water use visible, as well as other irregularities in water use. This is particularly true if the meters are linked into a Building Management System (BMS), which would allow the building's water use to be monitored remotely rather than having to go to the meter to collect the data (Pike, 2011). Cambridge University announced in 2005 that a system such as this in their buildings saves the institution more than £500 000 a year. Overall, between July 2011 and June 2012, over 200 000 gallons of water leaking were detected using a real-time metering system. Savings in the following years would be significantly less, assuming that UCSB repair leaks as they come to their attention (Cole *et al*., 2013).

5.6.4 Introducing new technologies

The installation of new metering technology on all water sub-meters will allow identification of areas with higher water consumption. Detecting and repairing leaks is one of the main components of water conservation. Old or poorly constructed pipelines, inadequate corrosion protection, poorly maintained valves and mechanical damage are some of the factors contributing to leakage. Leak detection has historically assumed that leaks rise to the surface and are visible. In fact, many leaks continue below the surface for long periods of time and remain undetected. With an aggressive leak detection program previously undetected leaks can be detected. The University of Venda recognises that achieving this goal will rely on successful implementation of multiple projects and activities over the next five years. The University of California Santa Barbara introduced new technologies between 1997 and 2008. New faucet aerators, low flush toilets and urinals, showerheads. The institution installed a smart irrigation, artificial turf and xeriscaping and began using recycled water for lawn to decrease potable water use and improve overall water use efficiency and 25% of potable water use was reduced.

5.6.5 Implementation of water wise gardening

Water wise gardening is about using plants that are appropriate to the local climate. It is becoming increasingly popular. A water wise garden includes indigenous plants, ornamental grasses, succulents; drought-resistant vegetation and hard landscaping materials like bark chips, mulch, rocks and gravel. Plants with high and low watering needs should not be planted in the same area. Trees help to reduce evaporation by blocking wind and shading the soil. Water-efficient irrigation and landscaping are ways to save water by choosing different irrigation equipment, different plants, and siting plants differently. They can also be combined with water reuse. Water efficiency must be considered from the initial irrigation system design phase through to installation to ensure optimal performance consistent management and maintenance is also essential (University of Pretoria, 2017). Failure to consider water efficiency from the design phase can result in significant losses in system efficiency from poor management, improper system design, installation, or maintenance.

In addition, simple step to watering wisely using water-efficient technologies can make a big difference in the volume of water used on the University campuses. Micro–irrigation or drip systems are generally more efficient than conventional sprinklers, because they deliver low volumes of water directly to plants roots, minimising losses to wind, runoff, evaporation, or overspray. Drip irrigation systems use 20 to 50% less water than conventional pop-up sprinkler systems and can save up to 115 000 litres per year (University of Pretoria, 2017). Currently, irrigation accounts for only about 1% of total University of California Santa Barbara campus potable water use (Cole *et al*., 2013). UCSB has been proactive in implementing potable water conservation practices and has made great strides in switching from irrigating with potable water to reclaimed water, both have reduced potable water consumption used for irrigation by 80% from the Baseline to the Benchmark.

The following should be implemented within the institution to ensure efficient water utilisation in the institutions landscaping:

5.6.5.1 Watering

Deliver water to the root-zone. Soaker hoses ensure that up to 90% of the water applied to the garden is actually available to your plants. Sprinklers are only 40 to 50% efficient. Drip irrigation and soaker hoses minimise evaporation loss and keep the areas between plants dry, which also helps limit weed growth. Aqua Cones are an economic and effective way to get water directly to the roots of individual plants. The Flat Soaker Hose delivers water slowly and evenly in garden or landscape beds.

5.6.5.2 Use free water

Rainwater is the best choice for plants. It is clear, unchlorinated and free. Use rain barrels or a cistern to collect water from downspouts. A study conducted by Su *et al*. (2009) showed that rainwater water harvesting is also widely used for non-potable water use in many regions of the world, and Noah *et al*. (2011), indicated that total non-potable indoor and outdoor water uses is typically 78.3 % for domestic and 86% for office buildings. This is a good indication for harvesting rainwater because the uses would be very high. A 12 square meter roof surface will yield 111.8 litres of water from 1 mm rain (University of Pretoria, 2017).

5.6.5.3 Plan before planting

By planning the University gardens before it is planted, the division of Landscaping can take advantage of the characteristics of the site, such as sun, shade, wind and soil. It should be planned that plants with similar water needs be grouped together. Furthermore, the division of Landscaping is also considering how the plants will get the water they need. A plant that is satisfied by getting most of the water it needs from natural rainfall requires a lot less maintenance and care. For drought-tolerant perennials, choose varieties that are native to the area (or a region with a similar climate). These plants will have adapted to the climate and soils.

5.6.5.4 Take care of the plants.

Healthy plants need less water, fertilizer and pest controls than stressed plants. By keeping on top of tasks such as weeding, thinning, pruning and monitoring pests' water will be needed less frequently.

5.7 Monitoring, evaluation and reporting,

The facilities manager must constitute a University Water Task Team (UWTT). The team should consist of a representative from the students, university staff, and university management including the facility manager from the maintenance department and chaired by the facilities manager. The task team should be formed so that they plan on how regular observation and recording of activities taking place within the institution such as water wastage, water utilisation and pipe burst can be addressed. The latter will lay the groundwork for successfully implementing efficient water use projects within the university campus. The committee should evaluate how the targets, reduction measures and the projects are implemented and function as suggested. If the intended results are not achieved, it is the task of the committee to examine the implementation process, provide leadership, highlight significant accomplishments and then offer recommendations for improvement.

Routinely gather information on all aspects of the water use reduction projects so that all changes can be observed and dealt with in time and give feedback about the progress of the project including the donors, implementers and the entire university community. The gathered information will be used in making decisions for improving project performances. Taking effective action to reduce the university's water use is difficult without reliable and relevant data. All efforts should be made to ensure that such data is collected robustly. Data should be made available to other departments and facilities managers on the university's website, and its availability should be publicised.

5.8 Contingency Plan

The purpose of this Contingency Plan is to identify actions and procedures that will be used to manage the available water during the occurrence of natural disasters (drought or flood) or municipal water shortage. This will enable UNIVEN to prepare and respond to water supply shortage so that adverse impacts can be minimised.

5.8.1 Water demand reduction

The Water Task Team should ensure that there is a balance between water demand and available water that is supplied during contingencies and water wastage should be minimised. Managing water demand is the key solution during the period of water shortage and this can also be achieved through students and staff adapting to water shortage without doing harm to their health, ecosystem and the environment, since increasing water supply will be impossible during that period. Therefore, water demand and consumption for both staff and students residing on campus and day scholars should be reduced. Due to drought in the year 2018, both students and staff in the University of Cape Town are restricted to consume 50 litres/person/day. Water restrictions can also assist to reduce the demand until when water is available in the sources and the restrictions can last for a short or long period depending on the duration of the drought. Water lost during showering can be captured and used for non-potable purposes, and a bowl can be used to wash dishes and vegetable to avoid wasting water.

5.8.2 Alternative water sources during water shortage periods

During emergencies due to drought or flood including when water is cut from the main line the institution can resort to bottled water or using borehole water which are drilled by the institution for potable purposes. Rainwater harvesting may help in getting through the dry season months. Through adaptation students and staff can simply shift to recycling water and reuse grey water for non-potable water uses.

5.8.3 Water use activities to be prohibited during emergency

- Watering lawns, garden and for agricultural purposes water consumption should be reduced as well
- Filling and topping of the swimming pool with municipal drinking water

- Washing vehicles and paved surfaces, such as streets and sideways with municipal drinking water must be strictly forbidden.

5.8.4 Public education and notification

The more severe the water shortage, the more vigorous the public information campaign needs to be; therefore, the University Water Task Team should consider the following methods to carry out communications to the university staff and students. Communication can be in a form of press release using other local media like radio, television, email, telephone hotline and publication in the newspaper and flyers or posters about the water situation and conservation instruction should be provided.

Chapter 6: Conclusion and Recommendations

6.1 Conclusion

Common water uses within the institution was cooking, drinking, washing, bathing, cleaning of rooms, cleaning and flushing of toilets, cleaning offices, cleaning lecture halls, washing pavements, agricultural purposes, gardening and washing apparatus in laboratories. The demand for piped water in the University of Venda was high and although the supply was unstable due to pipe burst. The institutional water demand was found to be between 415 740 l/d and 577 620 l/d, this implies that the availability of water plays a strong role on how much water each student or staff consider sufficient while the institutional water demand including illegal students varied between 282 2610 l/d and 406 6580 l/d, this indicates that more illegal students on campus increases the institutional water demand. The estimated daily water consumption in UNIVEN was approximately 66 341.9 litres. The monthly water supply for the academic year 2017 ranged from 38 429 mega litres to 118 945 mega litres. During summer and autumn season the institution consumed less litres while during winter and spring season water consumed was more. The reduction in the quantity of water that the institution use for different activities in the dry season is not an indication of their adjustment to water scarcity. Due to lack of water utilisation monitoring, lack of water awareness campaign which can help students and staff change their attitude and behaviour towards water consumption more water was wasted. Water utilisation within the institution was not efficient therefore water was not utilised in a sustainable manner. The water management plan targets to reduce potable water usage by 12% for the next five years and the plan will help improve water data and reduce water wastage.

6.2 Recommendations

- There is currently an absence of policies or of a code of practice on water use within the university, in addition there are no targets that have been set for reducing water consumption. The introduction of such water policies and of a code of practice will create a sense of commitment for sensible water use.
- Currently, there is no one who is responsible for water conservation or environmental issues in general within the university. It is significant that responsibility and accountability for environmental issues, including water conservation, are clearly defined through the appointment of an environmental coordinator.
- The infrastructure of the university is quite old, water leaks can constitute an important water loss. Adopting routine inspection and maintenance of infrastructure related to water could help to reduce water losses from leaks.
- An important limitation of the project was the uncertainty in the location of the meters and that there is no meter which records the outflow as well as missing information. It is of greatest importance that these issues are clarified, in order for the metering data to be truly meaningful, reliable and indicative of water consumption levels and trends.
- Sub-metering of each building and laboratories to closely monitor water consumption and identify water losses. Sub-metering allows for more accurate identification of water uses and therefore, more precise and effective intervention, compared to the meters that correspond to large facilities. Regular monitoring of water use enables us to understand the water usage patterns and detect any abnormalities in water consumption such as leaks and inefficiencies easily.
- Public information and school education are key to highlighting the need and benefits of initiating water demand strategies. Water awareness campaigns within the university with the aim of educating and motivating students and staff on the importance of conserving water and providing specific recommendations on saving water. Flyers, tags and posters should be placed throughout the institution.
- Competitions could also be initiated between university residence halls, rewarding those with the lowest consumption. Staff including laboratory assistances, university cleaners and gardeners, School of Agriculture manager and the laundry manager should also receive education and training on water conservation.

- UNIVEN Finance Department should create a budgetary envelope for measures to reduce the amount of potable water purchased.
- Academic calendar must be considered when computing annual institutional water demand.
- Gardeners should know the crop water requirement to avoid over watering of crops which does not require more water.
- Housing Department should develop a policy which prohibits housing students illegally.
- Proper data keeping at the main administration concerning the university population.

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Appendices

APPENDIX 1: SAMPLE OF STUDENTS QUESTIONNAIRES

<u>Students' questionnaire "A"</u>

SECTION A: PERSONAL DETAILS

NAME OF INTERVIEWER……………….........   SEX…………………….

DEGREE…………….   AGE….…………………

LEVEL…………………………   SCHOOL………………..

1. Where do you stay?

On campus	Off campus

2. If residing on campus, on which residence do you stay?

F3	F4	F5	Lost City Boys	Lost City Girls	Mango Groove	Prefab	Carousel	Bernard Ncube	Riverside

SECTION B: WATER SUPPLY

1. Is the tap inside the residence hall?

Yes	No

2. If no to question 1, how far is the tap from your own residence hall?

20m	30m	40m	50m

If other specify…………………………………………………………………………….......

3. Where does the water from the tap come from?

Municipal water supply	Borehole	I don't know

4. If municipal water supply to question 3, do you get water every day?

Yes	No

5. If no to question 4, how often do you get water?

2days/week	3days/week	4days/week

If other specify…………………………………………………………………………………........

6. Do you use borehole water if municipal water is not supplied?

Yes	No	I don't take notice

7. If no to question 6, where do you get water?

Fetch water off campus	Buy bottled water

If other specify………………………………………………………………………………………

SECTION C: WATER USES

1. What are the common uses of water in your residences?

Drinking	Cooking	Bathing	Cleaning	Laundry	Toilets	All of the above	Other

If other specify…………………………………………………………………………………

2. Do you cook your own meal?

Yes	No

3. If yes to question 2, how many times do you cook per day?

1/day	2/day

If other specify…………………………………………………………………………………….

4. Do you wash your cutlery?

Yes	No

5. If yes to question 4, how do you wash your utensils?

Use running water	Use water in a dish	Other

6. How do you bath?

Shower	Bath using a bucket	Both	Other

7. How many times do you bath per day?

Once per day	Twice per day	Thrice per day

If other, please specify..

8. If you shower to question 6, how long do you take in shower?

5-10 minutes	10-15minutes	15-30minutes

9. Do you turn off the shower while applying soap or shower gel?

Yes	No

10. What do you use when brushing your teeth?

Running water	Glass	Other

If other specify……………………………………………………………………………………

11. If you use running water in question 10, do you turn off the tap while brushing your teeth?

Yes	No	Sometimes

12. How many times do you go to the toilet per day?

Two times	Three times	Four times

If other, please specify...

13. Do you do your own laundry?

Yes	No

14. How often do you do your laundry?

Once week	Twice week

If other specify……………………………………………………………………………….

15. Do you use your main source of water to do laundry?

Yes	No

16. If no to question 15, where do you get the water?

………………………………………………………..…………………………………………

17. How much water do you require for the following uses?

Drinking	Cooking	Laundry	Bathing	Toilets

18. Is the water sufficient for all domestic uses?

Yes	No

19. What is your perception on recycled water?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

20. Do you use grey water?

Yes	No

SECTION D: WATER COLLECTION/STORAGE

1. Do you have a container which stores water in your room?

Yes	No

2. If yes to question 1, what do you use to collect water for use in your room?

5 litres container	20 litres container

If other specify…………………………………………………………………………………….

3. Do you collect water every day?

Yes	No

4. If yes to question 3, how many times do you collect water per day?

1/day	2/day	3/day

If more than 3 times per day specify…………………………………………………………

SECTION E: WATER CONSERVATION

1. Are water leakages common in your residences?

Yes	No

2. If yes to question 1, do you as a student act?

Yes	No

3. If yes to question 2, what do you do as a student?

Report to the block rep	Report to the residence manager	Report to maintenance

If other please specify…………………………………………………………………………..

4. If you report to the maintenance department, how long does it take for them to react?

Within hours	Within days	Within a week	Within a month	More than a month

5. Do you close your tap when there is no water?

Yes	No	Not sure

6. Have you attended any water wise programs here in UNIVEN?

Yes	No

<u>University Employees questionnaire "B"</u> (Cleaners)

SECTION A: PERSONAL DETAILS

NAME OF INTERVIEWEE…………………….................... AGE……………

LEVEL OF EDUCATION………………………....... GENDER………

OCCUPATION…………………………..

SECTION B: WATER USES

1. How often do you wash pavements?

2times/week	3times/week	More than 3times/week

If other specify……………………………………………………………………………..

2. How often do you clean the toilets?

2times/week	3times/week	More than 3times/week

If other specify……………………………………………………………………………..

3. How often do you clean the residences?

2times/week	3times/week	More than 3times/week

If other specify……………………………………………………………………………..

4. How often do you clean the lecture halls?

2times/week	3times/week	More than 3times/week

If other specify……………………………………………………………………………..

5. How many buckets of water do you use per lecture hall?

2 buckets	3 buckets	4 buckets	5 buckets

If other specify..

6. How much water do you require for the following uses?

Washing pavements	Cleaning the toilets	Cleaning the residences	Cleaning the lecture halls

7. Is the water enough for all the uses?

Yes	No

SECTION C: ENVIRONMENTAL KNOWLEDGE

1. Do you think that UNIVEN should use more indigenous plants in campus gardens?

Yes	No

2. Do you know what an alien plant is?

Yes	No

3. Have you noted alien plants in UNIVEN garden?

Yes	No

4. If yes to question 3, what did you do about the alien plant?

……………………………………………………………………………………………………

5. What is your perception on recycled water?

……………………………………………………………………………………………………

6. Do you use grey water?

Yes	No

7. Do you know what water wise is?

Yes	No

8. Have you ever undergone one UNIVEN water wise training?

Yes	No

9. Is there any policy that guides you on how to conserve water?

Yes	No

<u>University Employees questionnaire "C"</u> (Gardeners)

SECTION A: PERSONAL DETAILS

NAME OF INTERVIEWEE…………………….................... AGE……………

LEVEL OF EDUCATION………………………....... GENDER………

OCCUPATION…………………………..

SECTION B: WATER USES

1. How often do you water the garden?

2times/week	3times/week	More than 3 times

2. How do you water the garden?

With horse pipe	With bucket

3. If you use the bucket to water your plants, what is the size of the bucket you use for watering?

5 litres	10 litres

If other specify……………………………………………………………………………...

4. How many buckets do you use each time you water the garden?

10	30

If other specify……………………………………………………………………………...

5. For how long do you water the garden?

1 hour	2 hours	More than 2 hours

6. How much water do you require for gardening?

………………………………………………………………………………………………………

7. Is the water enough for gardening?

Yes	No

SECTION C: ENVIRONMENTAL KNOWLEDGE

1. Do you think that UNIVEN should use more indigenous plants in campus gardens?

Yes	No

2. Do you know what an alien plant is?

Yes	No

3. Have you noted alien plants in UNIVEN garden?

Yes	No

4. If yes to question 3, what did you do about the alien plant?

………………………………………………………………………………………………………

5. What is your perception on recycled water?

………………………………………………………………………………………………………

6. Do you use grey water?

Yes	No

7. Do you know what water wise is?

Yes	No

8. Have you ever undergone one UNIVEN water wise training?

Yes	No

9. Is there any policy that guides you on how to conserve water?

Yes	No

<u>University staff questionnaire “D”</u>

SECTION A: PERSONAL DETAILS

NAME OF INTERVIWEE…………………….. GENDER……………………….

EDUCATION…………………………… AGE………………………

OCCUPATION………………………………

SECTION B: WATER USES

1. Do you drink tap water when in your office?

Yes	No

2. If no to question 1 where do you get your drinking water?

Bring water from home	Drink bottled water

If other, please specify………………………………………………………………………..........

3. When using a tap do you ensure that the tap is properly closed after use?

Yes	No

4. When making tea/coffee do you heat as much water as required/needed?

Yes	No

5. How many times do you go to the toilet per day?

Two times	Three times	Four times

If other, please specify...

6. Do you have any live plants in your office?

Yes	No

7. If yes to question 6, how often are the plants watered?

Once/week	Twice/week	More

8. How much water do you require for the following uses?

Drinking	Making tea	Washing hands	Toilets	Watering plants

9. Is the water sufficient for all office uses?

Yes	No

10. During summer seasons (September-February) do you consume more or less litres of water? Specify………………………………………………………………………………………

………………………………………………………………………………………………

11. If more or less to question 10, justify the rate of consumption

……………………………………………………………………………………………........

....

12. During winter seasons (March-August) do you consume more or less litres of water? Specify……………………………………………………………………………………......

....…

13. If more or less to question 12, justify the rate of consumption

……………………………………………………………………………………………........

....

SECTION B: WATER CONSERVATION ISSUES

1. Are you interested in water issues?

Yes	No

2. Do you know the quality or quantity of water in our country or province?

Yes	No

3. Do you read articles about water issues?

Yes	No

4. Do you watch programs about water issues?

Yes	No

5. Do you know where to find water information?

Yes	No

6. Do you know how much the university spends on water bills per annum?

Yes	No

7. Do you think water conservation is important?

Yes	No

8. If no to question 7, please specify why you think it is not important.

……

……

9. Does the institution have any documentation encouraging water wise conservation?

Yes	No

10. Is there anyone working on water wise programs/ water conservations issues within the institution?

Yes	No

11. Is there any effort to create water awareness for the entire UNIVEN population?

Yes	No

12. If requested, would you volunteer to be a water ambassador for the University?

Yes	No

<u>School of agriculture experimental farm questionnaire "E"</u>

SECTION A: PERSONAL DETAILS

NAME OF INTERVIWEE…………………….. GENDER……………………….

EDUCATION…………………………… AGE………………………

OCCUPATION………………………………

SECTION B: WATER SOURCES

1. What are your sources of water?

Municipal water supply	Borehole	River	Tankers

If other specify……………………………………………………………………………..

2. From the sources above which one is your main source?

……………………………………………………………………………………………..

3. If you're main source is municipal water supply, do you get water every day?

Yes	No

4. If no to question 3, how often do you get water?

2days/week	3days/week	4days/week

If other specify…………………………………………………………………………….

SECTION C: WATER USES

1. What are the common water uses?

Watering plants	Drinking for live stocks

2. Do you have any other uses of water in this school experimental farm beside the ones listed?

Yes	No

3. If yes to question 2, what are those uses?

……

4. Is the water enough for all the uses?

Yes	No

5. How much water do you need for the following?

Watering plants	Drinking of live stocks	Poultry	Piggery

6. Do the livestock drink water from the main source?

Yes	No

If no, please specify……………………………………………………………………………...

7. Do you use the water from your main source to water the plants?

Yes	No

If no, please specify………………………………………...……………………………………...

8. How often do you water plants?

2 times/week	3times/week	More than 3/week

9. What type of irrigation are you using?

Surface	Subsurface textile	Sprinkler	Drip	Centre pivot	Localized	Non-electric (Using buckets)

10. Why did you choose the irrigation method used?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

11. Do you as the school of agriculture experimental farm perceive the need to conserve water?

Yes	No

12. If yes to question 11, what are you currently doing to reduce water usage?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

13. What is your perception on recycled water?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

14. Do you use grey water?

Yes	No

SECTION D: WATER LOSSES

1. Do you have the situation where the distribution pipe burst or breaks?

Yes	No

2. If yes to question 1, do you as the school of agriculture experimental farm take action?

Yes	No

3. If yes to question 2, what do you do as the school of agriculture experimental farm?

Report at maintenance	Report to the municipality

If other specify……………………………………………………………………………………...

4. If you reported at maintenance department, how long does it take for them to react?

Within days	Within a week	Within a month	More than a month

5. Do you close the tap when there is no water?

Yes	No	Not sure

<u>Laboratory technician questionnaire "F"</u>

SECTION A: PERSONAL DETAILS

NAME OF INTERVIEWEE………………........ SEX……………………........

OCCUPATION………....................................... AGE.......................................

SCHOOL………………....................................

SECTION B: WATER SOURCES

1. Do you use municipal water at the laboratory?

Yes	No

2. Do you sometimes use groundwater to supplement municipal water?

Yes	No

3. If no to question 2, if water is not supplied from the main source what do you do?

....

SECTION C: WATER USES

1. How many groups of students do you assist to perform laboratory work?

Three groups per day	Four groups per day	Five groups per day

If other, please specify...

2. What are the common water uses?

Washing equipment's	Rinsing lab dishes	Scientific experiments	Washing hands

3. Do you have other uses beside the one listed above?

Yes	No

4. If yes to question 3, what are those uses?

....

3. How many times do you wash the equipment's used at the laboratory?

....

4. What type of water do you use?

Type 1	Type 2	Type 3

5. Are you supplied with distilled water?

Yes	No

6. If no in question 5, do you filter the water on your own?

Yes	No

7. Do you filter the required amount of water?

Yes	No

8. If no to question 7, what do you do with the remaining water?

....

9. What is the amount of water that you filter?

....

10. How much water do you require to perform laboratory work per group per day?

20 litres	40 litres	60 litres	80 litres

If other, please specify...

11. After performing laboratory work how do you wash your hands?

Running water from the tap	Use a bowl

If other, please specify..

SECTION C: WATER CONSERVATION

1. Do you know what water wise is?

Yes	No

2. Have you undergone one UNIVEN for any water wise training?

Yes	No

3. Does this department have any documentation encouraging water wise conservation?

Yes	No

4. Do you think water conservation is important?

Yes	No

5. If no to question 4, please specify why you think it is not important?

....

6. What is your perception on grey water?

....

7. Do you allow students to reuse water while performing laboratory work?

Yes	No

8. Do you lecture students on efficient water utilisation before performing their laboratory work?

Yes	No	Sometimes

9. Do you remind students to check if the tap is properly closed after use?

Yes	No	Sometimes

10. As a technician what are you currently doing to reduce water usage or wastage at the laboratory?

....

....

SECTION D: WATER LOSSES

1. Do you have the situation where the tap breaks?

Yes	No

2. If yes to question 1, do you as the laboratory technician take action?

Yes	No

3. If yes to question 2, what do you do as the lab technician?

Report at maintenance	Report to the building manager

If other specify……………………………………………………………………………………..

4. If you reported at maintenance department, how long does it take for them to react?

Within days	Within a week	Within a month	More than a month

5. Do you close the tap when there is no water?

Yes	No	Not sure

6. When using tap water do you ensure that the tap is properly closed after use?

Yes	No
