Towards a Green Campus: Assessment of Sustainable Water Use and Management at the Namibia University of Science and Technology Campuses

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I, *Ann Deborah Symonds (Student number 219040338)* hereby declare that the work contained in the thesis entitled: *Towards a Green Campus: Assessment of Sustainable Water Management at the Namibia University of Science and Technology Campuses* is my own original work and that I have not previously in its entirety or in part submitted it at any university or higher education institution for the award of a degree.

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Table of Contents

List of Tables

List of Figures

Acronyms

ACU	Association of Commonwealth Universities
AMI	Advanced Metering Infrastructure
AMR	Automated Meter Reading
CoW	City of Windhoek
DICT	Department of Information and Communications Technology NUST
DVC: A&F	Deputy Vice-Chancellor: Administration and Finance
EESD	Engineering Education for Sustainable Development
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESD	Education for Sustainable Development
GCI	Green Campus Initiative
GIS	Geographic Information Systems
GRN	Government of Namibia
GRTC	Gobabeb Research and Training Centre
GULF	Global University Leaders Forum
GUPES	Global Universities Partnership for Environment and Sustainability
HESD	Higher Education and Research for Sustainable Development
HEI	Higher Education Institutions
HOD	Head of Department
IISD	International Institute for Sustainable Development
ISCN	International Sustainable Campus Network
ITS	Integrated Tertiary System
IUCN	International Union for the Conservation of Nature
IWRMP	Integrated Water Resource Management Plan
MET	Ministry of Environment and Tourism (former name of MEFT)
NRM	Natural Resource Management
NUST	Namibia University of Science and Technology
RMIT	Royal Melbourne Institute of Technology
SD	Sustainable Development
SDG	Sustainable Development Goal
SU	Stellenbosch University
SUFMPS	Stellenbosch University Facilities Management Property Services
UCT	University of Cape Town
ULSF	Association of University Leaders for a Sustainable Future
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNGA	United Nations General Assembly
UNHLPW	United Nations High-Level Panel on Water
WCED	World Commission on Environment and Development
WDM	Water Demand Management
WEF-GULF	World Economic Forum-Global University Leaders Forum
WGBC	World Green Building Council
WMS	Water Management Strategy
WRI	World Resources Institute

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Abstract

The Namibia University of Science and Technology (NUST) was amongst the top 40 water consumers in the drought year of 2019. Currently, the university does not have an Environmental Management Plan (EMP) which allows it to formulate strategies to conserve and manage resources on campus and thus does not yet comply with legislation that requires such Public Sector institutions in Namibia to implement one. A Water Management Strategy (WMS) forms one aspect of an EMP which will assist in the formulation of strategies to conserve and manage environmental resources on campus in the future. This study contributes baseline information towards the development of a WMS which will help the university play its part in addressing the chronic water shortage suffered in Namibia.

To understand the water consumption patterns and associated costs three campuses at NUST in Windhoek were studied. Surveys and interviews were conducted, and reports, observations and water meter readings were collected over a 13-month period. The study served to highlight several areas of concern, where wasteful and inefficient practices were observed. The results show that old and decaying infrastructure, reactive maintenance, poor management, and a lack of monitoring of water use all contributed to the high-water consumption recorded at the Upper and Lower Campuses. This is not only environmentally unsustainable but also results in unnecessary economic costs. In contrast, the heightened awareness and proactive behaviour of staff and students at the Hotel School Campus combined with the implementation of water-saving strategies demonstrated that there are easily implementable mitigation measures where water could be used more efficiently, and consumption reduced.

Qualitative surveys among students and staff indicated an awareness of the drought situation and the need to conserve water. The survey respondents suggested approaches and activities such as implementing water management strategies, educating, and devising techniques and technology to reduce water consumption. To support these findings, changes in management approaches in 2021 such as proactive maintenance and monitoring of consumption and municipal charges by the Facilities Department and at the Hotel School resulted in positive effects, thus suggesting the same action can be implemented across the whole university. Valuable lessons were learned from university initiatives elsewhere, such as target setting, public displays on consumption levels and real-time feedback on targets reached. These, and proactive drought mitigation strategies instigated in other countries and suggestions from key stakeholders, can form recommendations for a WMS to be implemented at NUST.

The findings of this study provide a basis from which to explore and practise the identified key interventions and methods. This will help reduce water consumption, make financial savings, and promote awareness of water issues leading to more environmentally favourable practices. Better water management through the development of a WMS could lead to improved sustainability and help NUST to move towards becoming a greener university for which the survey found good support.

Keywords: Environmental Management Plan, Water Management Strategy, sustainability, water efficiency, greening, environmental impact, Namibia University of Science and Technology.

Chapter 1 : Introduction and literature review

1.1 : Background

According to the UN World Commission on Environment and Development (WCED), 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" (Butlin 1987 p.37, UNESCO 2020). However, there is global pressure on resources and the environment (Arnell 1999) exacerbated by population growth, climate change and the effects of global warming, thus a need to sustainably utilise the resources that we depend on. In recognition of this, the United Nations General Assembly (UNGA) proclaimed the period 2018–28 the International Decade for Action: Water for Sustainable Development (UNHLPW 2018). One of the key tools to ensure sustainability is through the use of an Environmental Impact Assessment (EIA) (Wahaab 2003). This is a tool that can be used by industry, businesses, or other developments to reduce negative impacts on the environment and improve their environmental performance (Baby 2011). To promote the sustainable management of the environment and the use of natural resources Namibia promulgated the Environmental Management Act in Namibia, 2007, (Act No. 7 of 2007) (GRN 2007) which requires an EIA and subsequent EMP. The Plan is developed during the EIA process and describes methods and processes for mitigating and monitoring impacts on the environment (Baby 2011). According to the Act, public sector institutions in Namibia are required to have an Environmental Plan that assesses the environmental impact of an institution and its activities on the surrounding environment.

There are a number of studies (Stoss 1998, Saleh 2011, University of Exeter 2012, Filho *et al*. 2015, Kambura 2019 and Uelmen *et al.* 2020) addressing sustainable development and environmental impact mitigation in the tertiary education sector. Some African universities such as Stellenbosch University (SU) and the University of Cape Town (UCT) for example are spearheading improvements in the sustainable performance and operation of their buildings and establishing water consumption targets (McGibbon and Van Belle, 2015, ISCN 2020). In other universities, like NUST, facility managers have trailed behind in the adoption of green practices and water in most university campuses still does not rank highly in operational sustainability as compared to energy and solid waste (Portalatin *et al*. 2015). In addition, the focus of other studies has been on the role of behavioural aspects of campus environmental sustainability (Petersen *et al*. 2005, Wymer *et al*. 2014, Fu *et al*. 2017, Hunt and Shahab 2021)

In an article from Cape Town on experiences in managing water gained from their drought in 2018, it was announced that "water shortages will become more common in cities around the world during the 21st century due to climate change" (Parks *et al*. 2019). The paper emphasises that the stress on water supplies caused by drought is a global phenomenon and an increase in the human population and urbanisation will worsen the pressure on the existing water supplies that were developed decades ago (Parks *et al*. 2019). Current modelling estimates a significantly increased frequency and severity of drought due to climate change if the rise in average global temperature exceeds 1.5°C above pre-industrial levels or more (Parks *et al*. 2019). Rapid urbanisation had taken place in Cape Town which, combined with the drought in 2017/2018, severely threatened municipal water supplies (Sinclair-Smith and Winter 2018).

Similarly in 2019, the City of Windhoek (CoW) declared a drought in a media release using a drought severity index that a 15% water-saving would become mandatory, (CoW 13.5.2019). Total rainfall for the calendar year of 2019 was 109.6 mm compared to an annual average over the past 13 years of 423.5 mm (Namibia weather 2021), which led to restrictions on the use of water. In the most critical month, July 2019, consumers were using 97% of the available supply and efforts were made by the CoW to raise awareness of the long-term supply of water to the city and its residents. Water tariffs were increased on an incremental scale according to the number of units consumed to discourage heavy use. According to data from the City of Windhoek's Water Demand Management Section, statistics show in March 2019 that NUST was one of the top 40 overall highest consumers in both water units and costs in Windhoek and in the top 25 in June 2019 (D. Tolke personal communication, 3 Oct 2019).

The weekly online dam bulletins from NamWater (13 April 2020) stated that the Windhoek supply dams were filled to 56% of full capacity. At the same time in 2019, the value was 29%. For the central region, the Windhoek water supply dams, Von Bach, Swakoppoort & Omatako were filled to a combined 83% of full capacity. In 2019 at the same time, the capacity was 20%. 2020 was, in recent terms, a good year of good rainfall (measured in a calendar year rather than a rainfall season), however, water demand continues to rise with the growth of the city thus residents cannot become complacent when rains are good. Water needs to be stored as groundwater and aquifers replenished to prepare for years of lower rainfall. The Windhoek average rainfall is quoted as being between 300 and 350mm a year in the Atlas of Namibia (Mendelsohn *et al*. 2002), thus 2013, 2015 and 2019 received below-average rainfall. Between 2008 and 2012 rainfall was higher than it has been between 2015 and 2021 (Figure 1). In order to

accommodate for this lower rainfall water must be banked, but this alone is not sufficient, water conservation behaviour and water demand management must be practised by everyone.

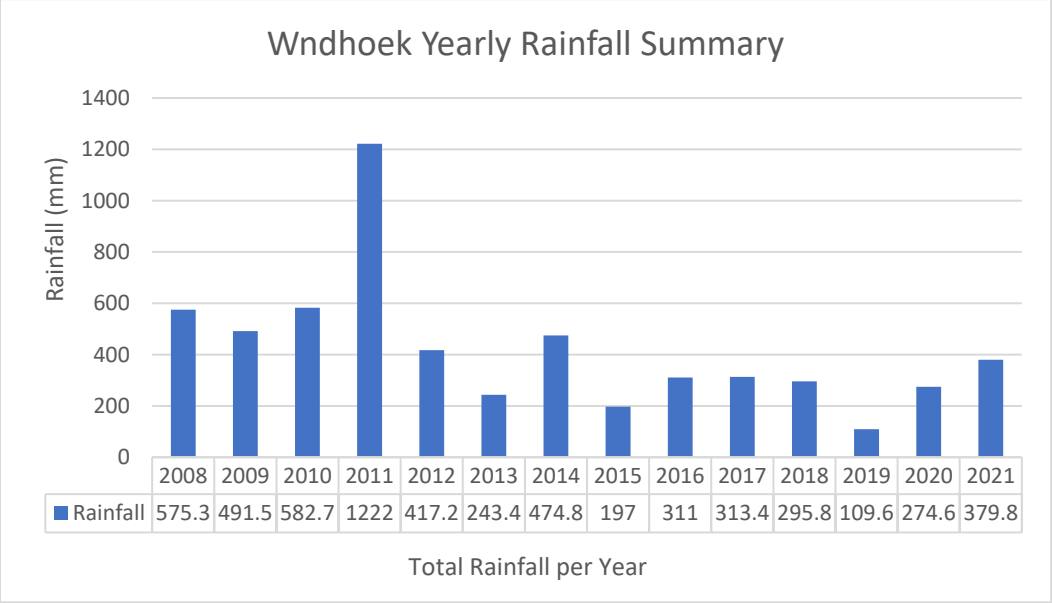

Figure 1: Windhoek Yearly Rainfall Summary

Source: Adapted from *Namibia Weather*, Windhoek, 2021.

Parks *et al*. (2019) recommend that cities and urban populations need to adapt both supply and demand-side planning, as well as existing infrastructure, to accommodate threats to water supplies. Windhoek's supply dams, Von Bach and Swakoppoort were predicted to run dry in May 2021 and April 2022 respectively based on the rainfall and the rate of usage at the time. The CoW was also accessing the 41Mm^3 (million cubic meters) per annum from the underground aquifer, which at the time was 80% full, which, provides a finite water supply. Based on the 2019 rate of abstraction of 10.21Mm^3 from the aquifer it would run dry by 2022. Fortunately, this was prevented in 2020 when better rainfall was received, and the dams and aquifers became naturally recharged and aquifers were partially artificially replenished as D. Tolke explained (personal communication, 22 Oct 2021). Despite the brief period of relief, the increased water use when rainfall is plentiful is unsustainable and national, regional, and institutional strategies to manage and monitor water use are essential.

During the particularly low rainfall year of 2019, the CoW cautioned consumers about the high water consumption. The maximum target water allowance of 482,970m^3 (48Mm^3) was exceeded in all months

between September 2018 and July 2019 except December. Windhoek was moved to Category D and 15% water-savings were enforced as of 1 July 2019 in an attempt to prolong the provision of water to its residents. In the same year, a series of public notice flyers were issued, to educate people and build awareness of the impending water crisis (D. Tolke personal communication, 22 Oct 2021). In January 2020 CoW again noted in its *Weekly Watch* flyer that Windhoek water consumption had exceeded the target use by 10% the previous week and re-emphasised the need to conserve water.

As illustrated above, Windhoek is under pressure from urbanisation and greater demands are being placed on its water supply, infrastructure, and services. There is a tipping point when this threshold is exceeded after which these demands can no longer be met resulting in social consequences such as increases in water tariffs (Eales *et al*. 1996). Therefore, the decline in rainfall, excessive consumption and poor water management in public institutions have influenced the need for a Water Management Strategy (WMS) to be put in place so NUST can play its part in the Windhoek community. Therefore, NUST as a Public Sector institution has to develop and implement an EMP in compliance with the Environmental Management Act.

The NUST campus was constructed in the late 1970s opening as an Academy for Tertiary Education with its first class in 1980. The Environmental Impact Assessment Regulations are part of the Environmental Management Act of 2007 (GRN 2007). The development of the Academy, which transformed over the years first into the Polytechnic of Namibia and more recently into NUST, was before the introduction of EIA's to Africa, thus none was conducted prior to its construction. EIA's are best applied before development, however, an EMP can help to ensure that the environmental and social impacts of the building and its operation are minimised (World Bank 1999). This is true for much of Namibia's infrastructure, developments, mines etc., but notwithstanding the Environmental Management Act of 2007 (GRN 2007) specifies that organs of state and any activities with a potential to have significant impacts on the environment should manage their environmental impacts. Since NUST does not have an EMP and an EIA was not conducted prior to its development, initiating approaches and strategies to mitigate environmental impacts are crucial. This study was conducted to stimulate awareness of the need to develop and implement a full-scale EMP, starting with one of the most important resources, water.

Water is a particularly scarce commodity that is constantly under threat in Namibia, particularly in Windhoek, so helping reduce water consumption at NUST will significantly contribute to it becoming a

"Green Campus" which is defined in 1.1.1 below. Reducing water consumption will in addition to this also lower the associated costs of water for the institution. As one of the most expensive city commodities, the financial savings are likely to be significant. The information and results gathered during the research should guide and contribute to the development of the water management section of an EMP for NUST and in so doing provide steps towards becoming a greener, more environmentally and economically sustainable, reputable and informed university.

1.1.1 : Sustainable development on campus

The WCED Report: *Our Common Future* (Butlin 1987), also known as the *Brundtland Report*, suggests that sustainable global development requires that lifestyles are tailored to fit the planet's ecological means (Butlin 1987). Pressure is exerted on natural resources from rapidly growing populations thus, for ecologically sustainable development to take place investment, technological development and institutional change must be synchronised in order to meet future human needs and requirements (Butlin 1987). The terms green and sustainability are often used interchangeably, however, for the purposes of this study the definition of a Green Campus refers to "a place where environmentally friendly practices and education combine to promote sustainable and eco-friendly practices in the campus" (GCI.2 p.1). Sustainability is taken to be broader and includes three main pillars: economic, environmental, and social aspects, which notedly incorporates education (UN 1993 and SU 2018). Each of these core dimensions relies on the other and is based on a grounding of good governance (Too and Bajracharya 2015) and sound management principles.

The Sustainable Development Goals (SDGs) are a set of 17 globally recognised goals that include new areas such as climate change and disaster risk, economic inequality innovation, and sustainable consumption amongst others (UNDP 2015). SDGs 3, 6, 11, 12 and 15 relating to good health, clean water and sanitation, sustainable cities and communities, responsible consumption and production and life on land are most affected by restricted water supplies. UNDP helps drive the progress of these goals in 170 countries, including Namibia. The Government of Namibia (GRN) has recognised the importance of the SDGs in the Environmental Management Act (GRN 2007) by emphasising the need to use precious resources in a sustainable manner assuring that sustainable development of all aspects of the environment is promoted. The Act (GRN 2007) emphasises the sustainable use of renewable resources and the involvement of all stakeholders in management and decision-making regarding resources (MET 2008). This presumes the

need for individuals, communities, industries and institutions to take responsibility so that quality of life is not compromised in the future.

Universities, like other large institutions, need to comply with sustainable development approaches associated with EIA and SDGs. Strategies such as Water Demand Management (WDM) should be used to increase equitable, efficient, and sustainable use of finite water resources (Gumbo *et al*. 2003). NUST cannot control the provision of water supplies, however, it can attempt to implement the strategy by managing its use to avoid the over-exploitation of the resource. With a learning community of over 12,500 students, the 870+ management, academic, technical and administrative staff at NUST can exert great influence on the sustainable use of water resources which can roll over to the Windhoek community and more widely to Namibia in general. An improved understanding of water utilisation and critical issues related to water consumption at NUST would enable the development of a WMS which will guide water-use reduction and monitoring.

In response to the impending crisis posed by climate change, there have been several initiatives already established elsewhere. The World Economic Forum-Global University Leaders Forum (WEF-GULF) International Sustainable Campus Network (ISCN) is one such initiative (ISCN 2017) which outlines best practices for campus sustainability. Many of their aims overlap with the global SDGs as they aim to develop skill sets within the campuses and encourage innovative research that contributes to social well-being thus making campuses showcases and living laboratories striving towards sustainable development (ISCN 2016).

The ISCN promote operational and management sustainability by ensuring the sustainable performance of buildings, multi-faceted sustainability planning and target setting. They encourage universities to become centres of innovation whilst integrating their research into teaching and liaising with the corporate sector to ensure the required capacities are developed to address future challenges (ISCN 2017). There are opportunities for NUST to improve its operational and management sustainability by ensuring water use in buildings on campus is optimised, strategies set in place and water consumption targets set.

There are only three ISCN member Universities in Africa, Stellenbosch University and the University of Cape Town from South Africa and Covenant University from Nigeria. The Stellenbosch University employed a whole systems approach that optimised water use through strategies focusing on reduction

and reuse for which they gained recognition as ISCN Award finalists in 2020. Their interventions included raising awareness to change behaviours, installation of water-efficient technology, a war on leaks to reduce loss through improving reaction time, investment in water probes in irrigated areas and smart water meters monitoring use in real-time. Existing water supplies were supplemented by rainwater used for cleaning and in laboratories, reuse of filtered grey water in toilets, use of boreholes and capturing groundwater for irrigation. The effect of the optimisation was a 50% reduction in municipal water use at the University (ISCN 2020). The University of Cape Town formed research groups that are engaged in interdisciplinary sustainability through project-based research using the university as a living laboratory ISCN (Rippon 2013). Its new Lecture Theatre building became the first UCT campus building to obtain a four-star green building rating in November 2015 by reducing potable water use, rainwater harvesting, and sub-metering and a Building Management System with a visual display or dashboard that monitors water consumption and the building's performance (ISCN 2015). Covenant University won the 2021 ISCN award in the category of 'Whole System Approach' as part of an initiative to continuously seek sustainable environmental solutions (ISCN 2021). Using different approaches all three universities employ more environmentally efficient and sustainable use of resources. NUST could be the first Namibian University to join ISCN if it initiates sustainable utilisation of water within its campus and other approaches that will put it at the forefront of green institutions in Namibia.

Besides adhering to the SDGs, EIAs and ISCN to build an adaptive water-sensitive University NUST can draw lessons from the drought that occurred in Cape Town in 2018. It can be hard to institutionalise space for learning amid a crisis, so mechanisms must be set up before a crisis to embed learning as part of the organisational culture (Ziervogel 2018). In her *Climate Resilience Briefing Note* Ziervogel (2018) warns that the near miss of ‘Day Zero’ in Cape Town when extreme water restrictions would have been enforced should serve as a warning for other cities as to what climate impacts might look like in future. Several lessons can be drawn from this crisis (Ziervogel 2019) and applied to NUST including a need to improve data to understand the situation, expertise and knowledge to adapt to it, and communication to build awareness, strengthen governance to develop adaptive capacity and adopt a systems approach that integrates all aspects of water management. Whilst the CoW tackles this problem on a municipal scale, NUST can make a significant impact on educating, promoting understanding, encouraging behavioural change, becoming a role model by monitoring, and managing its water demands sustainably and successfully.

A green campus assimilates environmental knowledge into all relevant disciplines. It incorporates environmental courses, provides opportunities for students to study campus and local environmental problems, conducts environmental audits of its practices, and makes environmental sustainability a top priority in, amongst others building planning (Filho *et al*. 2015). Therefore, Filho *et al*. suggest establishing a student environmental centre with students who seek environmentally responsible careers will help educate peers on the need to live and act in an environmentally responsible manner to implement feasible practical interventions in order to improve resource utilisation.

Overall, attaining a sustainable campus requires a strategic approach that is, at present, not in place. This research will provide the institution with an indication of the type of strategies required to initiate this action at NUST and take steps towards being amongst the first green universities in Africa by using the findings to develop an EMP. It will outline actions and innovative responses that will help build resilience and allow savings on water costs that can be reinvested in water-wise initiatives, in the longer term providing greater economic sustainability.

1.1.2 : Sustainable water management

The World Resources Institute (WRI) in 2019 ranks Namibia 20th in the high baseline water stress category which is particularly vulnerable to both increasing temperatures and reduced rainfall linked to climate change (Hofste *et al*. 2019). Being amongst Windhoek's highest water users means the 2019 water consumption levels were unsustainable. For this reason, it is imperative that NUST actively practices water conservation and puts water management and efficiency initiatives into place. In order to be compliant with Namibian's Environmental Management Act (GRN 2007) and demonstrate its commitment to environmental sustainability NUST must take steps towards the development of an EMP and becoming a greener sustainable campus. To achieve this NUST must identify ways in which it can institute better water management practices – addressing leaks promptly; mitigating against the adverse impacts of ageing pipelines and water infrastructure; focusing on water efficiency by installing water-wise technology; raising awareness and changing behaviours and attitudes, so ensuring that the population on campus conform to the new requirements set out in the Act (GRN 2007) and by the municipality through education and awareness initiatives acknowledging positive behavioural change. The successful reduction in water use at NUST involves the 'buy-in' of all those who living or working on the property. Engagement, consultation with and involvement of the management body, students, technical and academic staff are thus an essential component of the WMS. A water-saving initiative was tested at the CoW Bulk Water and

Wastewater Division where water-efficient technology reduced water consumption by 40% and active management resulted in an additional 50% reduction, D. Tolke (personal communication, 3 Oct 2019), A similar approach could have similar results at NUST. Studies, where water management has been put in place, show that engaging in active monitoring and management frees up operational costs that can be reinvested in capital costs such as water-saving infrastructure and improvements to related operational systems (Petersen *et al*. 2005, Silva-Afonso and Pimentel-Rodrigues 2011).

By developing a strategy that combines ways to motivate people to save water and measures to regulate the amount of water used and disposed of, through the minimisation of loss or waste, the preservation of water resources, efficient management, and effective use of water in large institutions such as NUST can have an impact on the overall availability of water for the residents of Windhoek.

1.2 : Problem statement

Namibia has a high baseline water stress induced by population growth, socio-economic development and urbanisation that pose increasing pressure on scarce water resources (Hofste *et al*. 2019), in addition to being one of the most arid countries in the world. It is increasingly challenging for Windhoek, Namibia, to sustain the water-consumption needs of its industries and residents (Lewis *et al*. 2019). Despite the university being one of Windhoek's water consumers in the drought of 2019 according to D. Tolke (personal communication, 3 Oct 2019), and the huge cost of water provision at the university, there are no specific water management and monitoring activities engaged in. The chronic water shortage in Namibia is magnified by a lack of understanding and wasteful practices (Gilley *et al*. 2006). Decision makers are being forced to find new water resource management approaches, the greatest challenge is changing the perception of the value of water and fostering a sense of responsibility towards it (Schachtschneider and Nashipili 2002). There is insufficient knowledge on how NUST can manage water consumption more effectively. The current water consumption levels through the practice of environmentally unsustainable practices and behaviours at NUST need to be identified, assessed, and rectified and a way forward developed to raise awareness among students and staff and to bring about change. Furthermore, NUST is required to be compliant with Namibia's Environmental Management Act (GRN 2007) and demonstrate its commitment to environmental sustainability by reducing its impact on the environment and natural resources. To achieve this, a WMS must form part of an EMP for NUST to identify ways in which it can institute better water management practices and ensure the NUST

population conform to the new requirements set out in the Act (GRN 2007) and by CoW (CoW 2019e). An EMP encompasses all biophysical and human resources (the three pillars of sustainability), but this study aimed to focus specifically on water management, as this seemed to be the most critical aspect and can be a catalyst for a more comprehensive EMP including energy, waste, biodiversity, air and social aspects and a strategy for a green university.

1.3 : Study aims and objectives

The overall aim of the study was to assess water management and behaviours at the Namibian University of Science and Technology to highlight gaps in and potential improvements that can be made to current practices and to propose new innovative but tried and tested approaches to address the that will inform the development of a Water Management Strategy that should be implemented as part of a future Environmental Management Plan.

1.3.1 : Objectives of the study

The specific objectives were to:

1. Assess sustainable and unsustainable approaches, activities and practices in relation to water consumption on the NUST campus.
2. Determine the awareness of and attitudes towards water-related environmental issues at NUST, and support and suggestions for sustainable green campus initiatives.
3. Using examples of best practices, adaptations and interventions make recommendations for the NUST Water Management Strategy and contribute towards becoming a greener campus.

1.4 : Significance of the study

Freshwater supplies are finite. At least 189 countries in the world, amounting to roughly 25% of the world's population, face water scarcity, a situation expected to worsen with climate change (Hofste *et al*. 2019). According to the World Research Institute (WRI) report of 2019, at least 27 countries, including Namibia, use 40 to 80% of their freshwater each year, placing them in the category of high-water stress. As a result, a narrow gap between water supply and demand will leave some countries vulnerable to droughts or increased water withdrawals (Hofste *et al*. 2019). Namibia is also very vulnerable for this reason; hence it is imperative that all Namibians actively practice water conservation.

NUST initiated this study to determine, monitor and reduce environmental impacts on campus and propose ways to improve it through a WMS. The research outlined in this study provides NUST with much of the content of a WMS outlining actions, key interventions and recommendations that will promote the long-term management and sustainable use of water on the University properties and will contribute to the implementation of a tailor-made EMP for the NUST campus in the future. It will involve close collaboration with local water sector stakeholders and the NUST community. The results of the study will be shared with NUST management, all stakeholders, and partners to update them on progress and involve them in selecting best practices that could be replicated and incorporated into the WMS.

The tracking and analysing of typical campus and building water use required a regular presence on campus by the NUST population upon which the average use could be estimated. Since on-site attendance varied during the study period and could not be estimated general trends were observed but per capita consumption estimations were not possible. The study focused on the 13 months from July 2020 after the lockdown eased and some consumption of water had resumed. The assumption made was that the pandemic would affect the entire campus occupancy and attendance rates in the different buildings. Therefore, water consumption was not an indication of general use in non-COVID times but was comparable across the different sites.

The potentially significant impacts identified, better water use practices, interventions, and approaches to reduce water use, change behaviour and attitudes towards water consumption are outlined in this research paper and will be made available to NUST staff and management.

Chapter 2 : Methodology

2.1 : Study area

The study was conducted at the Namibia University of Science and Technology (NUST), located in Windhoek, the capital of Namibia. The university consists of a Lower Campus, a main or Upper Campus and a Hotel School. The Upper Campus (East) has a building area of 35 814m² under roof, the Lower Campus (West) is 49 830m² while the Hotel School site is 3 455m² (Facilities Department 2021). The Erf sizes are 50910m², 36686 m² and 16496 m² respectively, (Facilities Department 2021) and are located in a predominantly residential neighbourhood. The Hotel School is on a separate site with the Hospitality and Tourism faculty and in that sense can be considered a separate self-contained site or campus. In addition to teaching activities, the Hotel School functions as a commercial accommodation and conference facility. The three campuses have one water meter each. All campuses have different populations, staff and student complements, activities and building use. The building composition of each campus is outlined in Figure 2.

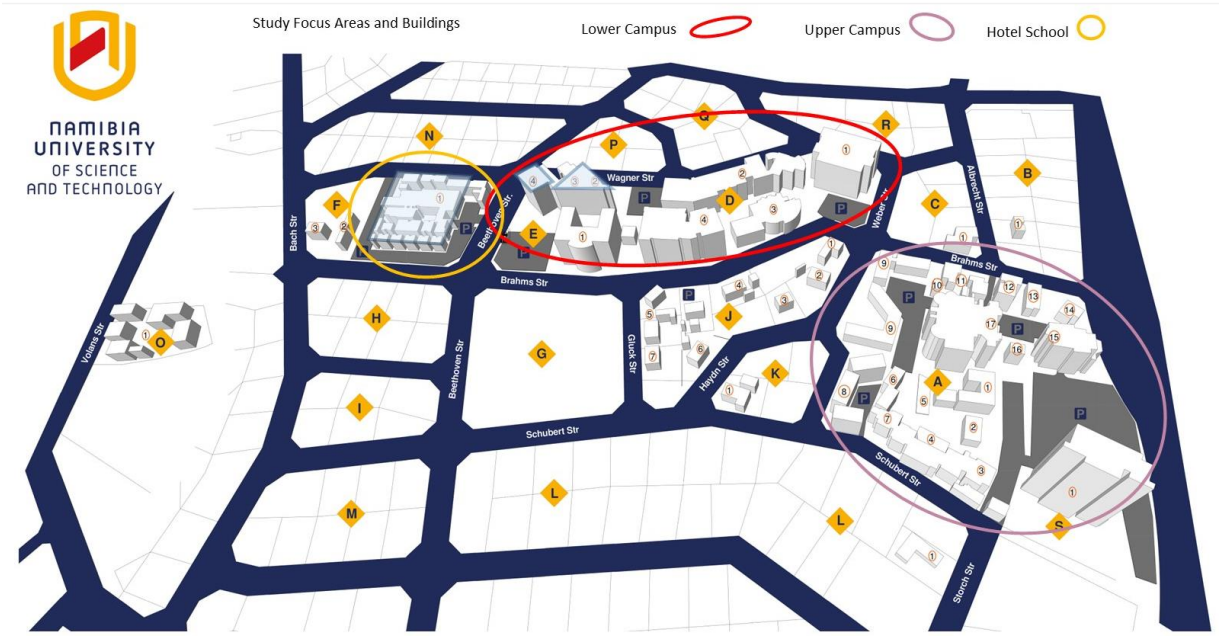

Figure 2: Map of NUST Campus highlighting areas and buildings studied (DVC: A&F. 2021).

There are no water reticulation plans outlining the water supply pipelines for the Upper and Hotel School campuses. The water reticulation pipeline and site plans provided by EMCON for the three new buildings on Lower Campus, Civil Engineering and Mining block (hereinafter referred to as the Engineering building) as well as the Architecture and Spatial Planning block (hereinafter referred to as the Architecture building) and Health and Applied Sciences (hereinafter referred to as the Health building), were examined during this study. The most accessible and suitable location for conducting water reading meters for this study was then determined. The existence of water reticulation plans for the Engineering and Architecture buildings meant these were most suitable for this study. The Engineering and Architecture buildings were constructed in 2012. However, the pipelines entering the Health building, constructed in 2011, were too large (110mm) to have water meters fitted.

General approach

Overall, the study involved an assessment of the general environment and conditions in which the research was taking place through a scoping study. This was carried out at the beginning of the study period to gather information about the study area and its water infrastructure and help identify what the critical water issues were. Consultation and collaboration with key stakeholders at all levels at NUST were considered essential, in line with best practices in environmental management (Sharma and Vredenburg, 1998). Therefore, the Facilities Department and its technical maintenance team, hostel matrons, Department of Information and Communications Technology (DICT) and academic faculty staff were consulted amongst others. Stakeholder consultation during the scoping for environmental impacts is considered a critical step (Clark *et al*. 1980).

Water meter readings were taken on the Upper Campus, Lower Campus and Hotel School, in addition to the Engineering building and Architecture building to ascertain water consumption, more detail is provided later in this chapter. The study involved quantitative methods collecting data from an online survey, existing and historical water consumption data and monitoring water use throughout the day and night over a period of thirteen months.

Qualitative research through an online survey provided insights into attitudes, awareness of and approaches to the water situation in Namibia and NUST specifically. Online surveys have been found a useful tool to gather data in EIAs and EMPs (Kitchin and Thrift 2009). The questions were a combination

of open and closed in order to gather detailed facts as well as more general opinions and attitudes. Qualitative reviews and interpretation of data from the five open questions, observation, semi-structured interviews, and verbal interactions during face-to-face meetings and discussions were used to assess current uses and attitudes towards water management practices. The social awareness survey and water meter readings in combination helped inform an attitude and behavioural assessment. Other aspects that have an impact on water management became apparent as the study progressed. Those that were considered critical such as environmental champions and stewards were investigated further. The overview provided by this study will inform the WMS design, reveal gaps in knowledge and propose recommendations for future studies. Research into sustainable practices at other institutions of higher learning was identified and synthesised to provide insight into key interventions that have been successfully implemented elsewhere and evidence that will guide the adoption of new practices at NUST to lessen the environmental and economic impact of overuse.

This study required working closely with the Director of Facilities and the maintenance team from the Office of the Deputy Vice-Chancellor: Administration and Finance (DVC: A&F). One of the roles of this office is the formulation of policies and procedures and the implementation of and compliance with national laws and the policies applicable to the institution. They are considered responsible for ensuring adherence to the Environmental Management Act (GRN 2007). The Facilities Department falls under the auspices of this Office. The new approaches that have the potential for the greatest impact have been recommended for NUST to initiate. They were discussed to determine which approaches should be implemented in future. These programmes, innovations and adaptations to current practices should be monitored for their impact. Follow-up discussions were held with DICT staff and management of the Facilities Department before drawing them up.

2.2 : Methodology Objective 1:

To assess sustainable activities and unsustainable approaches in relation to water consumption the campus was divided into multiple survey sites to help identify how levels of water consumption varied at the three different sites (Figure 2). To involve the campus in this initiative, at least 12 security guards were trained as water marshals and read the meters twice daily at the Upper, Lower and Hotel School campuses as well as the Architecture and Engineering buildings over the sample period 01 July 2020 to 31 July 2021 four times a day. They recorded information on monthly record sheets (Appendix 1) and provided

additional photographic evidence for leaks, burst pipes and other issues. The main supply line on the three CoW bulk meters were read twice daily once early morning before the campus became populated and early evening after most people had gone home. The difference between the readings taken within 24hrs indicated water units of water used in one 24-hour period. The daily use was aggregated into monthly use and used in the analysis. A pre-metering study period allowed for the monitoring of consumption trends and leaks over a longer period.

Two types of water meters were installed during the course of the study at the Engineering and Architecture buildings. Unlike the CoW main meters which only measure total use for each campus, the two analogue Zenner meters installed for the study were fitted on the pipeline where it entered the buildings. These were household meters that indicate smaller units and required manual reading. They monitored water consumption from 01 July 2020 to 31 January 2021 after which they were replaced by telemetric smart meters, part of a pilot Automated Meter Reading (AMR) system that gave readings at 90-minute intervals. The purpose of installing the smart meters was to compare the accuracy of readings and leak detection between the Zenner and smart meters (Figure 3). The pilot project demonstrated the abilities of the system and helped determine its effectiveness in measuring consumption and detecting excessive use and leaks. Access was given to the Heads of Departments in the buildings and the Director of Facilities to the online Utility Port platform where smart meter readings are uploaded. The two Zenner meters were read four times daily to allow for tracking of overall day and night water utilisation and comparison of water consumption and wastage within each building in proportion to the total use on Lower Campus. Night flow readings indicate leaks present while no other activities are in progress (McKenzie *et al*. 2003). Frequent readings at the two buildings enabled the prompt and accurate detection of water loss.

Figure 3: CoW Lower Campus meter, Zenner meter and Smart meter.

The spatial distribution of water outlets was tabulated in the Health, Engineering and Architecture buildings. Three environmental champions at Health, Engineering and Architecture buildings were involved in inspecting and reporting on leaks using the water audit log sheet (Appendix 2). This helped determine problem areas and hot spots. The log sheets were used to cross-check against water readings and the DICT Integrated Tertiary System (ITS) Service Desk reports. The Service Desk online reporting database, also known as the Help Desk, captures all problem reports and maintenance responses. They were downloaded for analysis. The Service Desk system was assessed, and the system was evaluated for its functionality and water leak reporting mechanism to allow recommendations for improvements in the WMS. The response mechanism to water leakage reports and response times was analysed.

This Service Desk data also provided an indication of behaviour (use) and attitudes (willingness to report leaks on the log sheets and the DICT online reporting system and urgency expressed in the need for maintenance). The level of concern or urgency expressed in reports and awareness indicated through repeated reporting of an issue was noted.

In addition to the meter readings, monthly municipal utility bills were collected from 2015 to 2021 and data studied by Kambaru (2019). The bills were used to identify any trends; increases or decreases in consumption levels and peak usages. The billings were juxtaposed with the detailed manual readings to give insights into some peak uses and losses. Hence, this information provided a long-term perspective on consumption compared to the meters. Additionally, high user statistics were collected from CoW to gain an idea of where NUST lies in terms of the top water users in 2019. Water loss data was extracted using the two systems, the water audit log sheets given to staff members and the Service Desk reports Both systems provided enough information to make a comparative analysis of; leaks and problem areas reported, maintenance response rates, and awareness of users (via repeated reports).

An investigation was made into whether there were maximum targets set for water use, any active monitoring of water consumption taking place and any repercussions for incurring excessive water use. An exploration of the mitigating actions taken to prevent water loss and methods used to cross-check consumption with payments was carried out.

After collecting the data from the municipal bills, water audit log sheets and DICT online reporting database the information was cleaned and sorted before analysis. The data validation process included; removing irrelevant comments from the logs, noting behaviours that affected data recording, converting data from manual and CoW invoice readings to Excel sheets, removing incorrectly recorded digits,

scrutinising readings above 25,000kl or non-existing numbers, combining night and day data and incorporating observations and photographic evidence. Quantitative data was analysed in Excel 2016, R Studio 2021.09.1+372 statistical software, descriptive statistical analysis and a pairwise correlation was done using Stata 16. Basic descriptive analysis was used to analyse the data in Excel and information was presented by means of graphs and tables. The primary purpose of the data was to enable management to understand the implications and use for water resource management and monitoring in the future. The interpretation of the data will serve as a baseline for monitoring and help determine the impact of mitigation measures once implemented in a WMS.

2.3 : Methodology Objective 2:

To assess the awareness of attitudes towards water-related environmental issues at NUST, a cross-sectional study was performed using an online survey. Additional questions were asked to gauge the support and suggestions for sustainable green campus initiatives at NUST.

An online questionnaire with both closed and open-ended questions was created using Google Forms and made available using an online link in May and June 2020, (Appendix 3). The target population was the NUST management, administrative, academic staff, and students, hence the online survey link was posted on the NUST and BRC Social Media sites. The survey was sent out twice to gain as many responses as possible to ensure the sample was representative during the COVID-19 lockdown. Unfortunately, the Covid-19 circumstances reduced the student sample size, a factor for which this study could not compensate. A convenience sampling method was used. It was assumed that this type of non-probability sampling procedure would provide sufficient information for the derivation of management propositions for this study.

Numeric summary tables were extracted from Google Forms and compiled in an excel sheet. Descriptive statistics were used to find the frequency of responses and the results were presented in graphical formats. The five qualitative open-ended descriptive questions were sorted into various categories according to their content and were also presented in graphic format.

The survey was also used to compare participant attitudes and awareness of current sustainable and unsustainable water use practices. Notable connections between wise or wasteful water use ascertained from the water consumption data and attitudes displayed in the survey, DICT problem reports, or visual

observations and behavioural practices were used in this assessment. Some of the indicative practices included a commitment to communicate faults by individuals, responsibility displayed in reporting problems, poor display of commitment (e.g., leaving taps on, not reporting water leaks), personal commitment to promoting water awareness, perceptions and understanding of the long-term water situation, management engagement (willingness to act) in water-related reports and readiness to engage in the development of innovative technology and sustainable education. Follow-up site visits and informal meetings were held with NUST community members to confirm and clarify information.

The Integrated Water Resources Management Plan for Namibia (IWRMP) recognises that the involvement of stakeholders in identifying mitigation measures as a solution to long-term resource security is essential (IWRM 2010) and forms part of best practice in Integrated Environmental Management thus in addition to the online survey, five semi-structured telephonic interviews were conducted with potential partner organisations, as well as informal meetings with twelve NUST employees and thirteen key stakeholders. The stakeholders are involved with water-wise technology, green thinking, and sustainable practices in Namibia. Suggestions made to make NUST more water-wise and environmentally and economically sustainable were captured. Direct observations were captured as recommended for water audits and EIAs (Fisher and Stoughton 2005).

2.4 : Methodology Objective 3:

To determine the most effective water practices, adaptations and interventions that could be included in the WMS and the initiation of green campuses, comparative studies were consulted. Recommendations for the content and approaches to be included in an integrated WMS and subsequent EMP were compiled. Activities and greener, more sustainable practices, used in tertiary institutions elsewhere were evaluated for their ability to lessen the negative environmental, and subsequent economic impacts experienced at NUST from the overuse of water. A meta-synthesis of information on these best practices was conducted using literature, articles and successful greening initiatives and campaigns. Successful awareness-raising, behaviour-changing, water-saving initiatives and communication principles pertinent to a university were captured from the discussions for consideration when drawing up a WMS.

2.5: Assumptions and Limitations

- A definition of sustainability was not given in the survey to contextualise comments and questions. Interpretation of that and awareness and knowledge of a subject are subjective and can vary greatly between people, therefore a deeper level of enquiry is required to ascertain actual knowledge.
- A self-selection bias may have created a bias in the sampling process as people may have been more inclined to respond to the survey if they were environmentally conscious or empathised with the subject of the study. Defining a target population more specifically to departments would filter out these bias-creating characteristics.
- Systems failure, such as the expiration of the Services Desk system licenses during the sample period, prevented leakage and damage reports from being collected and analysed.
- CoW billing months do not exactly coincide with calendar months, and varied according to when CoW read the meter, thus data for one month using different metering methods was not precisely the same period.
- Inconsistent readings by the meter readers (water marshals) and human errors resulted in some inconsistencies in the data collection. Attendance of a training programme for water marshals would have been beneficial to reduce this.
- Broken and faulty meters and missing CoW invoices led to gaps in the data sets on occasion.
- Towards the end of the study period, it became apparent that the fire pipelines were also used daily and had a separate meter. CoW charged for two meters at each site, however, only one was read by the water marshals thus the manual meter reading data collected was not the total use but only an indication of trends in use rather than total consumption.
- COVID-19 and the different timetables adopted as a result, plus the combination of online and face-to-face teaching meant occupancy of buildings was difficult to gauge which influences the overall water usage. Exact occupancy data could be drawn from the sign-in sheets employed at some buildings for some of the time, however, this system used for track and trace was not permanently in place and was not used for entry onto the campus but only the faculty buildings. Conducting the study during a non-pandemic year would have provided more accurate occupancy data.

Chapter 3 : Results

3.1 : Results Objective 1:

To assess environmentally sustainable and unsustainable practices and activities in relation to water use on the NUST campus activities were clustered into four groups namely: existing water infrastructure audits, water consumption trends, sustainable water practices and strategies, and unsustainable practices requiring mitigation.

3.1.1 : Water Infrastructure Audits

Overall, the results revealed the following regarding the existing water infrastructure; a lack of reticulation plans indicating main distribution pipes for the three campuses; existing internal water meters on campus were all out of order; no water meters for separate buildings/floors; no offtake isolation valves; no possibility to isolate or retrofit meters on supply lines to heavy consumers; no standardisation in pipeline diameters and fittings; and water inefficient sanitary fixtures in all lavatories except those constructed after 2011. However, improved efficiency sanitary appliances in newer buildings still do not comply with CoW recommendations for reduced cistern capacity and low-flow taps. Only the lecture building was fitted with water-efficient technology as part of a Pearl Water pilot study with waterless urinals, low-flow taps with aerators and toilets blocks in the cistern to reduce the volume of the flush. The Hotel School had devised water-saving equipment of their own such as bricks in toilet cisterns and buckets collecting shower water offtake.

According to the water infrastructure audit results the Health building had more than 250% more water outlets than the Engineering building and 500% more than the Architecture building. These outlets include toilets, sinks, water fountains and external water dispensers for all the buildings. While the Health building has laboratories and extra floors which are not found in the other buildings. The bulk water meter infrastructure allowed for general comparison and proportional use by campus, but specific consumption could only be tracked in the two buildings fitted with new meters.

The audits also showed that basic water tariffs increase with the diameter of the offtake pipe from N$124.37 (20mm) to N$18,713.84/month (>80mm). All CoW meters are combination meters which combine fire and non-domestic use. Basic water tariffs are charged in addition to the water consumption

at the business rate. Upper Campus has a combination meter of 40mm and 150mm, Lower Campus of 20mm and 100mm, and Hotel School of 50mm and 100mm. Fire meters used only in emergencies are charged N$2100.00/month. Any meter >80mm in regular use carries the highest basic monthly municipal basic water tariff of N$18,713.84. Thus, when the water meter is combined with fire meter the basic charges increase up to N$16,613.84/month on each meter (CoW 2019d). This is an annual cost of N$199,366.08 for one meter. Splitting the three municipal meters would reduce monthly basic water tariffs by N$598,098.24 annually overall. (Appendix 4). The Upper and Lower Campus fire meters were being used for general daily use, however, though fitted with a combination meter the Hotel School had isolated their fire meter supply line so it could not be used.

3.1.2 : Water meters

The main meter at Lower Campus was faulty for over 21 months before being replaced in June 2020, then again for 6 weeks before the study, and stuck twice during the study. The Hotel School meter was also broken prior to the study from 2015 until it was replaced in November 2018.

The broken water meters confirm that water consumption is not monitored or metered, and unit readings are not cross-checked with municipal utility bills. The CoW did not always read the meters every month thus municipal bills contained a zero reading for some months with charges including interest on arrears incorporated into the following months' statement. Charges are levied for meters that are stuck and not reported. As a result, a faulty meter was not detected incurring Interim and stuck charges of N$1.5 million levied by CoW whilst estimates of usage were also made. These were paid without apparent questioning or attention to the cause. The lack of monitoring was also borne out by monthly tariffs and interest charges paid varied between N$517 and N$16,529 in 2019/2020 on Lower Campus. No quotas or maximum water use targets were set and there is no follow-up on overconsumption.

3.1.3 : Water infrastructure management

Based on the information provided by the DICT Service Desk, part of NUST's central administrative ITS, there were 628 records of plumbing problems and water maintenance issues reported between 1 January to 31 December 2020 (Figure 4).

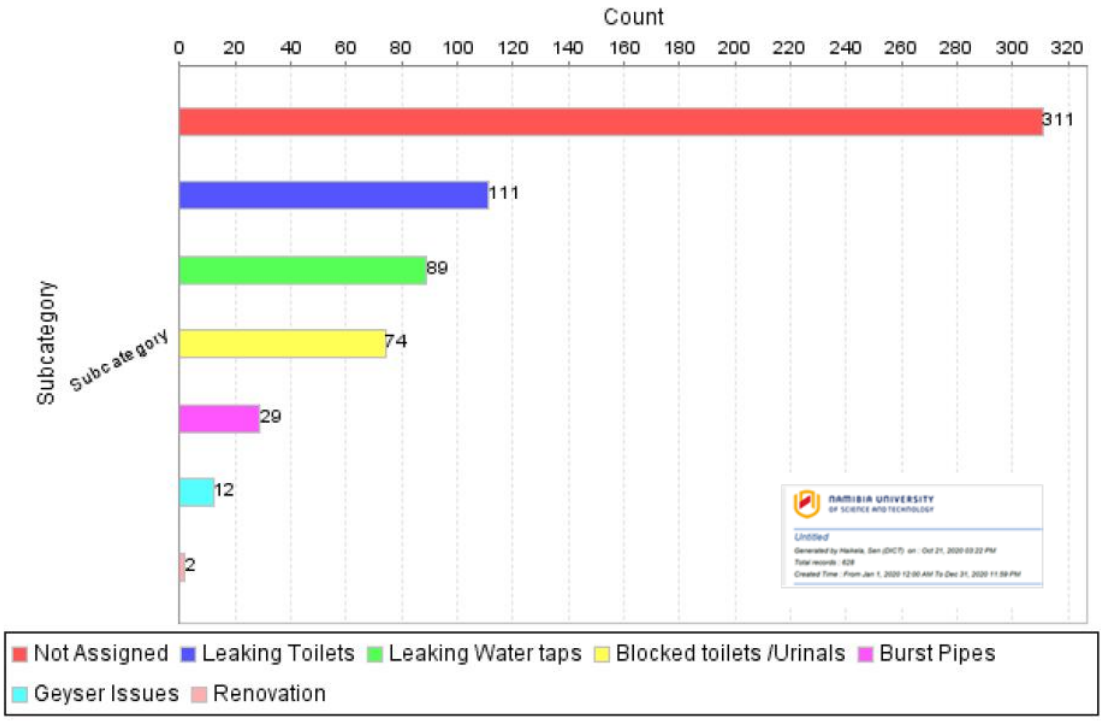

Figure 4: Plumbing problems reported on the DICT Service Desk system (DICT 2021).

Of the 628 plumbing problems 311 could not be assigned to a sub-category as they were incorrectly or incompletely captured due to a system design fault thus the type of problem could not easily be defined or categorised. Manual sorting of the narrative descriptions enabled more accurate classification. The analysis revealed which hot spots that are priority areas for repairs and maintenance.

3.1.4 : Problem areas and hot spots

A total of 1600 plumbing problems were recorded in 38 months between January 2017 and February 2020, as extracted from archived reports. This was an average of just less than 10 plumbing problems a week. Between January 2020 and December 2020, 624 problems were reported, an average of 12 a week, thus indicating that the number of maintenance issues increased by an average of 20% on a weekly basis in 2020.

Figure 5 shows 27% of the total plumbing issues reported were related to water infrastructure in the hostels. Showers were 240% more prone to problems than burst pipes which were the next most frequent problem. On average there were 11 problems with the showers every month and 1 burst pipe a week.

Burst pipes frequently occurred in January when the water was used heavily, releasing built-up pressure after a period of low use during the holiday (L. Liebenberg, personal communication, 27 Oct 2021).

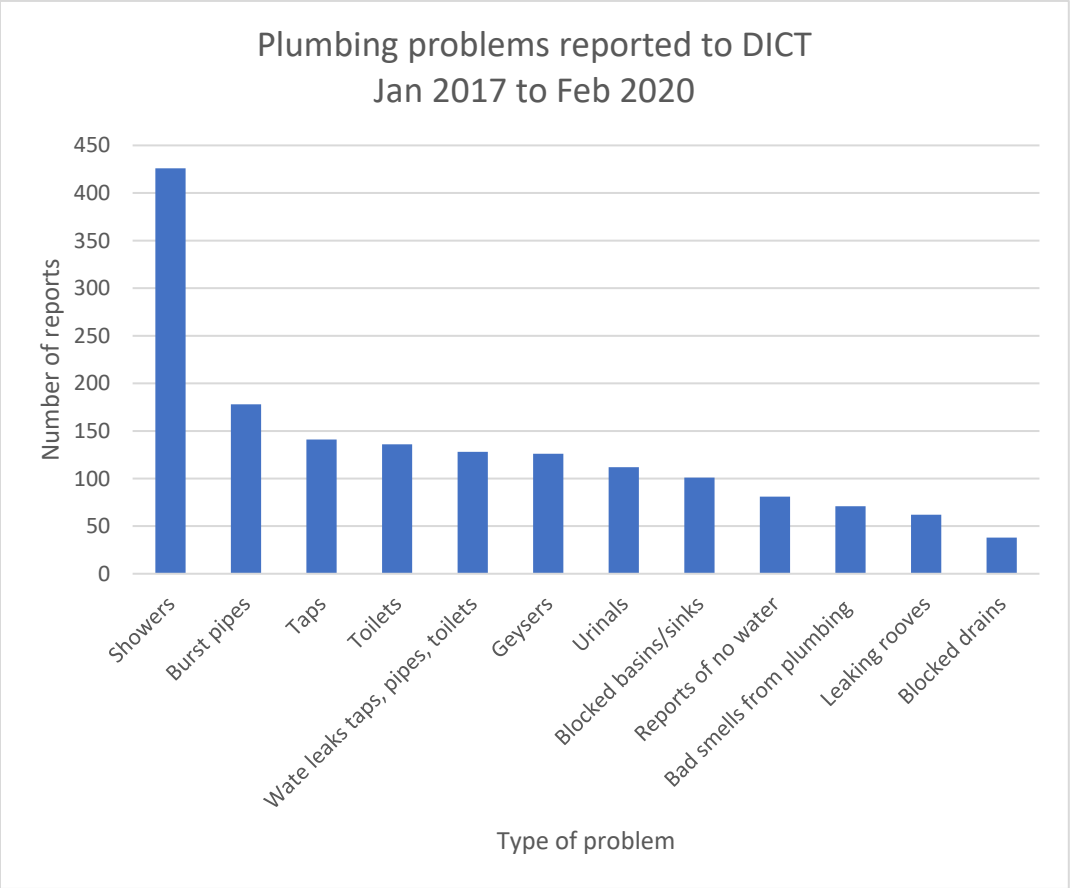

Figure 5: Nature and frequency of plumbing problems reported on the DICT Service desk system.

The frequency of problems (Figure 5) indicates the hot spots where maintenance and renovation were not given enough attention or infrastructure was ageing.

According to the results, most plumbing problems occurred in the Shangri La Men's Hostel with 769 reports, followed by the Science and Technology building with 532 reports and the Library and Information Services, having 522 problem reports. These three buildings constitute just over 50% of all the plumbing problems reported (Figure 6).

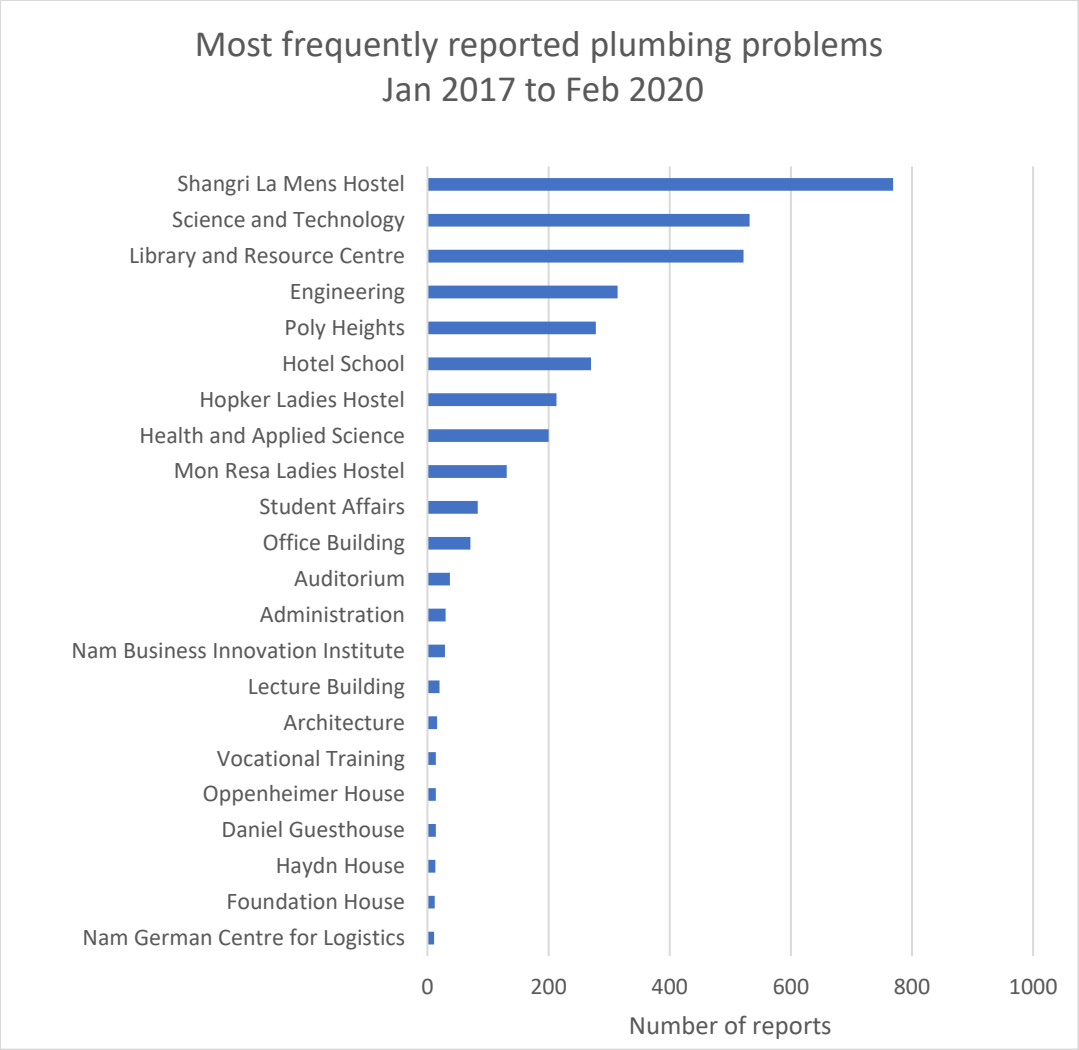

Figure 6: Plumbing problems at NUST reported over 3 years.

Several periods were noted when the leaks carried on for over a week and were photographed (Figure 7). They occurred in April 2020 and went unattended for several days, in some cases.

Figure 7: Examples of leaks detected during the April 2020 lockdown.

3.1.5 : Water consumption trends

The statistical analysis and pairwise correlation comparison (Table 1 and 2 respectively) between time and the three campuses and the two buildings for proportional contrast produced the following results to analyse the upward or downward trends in five locations.

Table 1: Descriptive statistics for all five study sites.

Descriptive Statistics

Variable	Obs Months	Mean (kl)	Std. Dev. (kl)	Min (kl)	Max (kl)
Lower Campus	13	1555.462	1739.146	394	7175
Upper Campus	13	1109.231	723.331	452	3160
Hotel School	13	529.077	233.589	37	796
Engineering	13	62.139	30.343	7.79	111.948
Architecture	13	33.754	18.502	6.387	75.702

Table 2 details that the Lower Campus has the highest consumption rate but also the highest variation in consumption compared to Upper Campus. Lower Campus has a high standard deviation. The lowest consumption per site is Architecture, however, that is a building rather than a campus. Campus recordings are inevitably higher than individual buildings, but this description of the data does not serve to compare the campus and buildings to each other but rather look at consumption trends and variance.

Table 2: Pairwise correlation comparison of five metered sites using two variables, location, and time.

Pairwise correlations

Variables	(Month)
(1) Month	1.000
(2) Lower Campus	0.043
(3) Upper Campus	-0.308
(4) Hotel School	0.714
(5) Engineering	-0.492
(6) Architecture	-0.315

Table 2 indicates that the Hotel School had, on average, the strongest increase in water consumption (r= 0.714) whilst the Engineering building had the strongest decrease on average over time (r= -0.492). The Upper Campus showed, on average, a moderate decline in water consumption over the sample period (r=-0.308). The Architecture building displayed a similarly moderate decrease in water consumption (r=-0.315). The Lower Campus had a small increase in water consumption (r= 0.043).

Both the Engineering and Architecture buildings are located on the Lower Campus. Interestingly, despite both their moderate declines in water consumption, r=-0.492 and r=-0.315 respectively, the Lower Campus displays an overall increase in water consumption over time. This suggests that other non-metered buildings on the Lower Campus, not specified in this study, may potentially be experiencing, on average, significant rises in water consumption. As seen in Table 2, most of the water usage does not stem from these two buildings but could rather result from the building(s) unspecified in this study.

The average trend on Upper Campus is influenced by the two peaks in October 2020 and February 2021. Fluctuating residence in the hostels and Poly Heights accommodation resulted in irregular usage patterns.

3.1.6 : Comparison of campus consumption

The monthly comparisons taken from CoW readings (Figure 8) show how the unusually high consumption is not the norm for the Lower Campus which is generally below Upper Campus consumption rates. The zero values do not represent zero water use, but that no readings were taken that month and the CoW issued an invoice with a zero value, or no invoice was available.

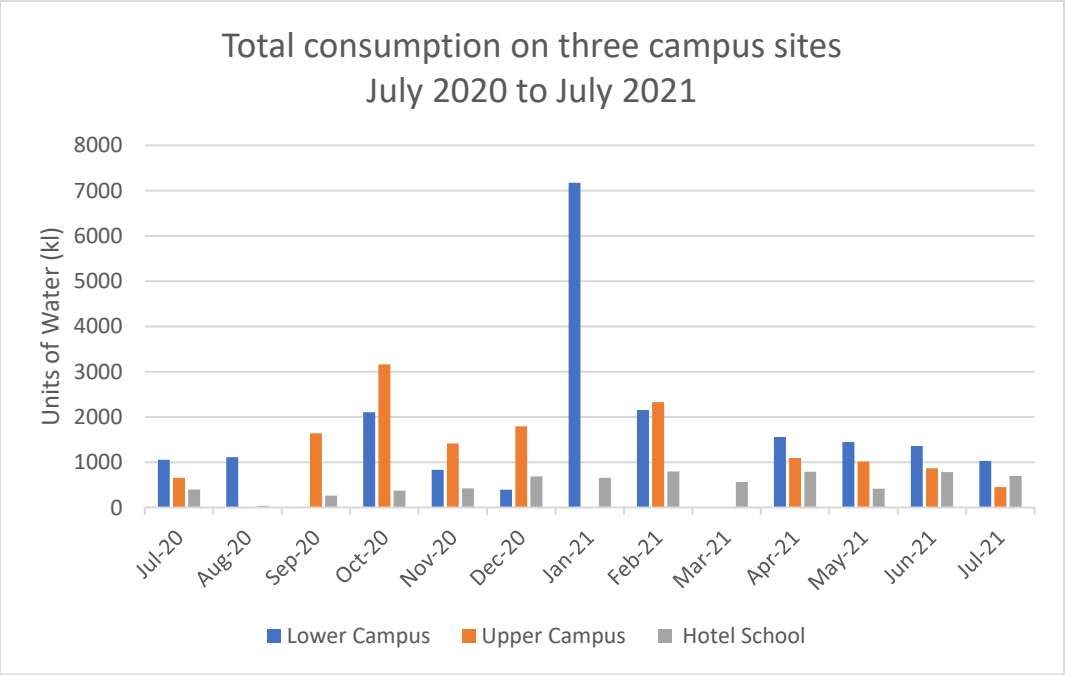

Figure 8: Proportionate monthly use of water on main campuses using CoW readings.

In the latter half of 2020 and early 2021 Upper Campus largely had the highest monthly consumption rates however, it dropped in 2021 when the hostels and Poly Height residences were predominantly empty. In seven of the thirteen months, Lower Campus had higher use possibly because of leaks going undetected and not resolved. October 2020 and February 2021 were higher than normal consumption months.

According to the daily manual readings at the three campuses (Figure 9), the Upper Campus had the overall highest daily consumption with readings for the 13 months ranging between 42.99kl and 125.8kl, followed by Lower Campus and the Hotel School. The Lower Campus had the most irregular consumption pattern. Readings indicate spikes in use between July 2020 and July 2021.

Despite the Hotel School having 20 guest rooms, two kitchens, and a small laundry consuming more water, as well as training rooms, conference facilities and offices the highest daily reading was 123kl/day in July 2021, a time when the occupancy had picked up following the end of Covid-19 lockdowns. Five of the highest readings at the Hotel School were in July and seven during the holidays between December 2020 and January 2021. This was due to a pipe that burst on 25 December 2020 that was not fixed for 10 days (personal observation) since there was no presence of staff on campus during this time.

Daily (07h30) and nightly (16h30) manual readings were totalled for the Upper, Lower and Hotel School Campuses to give 24-hr readings (Figure 9). The results of the daily metering indicated times of apparent zero use and spikes caused by stuck or faulty meters and leaks respectively.

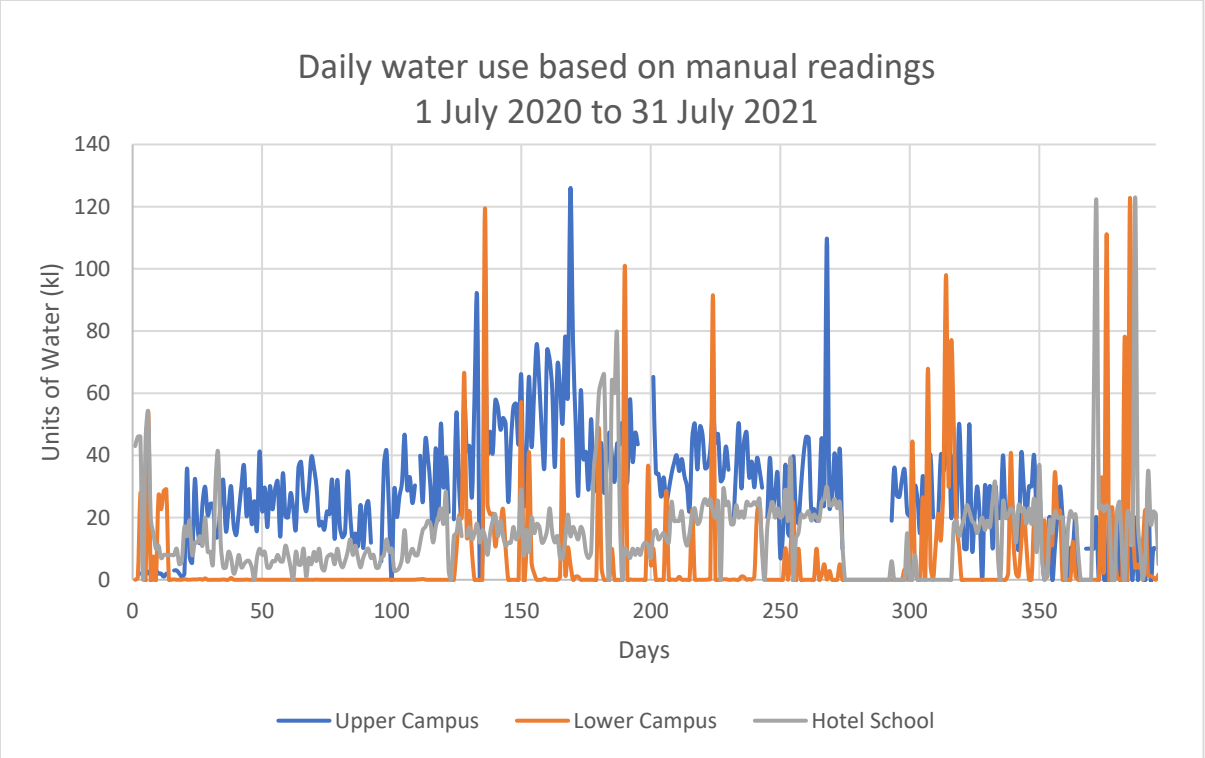

Figure 9: Overall daily water consumption indicating excessive water use over the study period.

3.1.7 : Comparing metering methods

A comparison was made between the manual readings taken by the water marshals and the CoW monthly utility bills. CoW indicate two meters for each campus on their monthly invoices. Though some of the variances between the readings can be explained by the varying dates readings were taken by CoW, there were also gaps in readings and misreadings. The units consumed in all campuses, compiled from all data sources, show inconsistencies in manual and CoW readings that are not read regularly, subject to human error such as misreadings or improper data entry, affected by rain, such as reluctance to get wet and the manhole filling with water, and faulty meters. As a result, CoW invoices do not always correlate with manual readings. The mistakes made in readings altered the apparent consumption. The comparison illustrated the benefits of having a second source of more reliable readings for more accurate analysis.

The automated smart meters were programmed to take readings at 90-minute intervals and compiled digitally and downloaded in an excel format. The readings were automatically graphed showing current trends of water use compared to the previous period, the period of the same length immediately

preceding the one displayed. This aided the monitoring of spikes in use and highlighted times of peak consumption. (Figure 10).

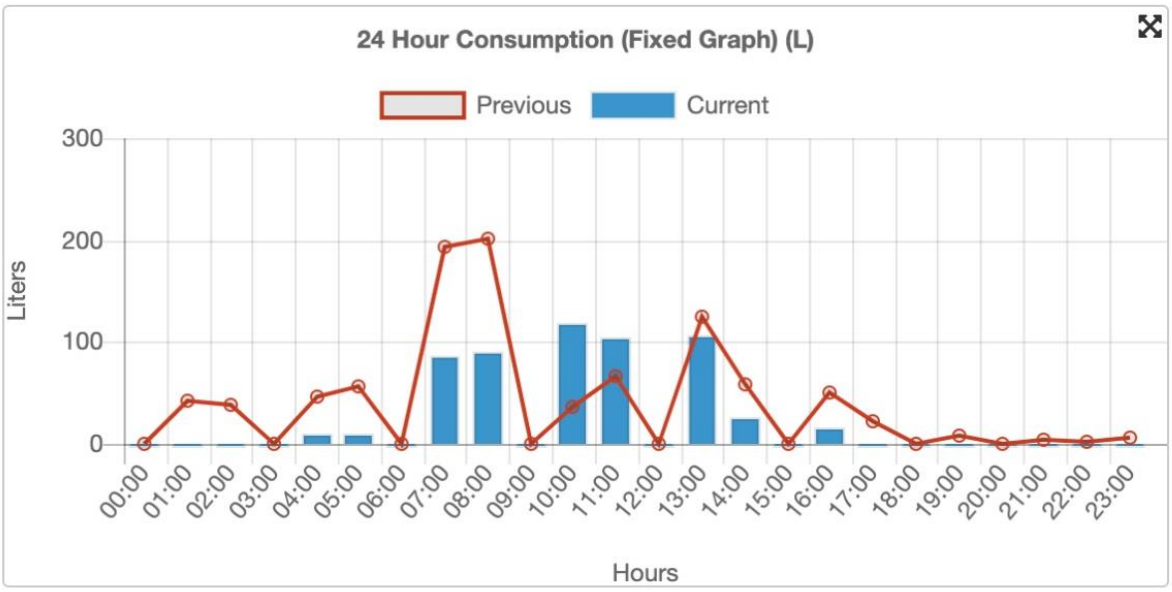

Figure 10: Smart meter data showing water use in the Engineering Building on 8 July 2021.

The online dashboard enables daily, weekly, and monthly comparison of consumption to show trends in increasing or decreasing consumption, (Figures 11 and 12).

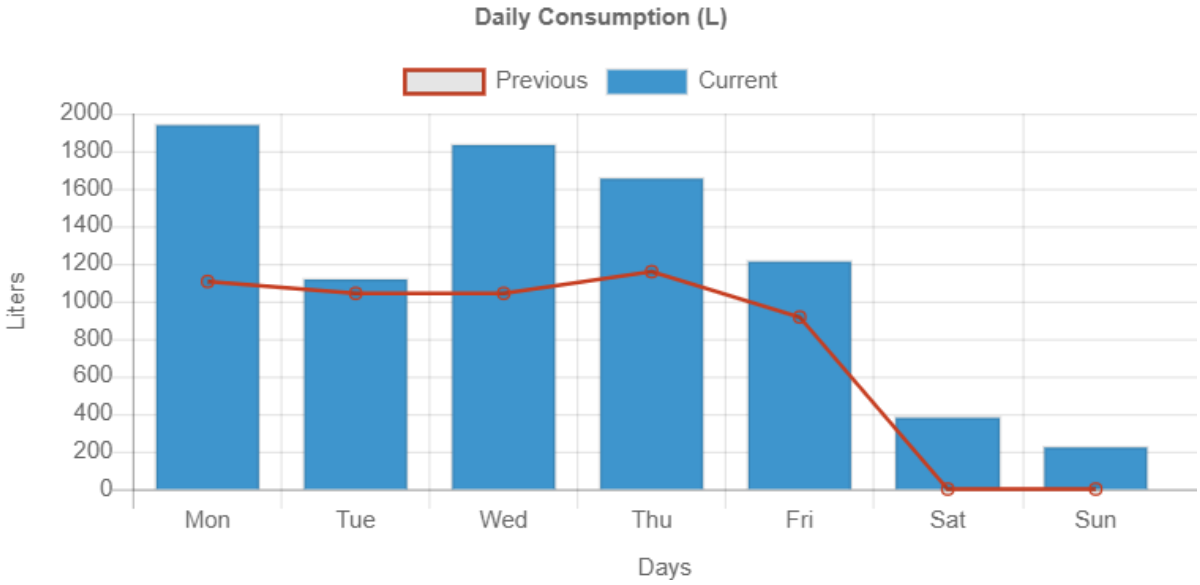

Figure 11: Water consumption at the Architecture Building 21 to 27 March 2021.

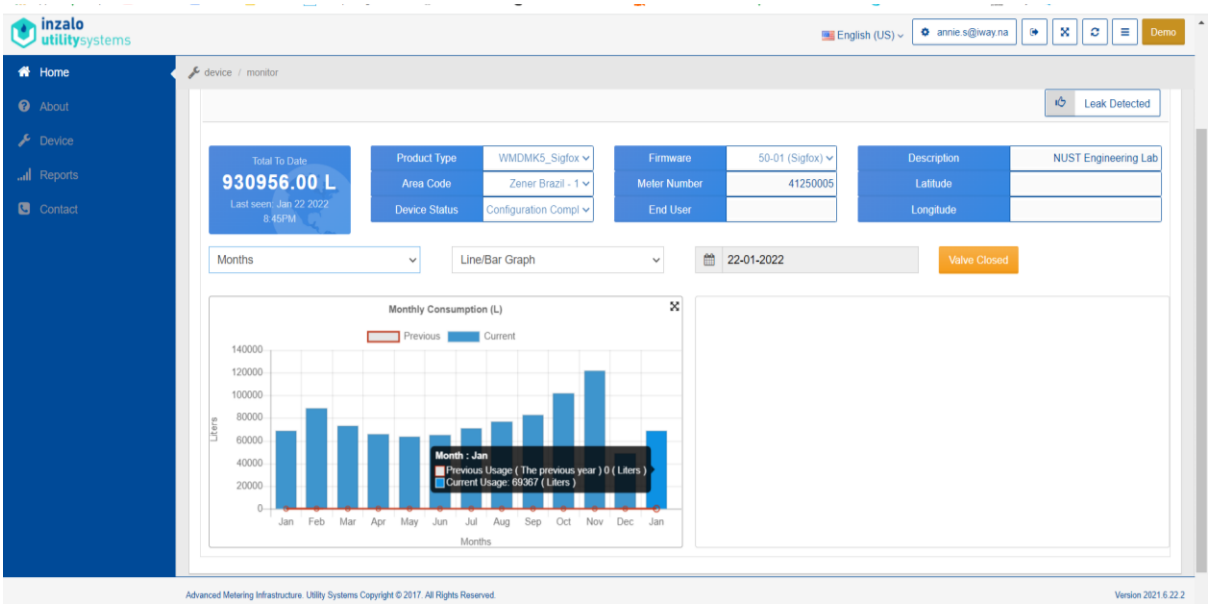

Figure 12: Smart Meter Utility Port live dashboard indicating monthly usage in the Engineering building.

3.1.8 : Comparison of sites

The Hotel School, being physically separate and self-contained, operates like a small campus. The consumption at this mini campus was compared with the Upper and Lower Campuses. The units from the same meter that was read manually were captured and labelled as CoW readings with the meter number, and the total of the two combination meters read by COW is recorded as the total kl units consumed which gave the balance of consumption (Figure 13) The comparison of both combination meters on each site revealed that some of the heavy leaks were on the pipelines monitored by the second fire meter such as the leak on the Lower Campus in early 2021 of 7175kl water which took a few days to detect and repair. Heavy use of the fire pipeline incurs higher basic charges on that meter. Since the Lower Campus appears to experience more burst pipes its overall consumption could have been lower than the Upper Campus and Hotel School, where there is accommodation, had it not been for the leak underground in January 2021 and the relatively high units consumed the following month.

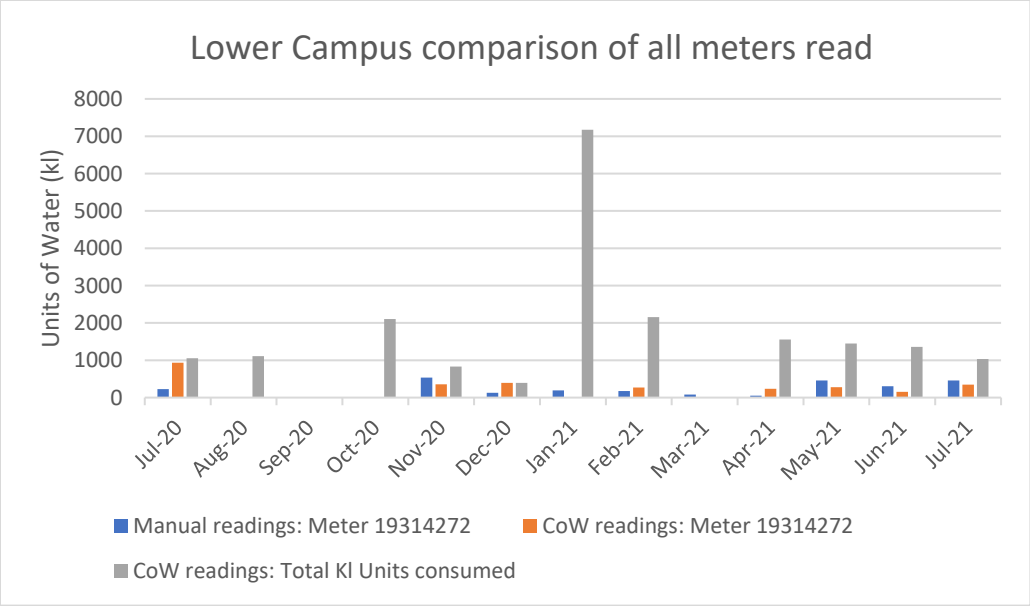

Figure 13: Comparison of water units used on all meters at Lower Campus.

Similarly, the high-water consumption in Upper Campus in October 2020 of 3160kl was due to heavy use of the secondary fire meter (Figure 14). These were not registered in the manual readings of the meter intended for daily consumption.

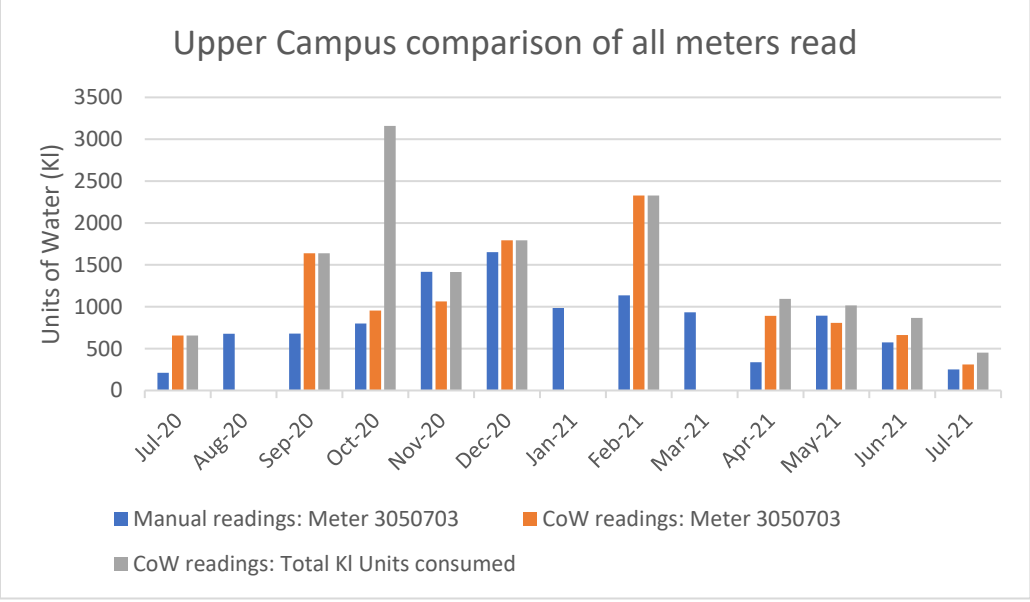

Figure 14: Comparison of water units used on all meters at Upper Campus.

The Hotel School Manager monitored their meters and submitted the manual self-readings to the Finance Department. The manual readings and CoW billing for the Hotel School Campus were closely aligned the

total overall use demonstrating monitoring efforts and containing use to the correct 50mm supply line had been successful. (Figure 15).

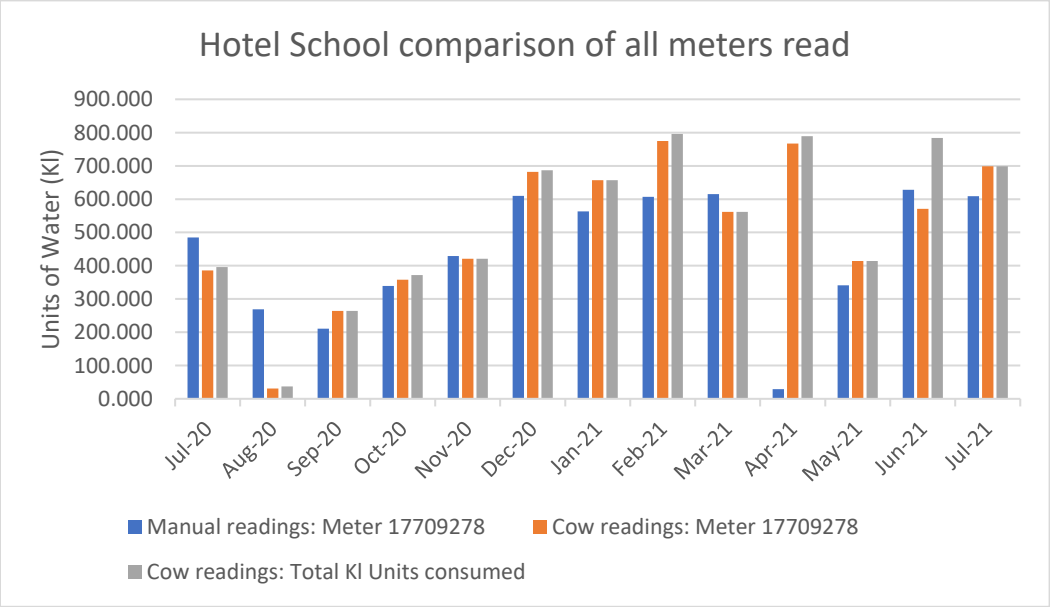

Figure 15: Comparison of water units used on all meters at the Hotel School.

Figure 16 provides a summary of the 13-month sample period's water consumption between 1 July 2020 and 31 July 2021. The total kl readings indicate the units used on both combination meters showing the heavy use of the emergency fire pipeline on the Lower Campus, and partial use on the Upper Campus.

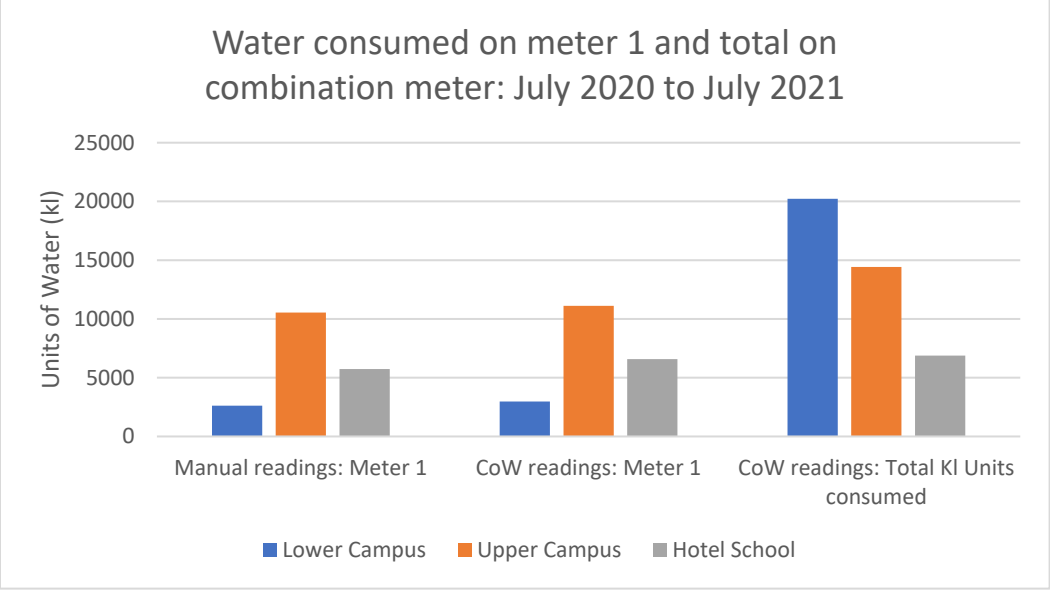

Figure 16: Cumulative total use on three campuses in 13 months.

3.1.9 : Water consumption costs

Based on the CoW readings over the 56-week study period in the Lower Campus, including a partial lockdown, 20,221kl water (av. 361,089 litres/week), cost NUST N$1,103,662.18 excluding the basic charges for the water meter. Upper Campus bills equated to N$787,043.60 over the same period. The water used in Upper Campus, was 14,420kl the equivalent of 600,833 showers - 1533 showers/day based on the CoW recommended 4-minute showers using 24 litres of water per shower (CoW Marshal Guide for Consumers 2021).

During a six-day period at the NUST Hotel School between 1 July 2020 and 6 July 2020, 234kl of water was lost when the pipes burst, equivalent to 9750 showers. Based on the water tariffs (CoW 2019d), the cost of this loss amounted to 234 x N$54.58/kl = N$12,771.72. During just eleven days at the NUST Hotel School between 25 December 2020 and 4 January 2021, 519kl = N$28,327.02 worth of water was lost when the pipes burst during a period when the University and Hotel School was closed. The CoW charge for sewerage based on 85% of water units consumed, thus incurring higher costs as a result of leaks.

3.1.10 : Proportional use of water

The buildings on Lower Campus include the study buildings Civil Engineering and Mining Building, Architecture and Spatial Sciences Building and additionally the Faculty of Health and Applied Sciences, the Library and Information Services, the old Engineering building, the Auditorium building, and the Science and Technology building. The Health building uses water for practicals as does the Engineering Building, whilst the other buildings use water for sanitary and drinking purposes only. The increased use in August, November and December 2020, and July 2021, when practical classes were concentrated, could be attributed to this, though possibly exacerbated by taps and toilets left running or burst pipes. Running water in the taps and toilets provides the only feasible explanation for the high proportional use by Architecture in December 2020.

Architecture and Engineering, as the only two individually metered buildings in this study, use 8% of the average monthly water consumed in Lower Campus. Their combined average monthly water consumed as a proportion of the combined Upper and Lower Campus is minimal, at below 1%. Figure 17 indicates the minor proportion of the total water use on Lower Campus total that Engineering, and Architecture

used over the study period. Between the two buildings Architecture has the lowest consumption with Engineering (and Mining with two laboratories) slightly higher.

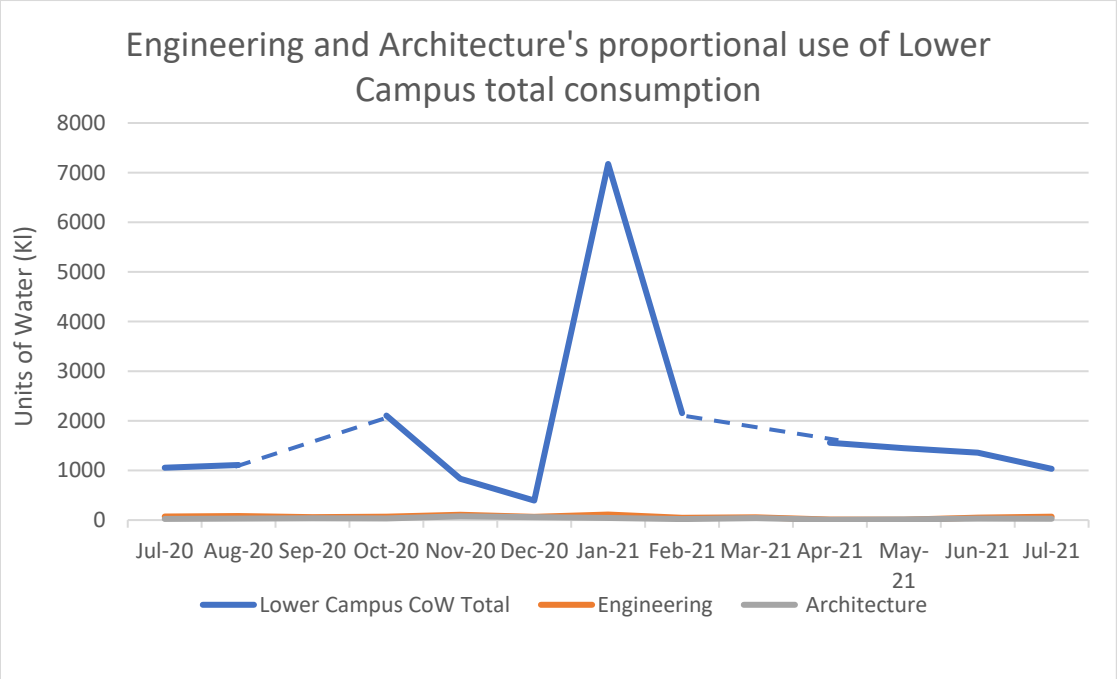

Figure 17: Comparative water consumption at study buildings compared to total use on Lower Campus.

The dotted line section of the Lower Campus CoW total (Figure 17) represents missing data where estimates were made. Heavy use and leakages in December and January are attributed to other, unmetered, buildings on Lower Campus.

Figure 18 illustrates a comparison made between the two sites that provide accommodation and have kitchens. Though the occupancy of the Upper Campus hostels and Poly Heights accommodation was difficult to track, these, and the kitchens probably contributed to their high consumption rates. Occupancy at the Hotel School during the period was equally difficult to track however units consumed indicate the reduction that was achieved with monitoring, self-metering, and prompt maintenance.

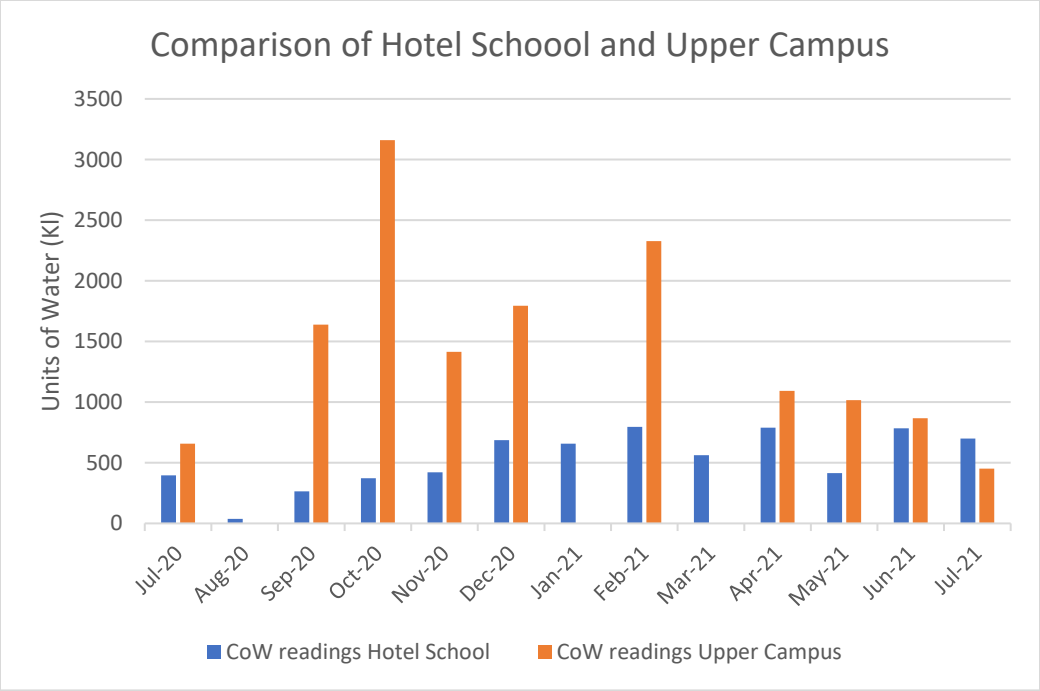

Figure 18: Diagram illustrating the Comparison of Hotel School to Upper Campus water consumption.

3.1.11 : Leak detection

The smart meters installed during the study were able to detect leaks. A leak evidently occurred during the December holiday period on 27 December 2021 at the Engineering building. Figure 19 shows the leak alert. The leak continued into mid-January as the campus was closed there was no emergency maintenance team on duty. The calculation displayed on the live dashboard indicates in December 2021, during the Christmas recess, 49,076 litres of water were consumed.

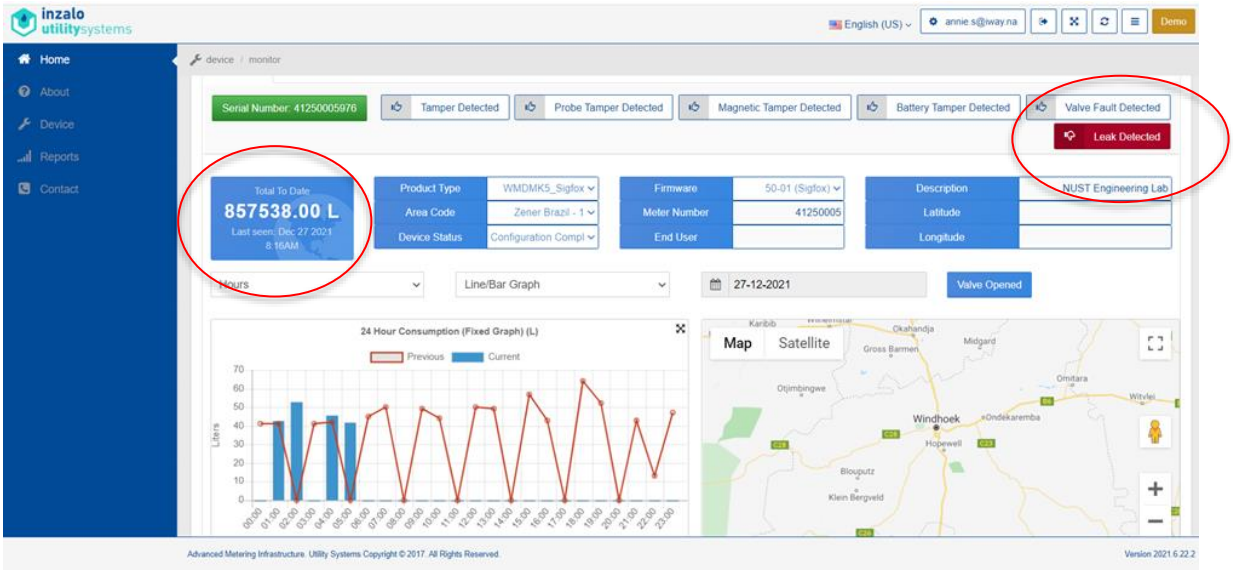

Figure 19: Leak detected on 27 December 2021.

Figure 20 shows that between 1 January and 22 January 2022, 69,307 litres of water was consumed, during a period when the University was still closed. During the week of 2 January 2022 to 8 January, an average of 800 litres a day was consumed. Based on the recommended per capita daily consumption in tertiary institutions this was excessive use. There were just two security guards on campus day and night so the majority of it was assumed to be water loss. According to the dashboard, the leak appeared to have been repaired on 21 January 2022, 26 days after it was manually reported.

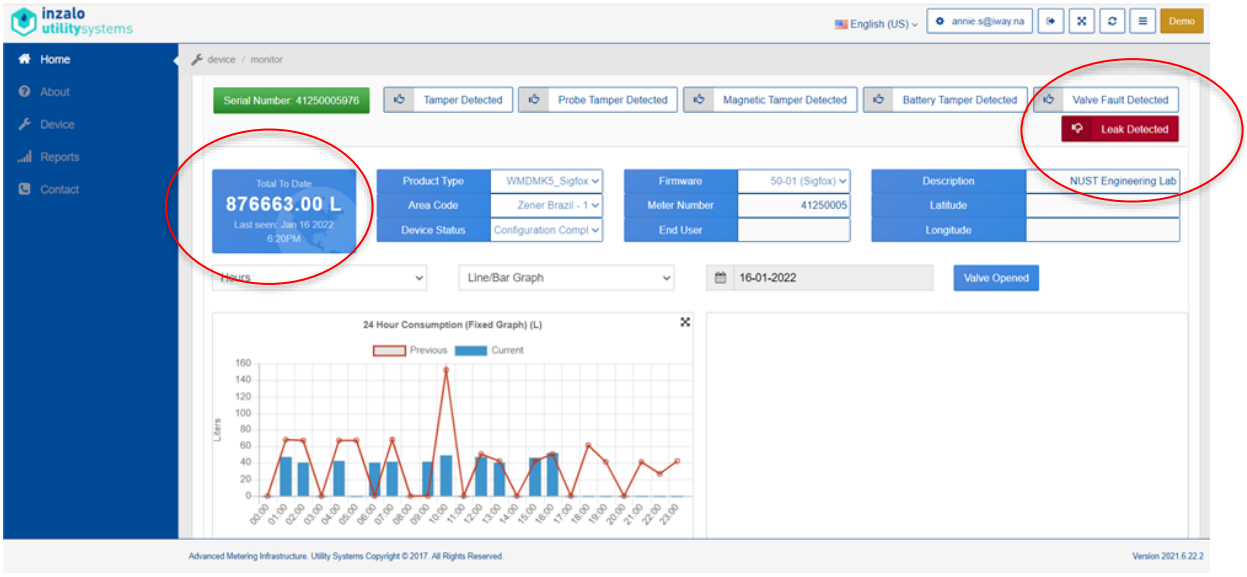

Figure 20: Leak detection alert continued 16.1.2022.

A small number of problems were reported on the manual water audit log sheets system such as leaking basins on 8 September 2020 in the Engineering building and on 23 October 2020 in the Health building, and two toilets were reported as still not fixed a month later, and the entire building was without water for a few hours on 02 November 2020. The audit sheets, used to cross-reference with the DICT Service Desk reports, indicated a slow response in containing water loss. The audit sheets served to raise people's awareness of monitoring problems, however, few problems associated with excessive consumption occurred during the monitoring period due to the university closure.

3.1.12 : Historical consumption

CoW metering data for both campuses were collected from 2015 to 2018 (Figure 21) which found water consumption patterns were non-linear. It was extended to October 2021 in order to determine if there are any long-term trends in water consumption at the three campuses.

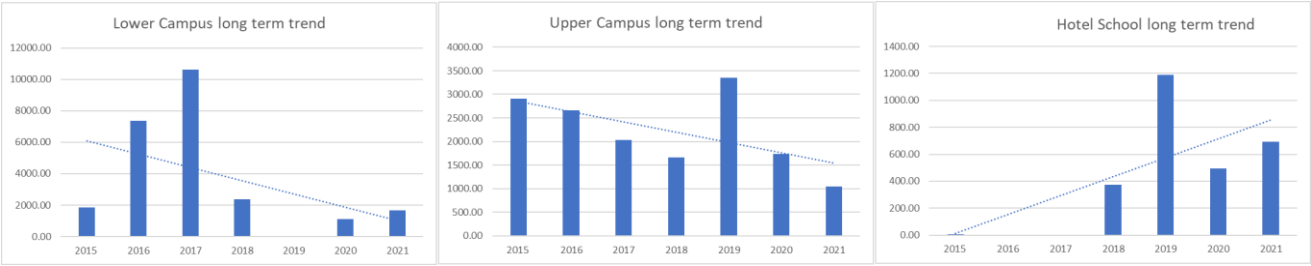

Figure 21: Historical annual average water use trends.

Overall consumption declined since 2015 at both Lower and Upper Campuses but increased at the Hotel School Campus. However, since 2020 and 2021 were not representative of normal occupancy, and therefore normal consumption, 2019 consumption should be regarded as the last indicative year of water consumption data. The annual averages from seven years from 2015 to 2021 in Figure 21 indicate that at Upper Campus, despite the drought, consumption had a higher average use in 2019 than in 2018 and 2017. Upper Campus had the most complete data set, though it still contained missing months that were incorporated into the following months' readings. The Hotel School showed an increase in 2019 but the data was only available from late 2018 so this distorts the average and Lower Campus had too much missing data as a result of faulty meters to draw conclusions from the trends.

3.1.13 :Sustainable and unsustainable practices

A summary of sustainable versus unsustainable practices in terms of metering, monitoring of consumption, maintenance of infrastructure and management of the water situation was observed and is summarised in Table 3.

Table 3: Sustainable and unsustainable practices at NUST.

	Sustainable practices	**Unsustainable practices**
Metering	• Hotel School consumption monitored daily, self-readings submitted to Finance Department and identified leaks promptly. • Hotel School isolated the fire meter to prevent use and reduce charges. • Two pilot smart meters installed demonstrated their monitoring capabilities.	• Leaks and high consumption went unnoticed or unresolved on Lower Campus and at the Hotel School. • Sewerage charges incurred based on 85% of water units consumed/lost. • As a result, water and financial resources were wasted. • The three main campus combination meters, incur unnecessarily high basic charges and water tariffs. • NUST exceed CoW recommended water consumption of tertiary institutions of 15 to 20 litres a head a day.
Monitoring	• Digital smart meters installed raised alerts to leaks. • Maintenance team is informed of issues through the DICT Service Desk system. • More active engagement by Facilities Director in 2021 meant: - outstanding CoW arrears were cleared, and over-payments and interest charges recouped - COW payments are captured on a database. - Advanced Metering Infrastructure investigated.	• Meters are frequently broken or faulty and not replaced. • Interim and stuck charges issued by CoW and interest charged on incomplete payment of bills. • No one was appointed to monitor water use and detect leaks. • CoW bills are not scrutinised for use or compared against projected use • No targets were set for maximum daily and monthly consumption. • No follow-up on excessive use.
Maintenance	• Pearl Water-free Technologies pilot project in the Lecture Building of water-efficient sanitary ware installations proven to reduce water consumption.	• No confirmation could be given that maintenance plans were in place - plumbing problems appear to be crisis management.

		• Maintenance and renovation were reactive (O. Quarmby personal communication, 28 Oct 2021). • Leaks and burst pipes are often not addressed promptly. • Inconsistently sized inlet pipes reduce efficiency in maintenance. • Repeated problems in certain hot spots Shangri La Men's Hostel, Science and Technology and Library and Resource Centre.
Management	• From early 2021 water use and municipal bills were monitored by the Facilities Dept. • Economic incentive for the Hotel School to actively monitor water consumption as they pay 60% of their own water costs. • The Hotel School awareness raising and water-saving efforts reduced consumption.	• Prior to 2021 water use was not monitored, nor were CoW bills or units consumed checked. • Despite Hotel School's efforts municipal bills are amassed and the cost of use is divided out proportionally thus they are charged in excess of what they use (L. Liebenberg personal communication, 27 Oct 2021). • Shortcomings in the DICT reporting system thus data requires much analysis and processing to gain information that could be used in site maintenance.

3.2 : Results Objective 2:

The awareness and attitudes towards water-related environmental issues at NUST, suggestions and support for sustainable green campus initiatives were determined from an online survey, face-to-face and telephonic interviews as expanded on in chapter 2.

3.2.1 : Online Survey responses

Responses to the survey were received from 233 people across the University. This is just less than 2% of the total campus population. Of the 223 respondents, 114 were females and 108 were males, with one withholding gender. Age structure revealed that 52% of respondents were between the age of 25 and 44 years, 86% were staff and 14% were students, though the staff were distributed between a variety of categories with more academic staff (58%), administration (21%), fewer from management (4%) and the

least from Technical (3%). The academic staff comprised 5% of the total campus population (693 full-time with additional part-time staff) whilst student respondents were the fewest, less than 1% of the 12,647 registered students (Table 4), as a result of campus closure due to Covid-19.

Table 4: Staff and student respondents' categories.

NUST population categories	Survey respondents	Percentage of total responses	Actual population 2021	Percentage of total population category
Academic staff	129	57.85%	693	18.61%
Full-time Management, Technical & Administration	62	27.80%	176	35.23%
Student	32	14.35%	12,647	0.25%
TOTALS	**223**	**100%**	**13,516**	**1.65%**

Only 220 specified the department they were in at each site. Most of the respondents came from the Upper (102) and Lower Campus (88), (including 32 from the two focus buildings) with the least from the Hotel School Campus (5) and the rest were off campus.

3.2.2 : Attitudes and awareness

The results provided good insights into attitudes that could be compared with behaviour regarding water utilisation. In June 2020 when the survey was conducted 94% of the respondents, of which 46% were female and 47% male, were aware of the crisis surrounding water availability in Windhoek. Only 1 male and 1 female responded no. According to the age analysis, the least aware respondents (5%) came from the younger age groups 18 to 34yrs.

Awareness of the water crisis was high with the equivalent of more than 87% across all the job categories (Figure 22). It is important to note that the level of awareness was not defined, thus knowledge could range from basic knowledge that water is scarce to a detailed understanding of the water supply situation in Windhoek.

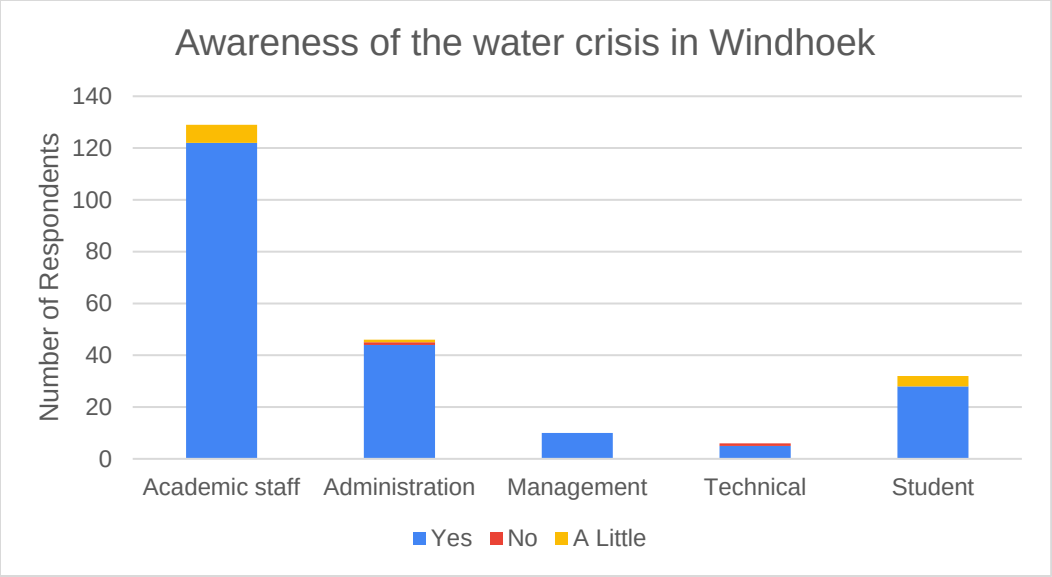

Figure 22: Awareness of the water crisis by job category.

However, despite the awareness expressed, overall, 73% of people felt that wanted to be more informed about the water situation whereas 8% of people didn't feel that they needed to learn more (Figure 23).

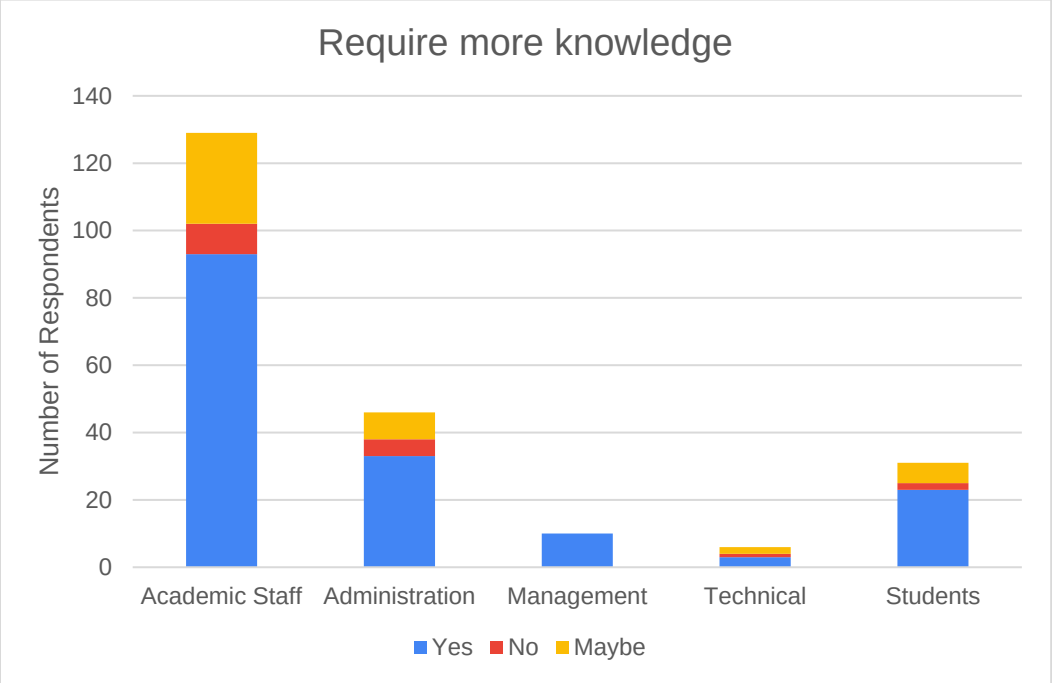

Figure 23: The need to know more about the water situation.

As an indicator of interest in the water situation, the survey asked about monitoring rainfall trends. As a matter of interest, 50% of management staff monitor rainfall at home, with academic staff following at 37%. The least interest was expressed in the technical staff category, with the equivalent of 17%, monitoring rainfall. (Figure 24).

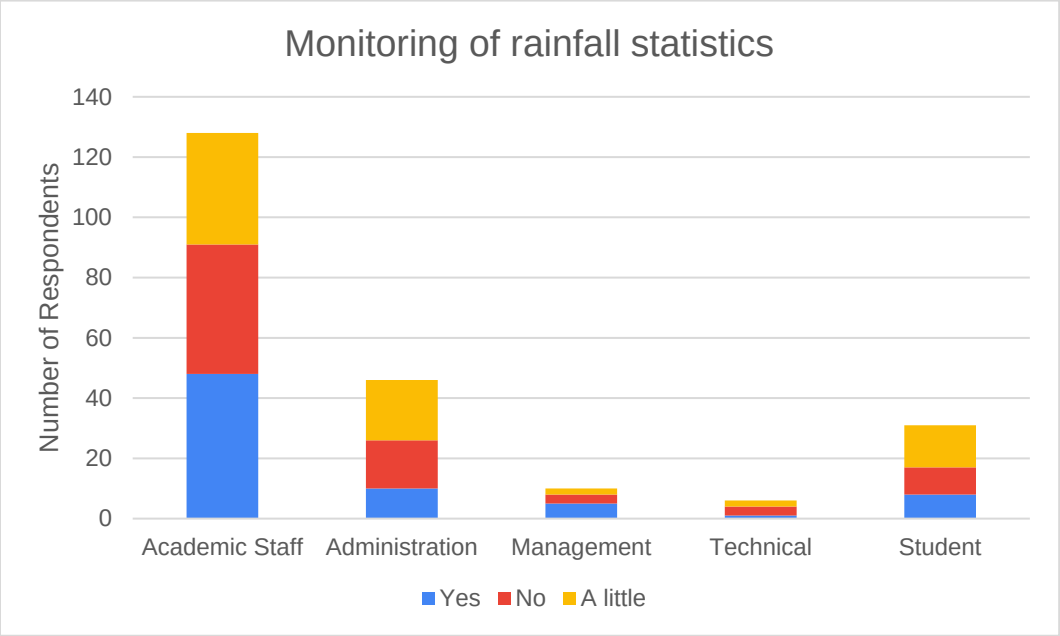

Figure 24: Interest in monitoring rainfall by job category.

Further survey results indicated that 21% of male respondents in all age categories monitor rainfall statistics with more from the 25-to-54-year age groups compared to 12% of females and more from the 35-to-54-year age category.

Investigating the knowledge of the aridity of Namibia, revealed that 48 people classified Namibia as an arid country and 140 semi-arid, (a combined total of 83%), whilst 16 from the wetter northern regions, Khomas and Erongo considered it sub-tropical and 18 from the north-central regions classified it as tropical wet and dry (Figure 25).

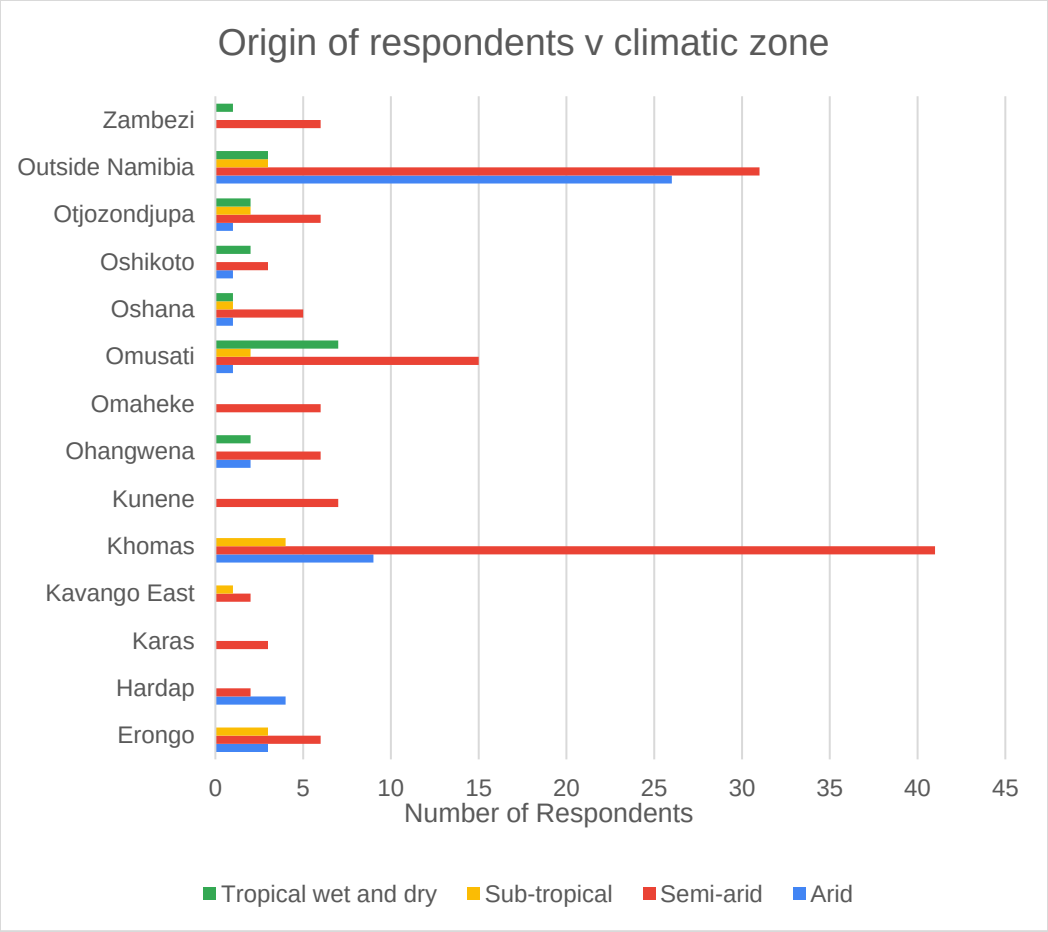

Figure 25: Classification of Namibia's climatic regions by respondents.

More than half of the respondents realised that one season of good rains was not sufficient to alleviate the city's water supply problems and still felt the water situation was critical. However, when combined, an equal proportion of the Lower Campus academic staff and off Campus administration staff also felt the situation was less critical or not at all critical after the recent rainfall. Those who were less worried equalled those who still felt it was serious. Proportionally more students on Lower Campus were less concerned than on other sites. (Figure 26). Overall management staff (100%) were the most concerned followed by students (77%) and academic staff (73%).

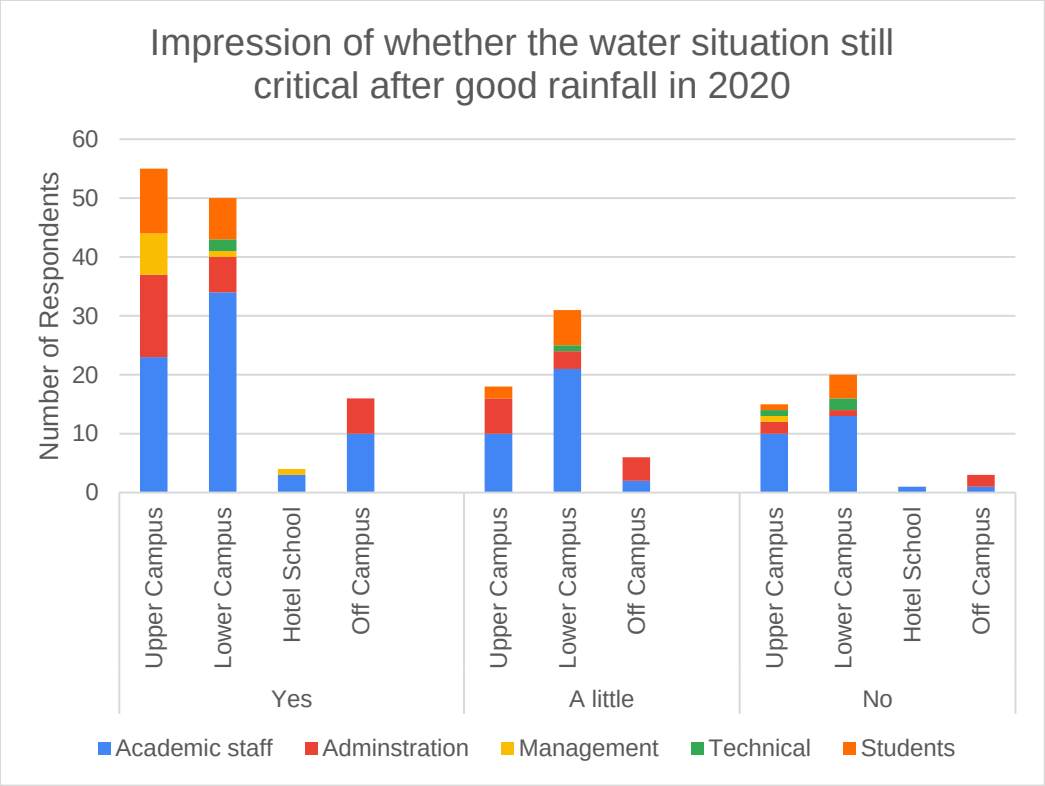

Figure 26: Assessment of whether the water situation is still critical after the good rain in early 2020.

At the Hotel School, 80% were concerned or very concerned about the water situation, and only 1 respondent felt that it was not as critical after the good rainy season. On the other campuses, 26% of respondents were neutral, not concerned or did not know if the situation is no longer considered critical (Figure 27). In a comparison of job categories more academic and administrative staff were found to be neutral, not concerned, or did not know how they felt about the situation.

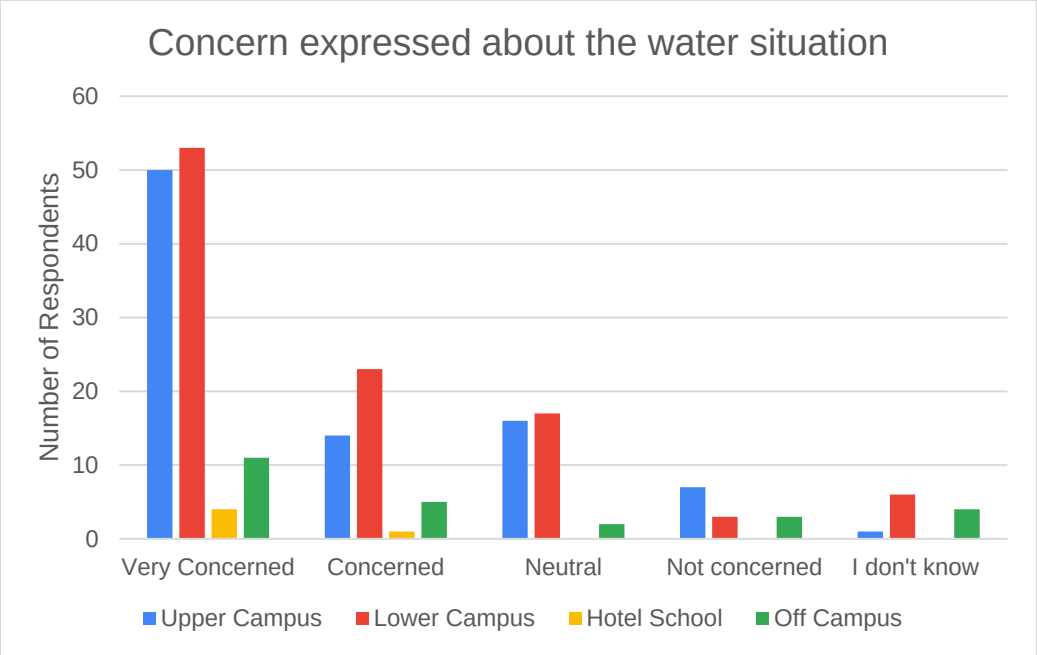

Figure 27: Diagram expressing respondents' concern on the overall water situation in Namibia.

The opinions on what NUST could do to mitigate the overuse of water were sought in the survey. Respondents had to indicate the degree of importance that they would place on actions and ideas to help reduce water consumption.

The following suggestions were ranked as important or very important for mitigating the overuse of water by over 90% of the respondents; educating about the water crisis during Freshers Week; using social media to get the message across; harvesting rainwater; performing water and sustainability audits and assessments; including more about sustainable use in the curriculum; and joining a worldwide Green University initiative with almost 100% support for implementing water-wise technology (Figure 28). Setting water use targets and raising awareness with posters, fliers, and visual media were ranked by more than 85% of respondents as important.

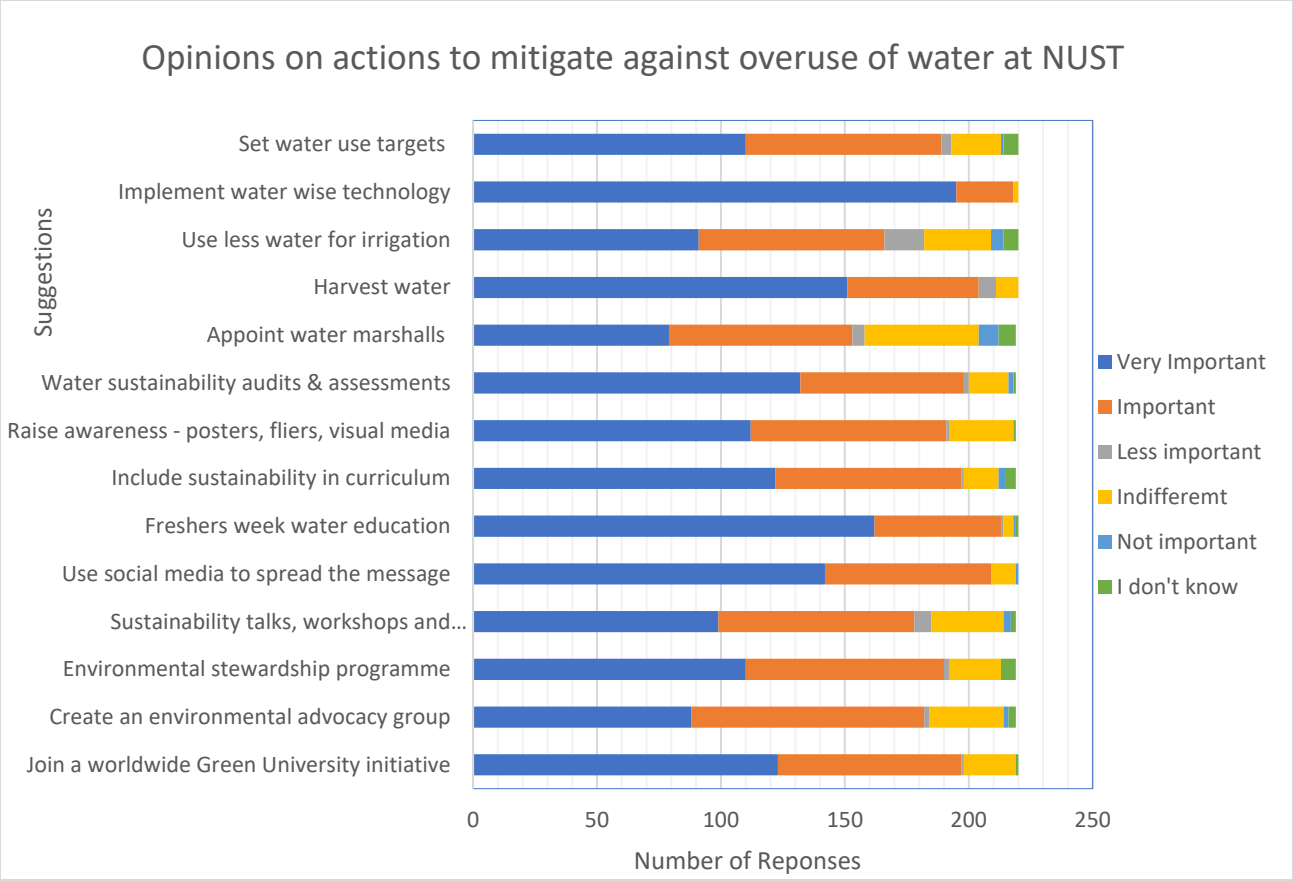

Figure 28: Actions suggested by respondents to mitigate the overuse of water.

When asked to describe additional actions they felt were important to mitigate against overuse of water some respondents reinforced mitigation measures that had been suggested previously verifying the importance of recycling grey water (13%), enforcing limitations on water use (12%) which could be done through the water-wise technology (12%) and landscaping (5%) and improving the response rate to plumbing problems (10%). Other suggestions included installing water meters, seminars and holistic environmental awareness, and engaging qualified artisans to maintain water-related infrastructure. Competitions and rewards were suggested as motivating people to save, as well as inserting water-saving tips in email signatures of staff or on the intranet from time to time.

Survey respondents were asked for suggestions on how they would raise awareness about the water situation affecting Namibia. Many recommendations were made yet the most frequently mentioned included; social media, and visual and graphic public displays (27%), whilst 11% of the suggestions were related to flyers and posters as an effective medium of informing people. Only 9% of responses mentioned holding short workshops, debates, and public lectures, meanwhile, 8% proposed less formal interactive

discussions in lectures. Fewer (5%) suggested formally incorporating awareness and education into the curriculum. Others suggested outreach activities and announcements and talks on the University radio station NUST FM (Figure 29).

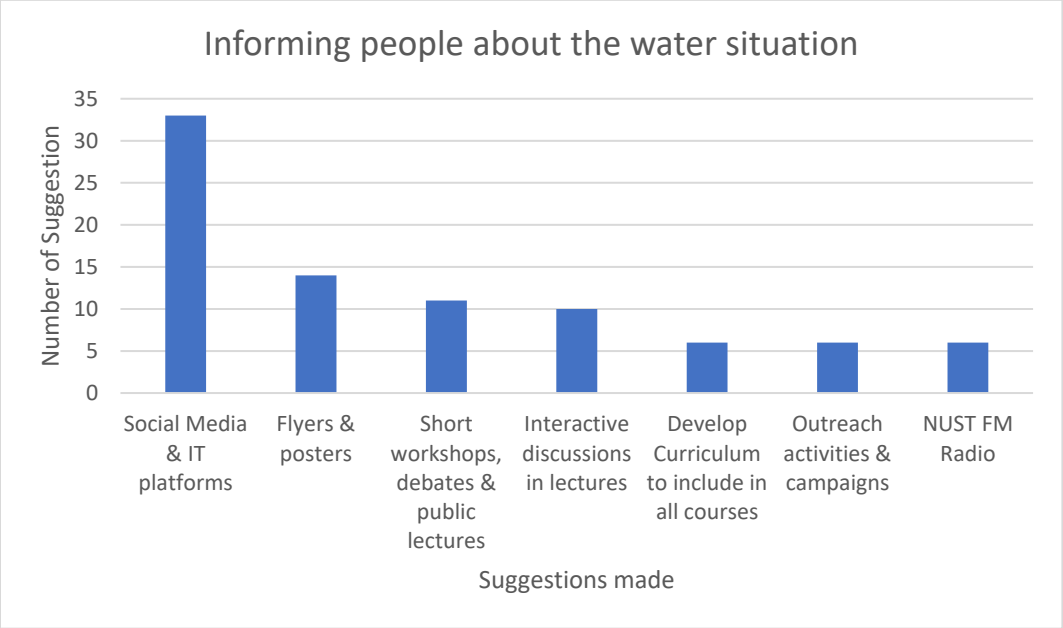

Figure 29: Top 7 of 23 suggestions on how to inform others and promote knowledge and awareness at NUST.

3.2.3 : Level of Responsibility

Displaying a strong need for joint effort and responsibility, an overwhelming 92% of the survey respondents expressed that everyone, rather than any specific group only, had a role to play indicating that combined individual efforts have an impact in solving the water crisis in Windhoek and on Campus. Contrastingly, however, only 32% held themselves personally accountable. While 42% also indicated that the Government and the City of Windhoek should help resolve the water crisis, 28% felt NUST as a big institution with research capabilities could play a significant role in solving the crisis (Figure 30).

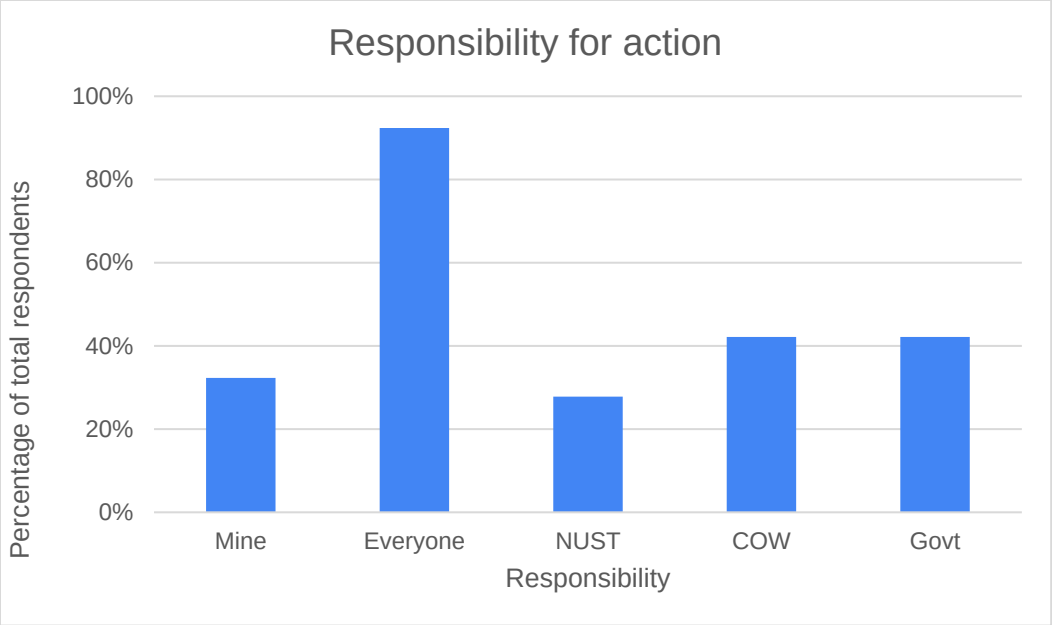

Figure 30: Indication of who respondents felt was responsible for solving the water crisis.

In light of the high proportion of responses from the different campus locations of people willing to make lifestyle changes in Lower Campus (93%), Upper Campus (97%) and the Hotel School (100%) it indicates people are ready to embrace pro-water-wise lifestyle changes (Figure 31), which was also borne out in a further comparison with job categories where results showed that 93% of staff and students overall were willing to make positive lifestyle changes.

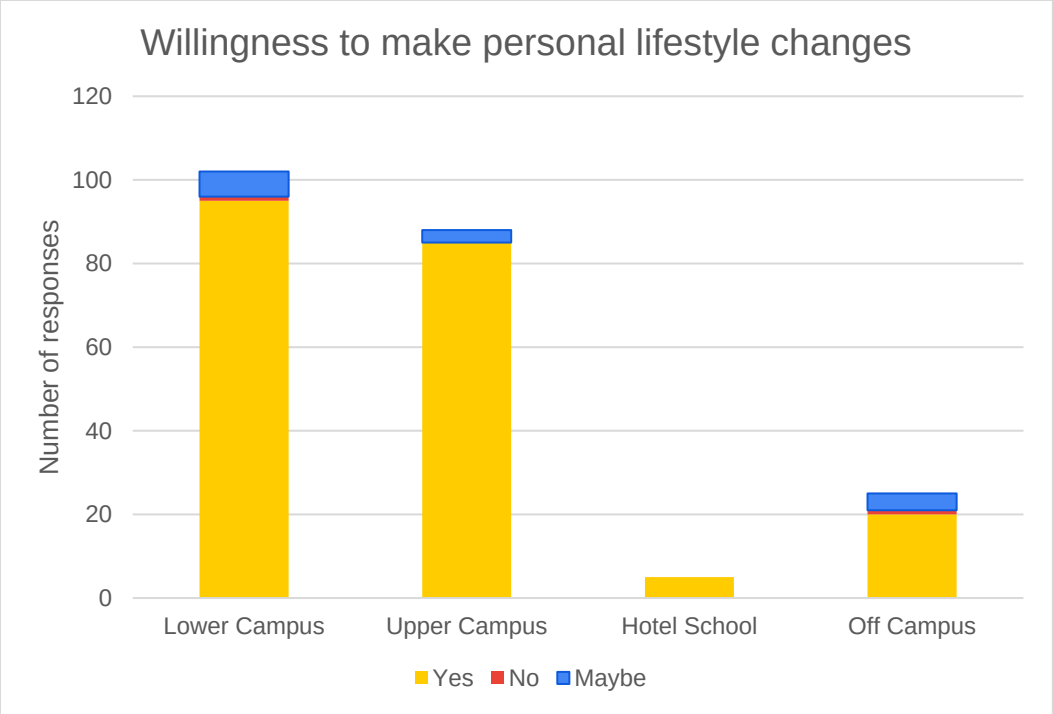

Figure 31: Indication of willingness to make personal lifestyle changes by campus.

The willingness to personally do something about the situation and take responsibility while making behavioural or lifestyle changes was very evident with over 200 positive responses out of 223 to both questions (Figure 32). This commitment could define the success of a programme to green up the university if similar proportions of the total NUST population were willing to make personal contributions towards the water situation. Other questions were posed to determine the level of personal contributions that people would be prepared to make, and 51% felt that could contribute to finding a solution to the water situation on campus but also in Windhoek as a whole.

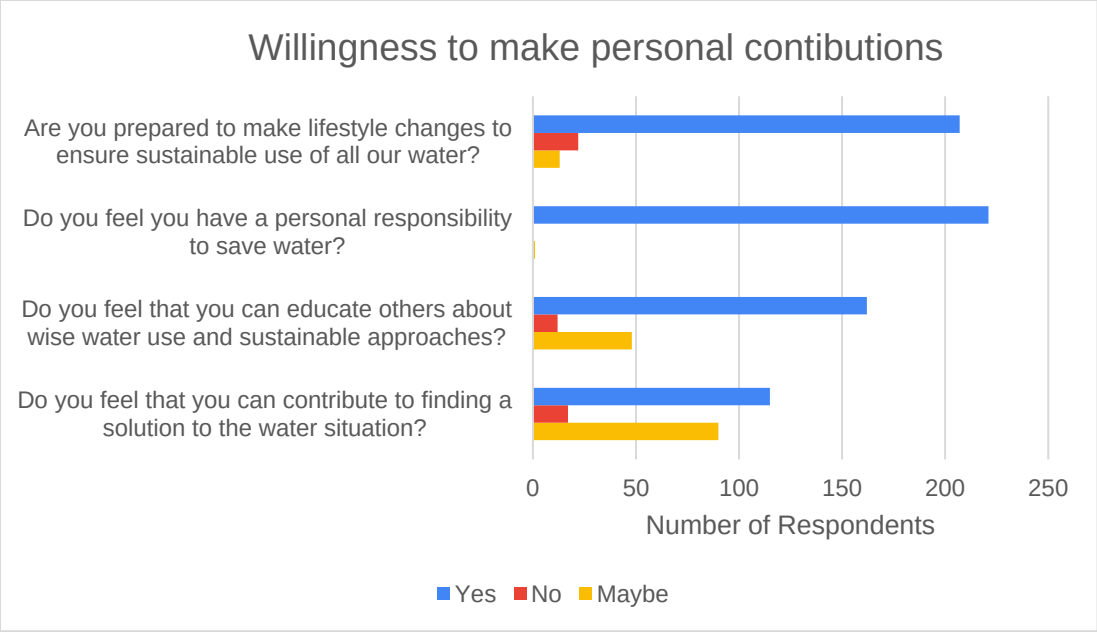

Figure 32: Commitments to personally contributing to sustainable water use.

These positive commitments endorse that most respondents are willing to change their lifestyles, but over 53% of the respondents felt teamwork involving every consumer was necessary to achieve the goal to reduce water consumption (Figure 33).

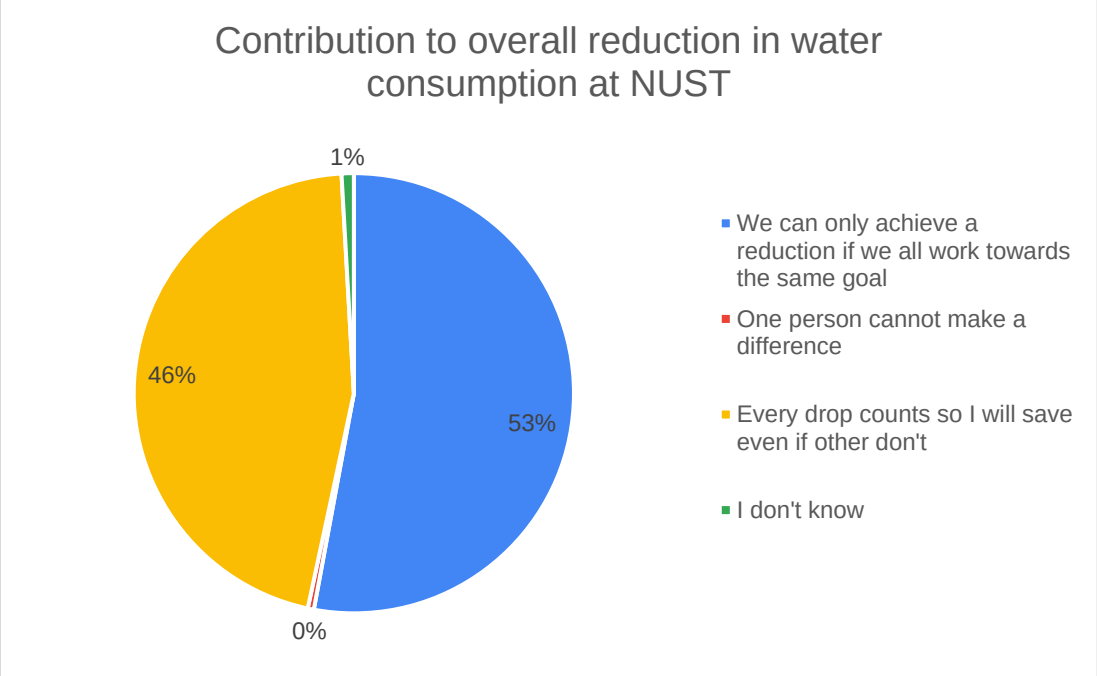

Figure 33: Level of personal impact in achieving sustainable water use.

Respondents' sense of responsibility and motivation towards saving water was strongly influenced by self-motivation (74%). There was a higher degree of agreement with being informed about water (78%) and cost savings (74%) to encourage people to achieve goals. However, 22% did not agree with water restrictions and 27% did not feel that being given an incentive would result in water savings (Figure 34).

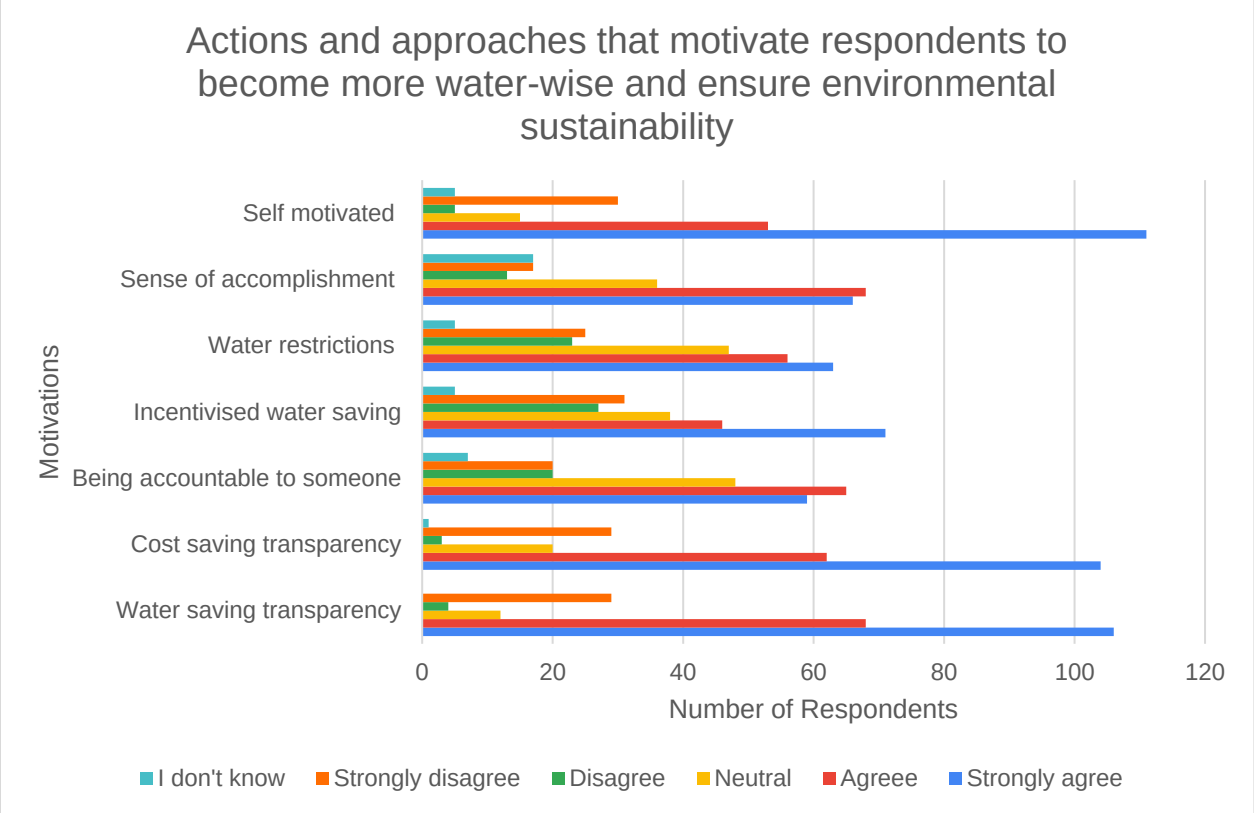

Figure 34: Actions that would encourage people to save water.

3.2.4 : Personal contribution

The survey asked what three significant personal contributions or actions they would be prepared to make to save water at NUST. Responses were broad with suggestions cited most frequently being 19% of respondents recommending short flushing toilets, hand sanitisers instead of water and sparing use of water promoted by water-efficient technology and sensors; 15% suggested a contribution that they could make would be to sensitise and educate students; 12% indicated that they would report leaks immediately; 11% proposed that they would turn taps off, stop toilets running and prevent leakages where they could; whilst 7% wanted to become more personally aware of their own water use. A few

were interested in harvesting and purifying water and in encouraging innovation of new concepts and designs to save water. Only 2% of respondents indicated they would check the bathrooms before they left work to ensure water didn't run overnight. Other pertinent written responses and suggestions were made in the survey and are illustrated in Figure 35.

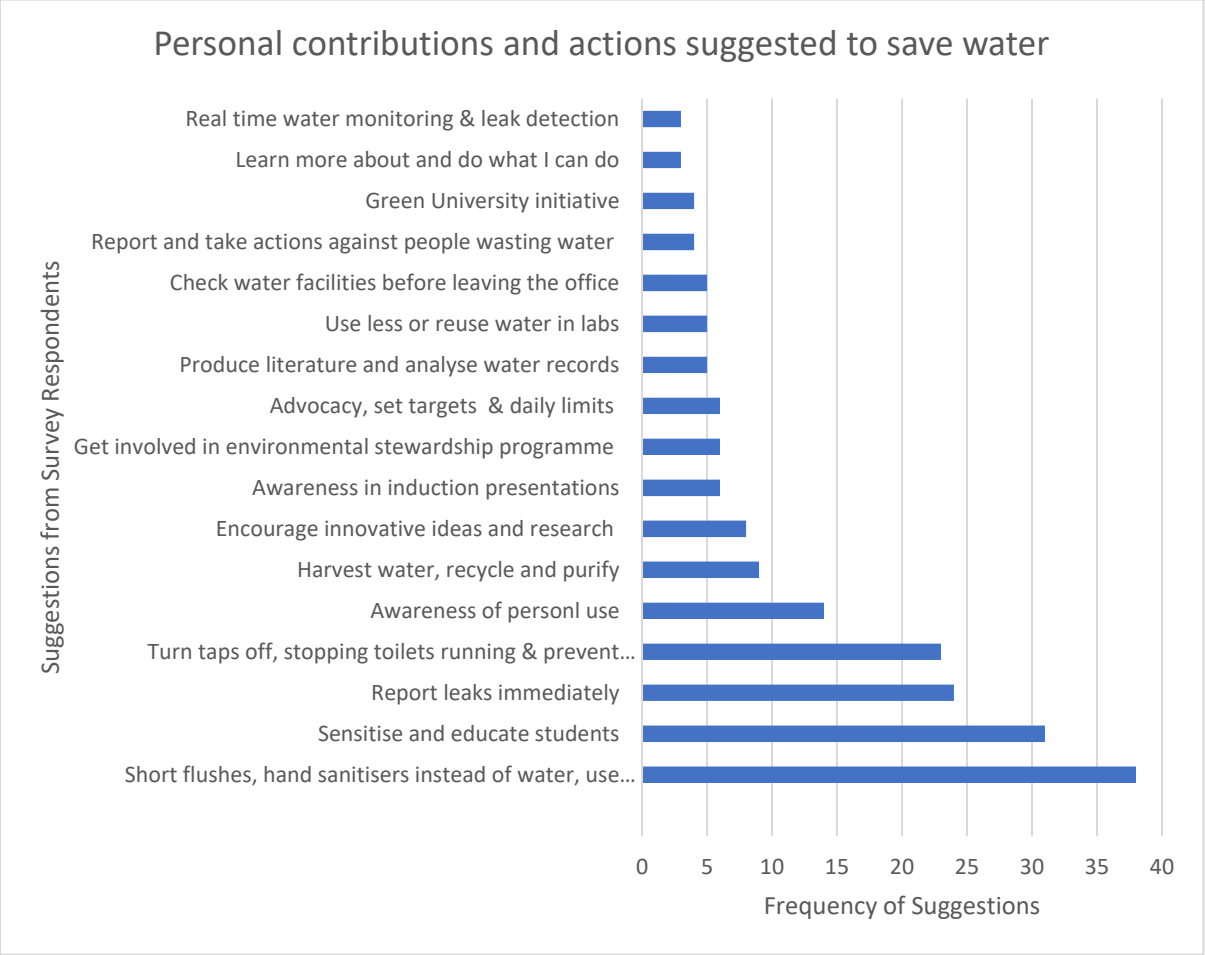

Figure 35: Actions respondents were personally willing to make to save water.

3.2.5 : Options and Approaches for NUST as a collective

Besides personal contributions, strategies to raise awareness at NUST were identified that could be used to mitigate damaging behaviour and practices campus-wide (Figure 35). Many responses were similar to those associated with individual efforts (Figure 36).

Environmental education was emphasised with at least 28% of respondents stating that awareness and sensitisation were key to improving water use at NUST. A further 17% suggested the installation of water-

wise technology while 11% recommended that leaks and plumbing problems should be fixed promptly by better-trained and skilled artisans. A few (less than 7%) mentioned monitoring water use using real-time displays and competitions to encourage a reduction in water consumption; recycling grey water using a treatment plant; improving maintenance and leak detection activities as well as enforcing compliance through water restrictions and the implementation of water-saving plans and campaigns. Other more minor suggestions included rainwater harvesting, offering departmental incentives and rewards, and education about the aquifers and recharge rates, as well as dam levels to aid understanding and motivate people to save water, whilst water-wise landscaping and imposing a measuring or metering system were also mentioned.

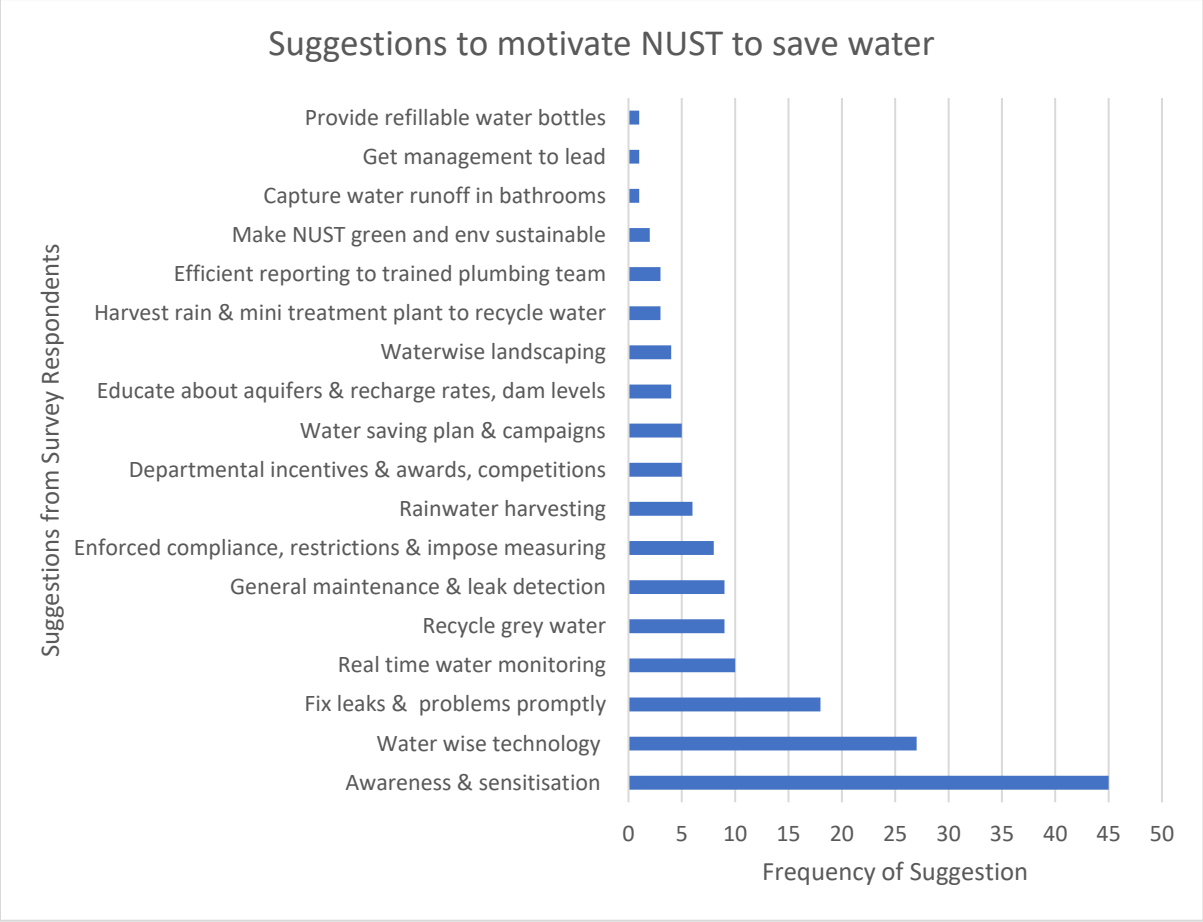

Figure 36: Suggestions proposed on how to motivate the NUST population to save water.

Though only 5% suggested incorporating SD into the curriculum to raise awareness when asked a direct question regarding incorporating more about sustainable use in the curriculum, 88% of responses indicated that it is important or very important to include more about sustainable use of water in the

curriculum. This showed a high degree of support for the incorporation of Education for Sustainable Development (ESD) across all subjects. Most of the respondents who supported this notion included academic and administrative staff, and students (Figure 37).

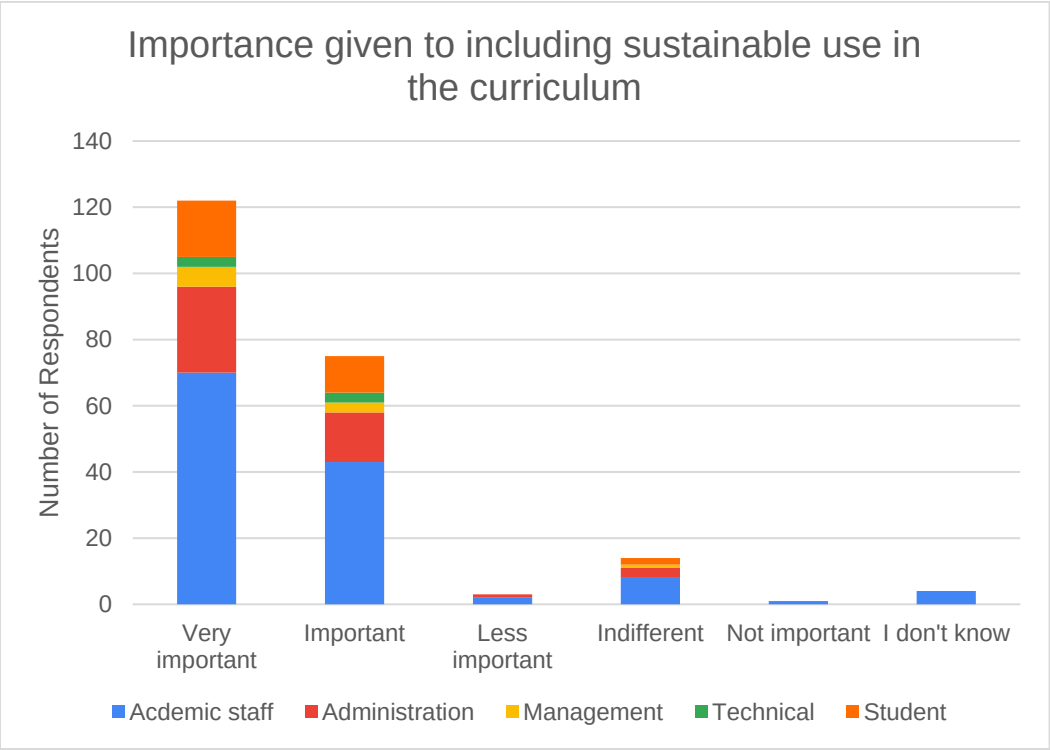

Figure 37: Emphasis given to incorporating ESD across the curriculum.

Confirming the importance given to introducing sustainability across the curriculum more than 61% of survey participants felt that it was very important and 38% thought it was important to include it. Of those who felt it should be included 47% came from the Lower Campus and 39% Upper Campus. Less than 2% said it was not important or less important than some other measures identified to reduce water consumption. The recognition given to including sustainability in the curriculum indicates good support for a move towards becoming a Green University.

A small proportion of respondents were hesitant about their ability to educate others about wise water use and sustainable approaches, however, 73% across all the categories said that they could. Additionally, the results indicated 73% need to know more about the water situation which indicates that incorporating sustainability into the curriculum and educating others had wide support (Figure 38).

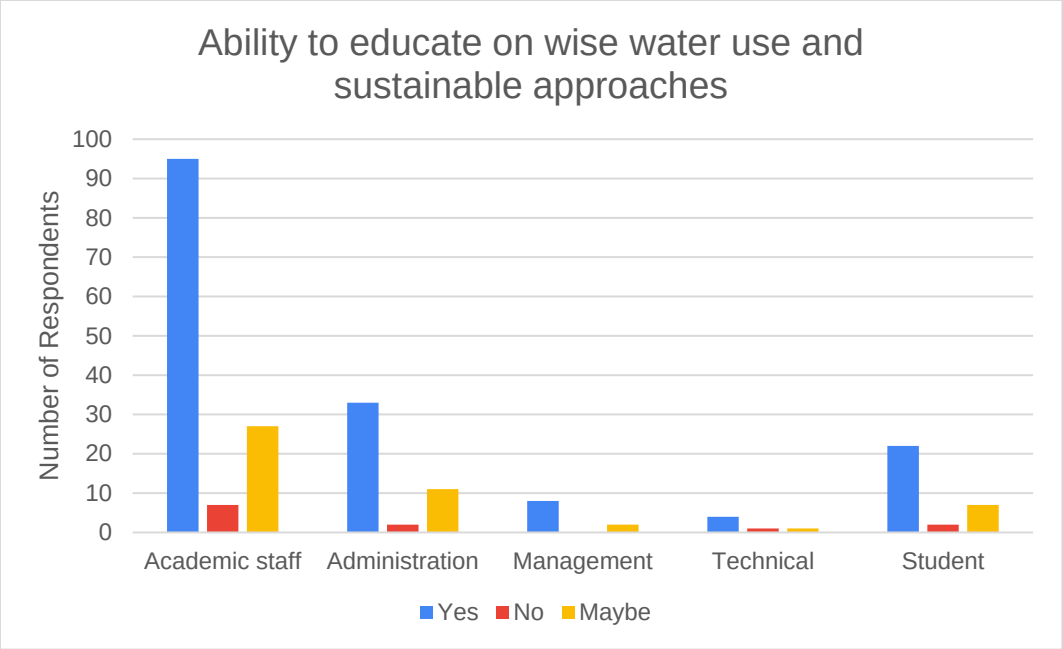

Figure 38: Confidence in the ability to educate others about sustainability according to job category.

More people on the Lower Campus were hesitant about being able to contribute towards a solution despite the Engineering and Architectural departments which have the technical and practical know-how and could innovate to find hands-on solutions that are situated on the Lower Campus (Figure 39). Only 8% stated that they were unable to find or suggest a solution to water overuse. This indicates that more people were willing to change lifestyles which would reduce the high consumption rates, but fewer would be prepared to assist in finding a solution to the water situation themselves

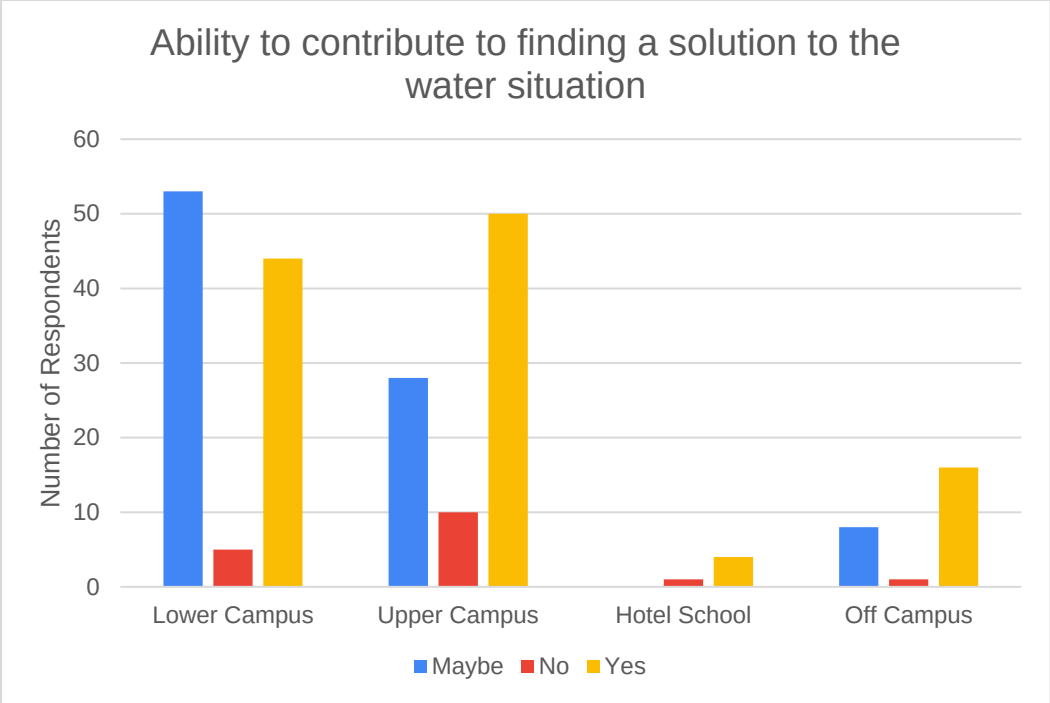

Figure 39: Personal contribution to finding a solution to the water situation.

3.2.6 : Green initiatives

Appetite for becoming a greener university was gauged. More than 83% of survey respondents demonstrated a high degree of support or felt strongly that NUST should become greener and more environmentally sustainable. Only 14% expressed negative opinions towards greening up the university. The strongest support was shown by Upper Campus (89%) and slightly less by Lower Campus (76%). Almost 90% supported NUST becoming part of a wider global Green University initiative which, amongst other environmental benefits, would help mitigate against overuse of water at NUST. Across job categories, including students, more than 89% felt it was important to join a global programme with the exception of the technical staff of whom only 67% supported the idea. The most support, 50%, was gained from the 25 to 44 age group.

Furthermore, 80% of respondents agreed that they would be proud to be part of a greener university initiative of which staff in management showed the least potential fulfilment (70%) and administration the most (91%), however over 60% of students disagreed that they would gain any personal satisfaction from being part of a worldwide initiative. Only 14% strongly disagreed though the reasons why they would not be proud could not be stated in the survey (Figure 40).

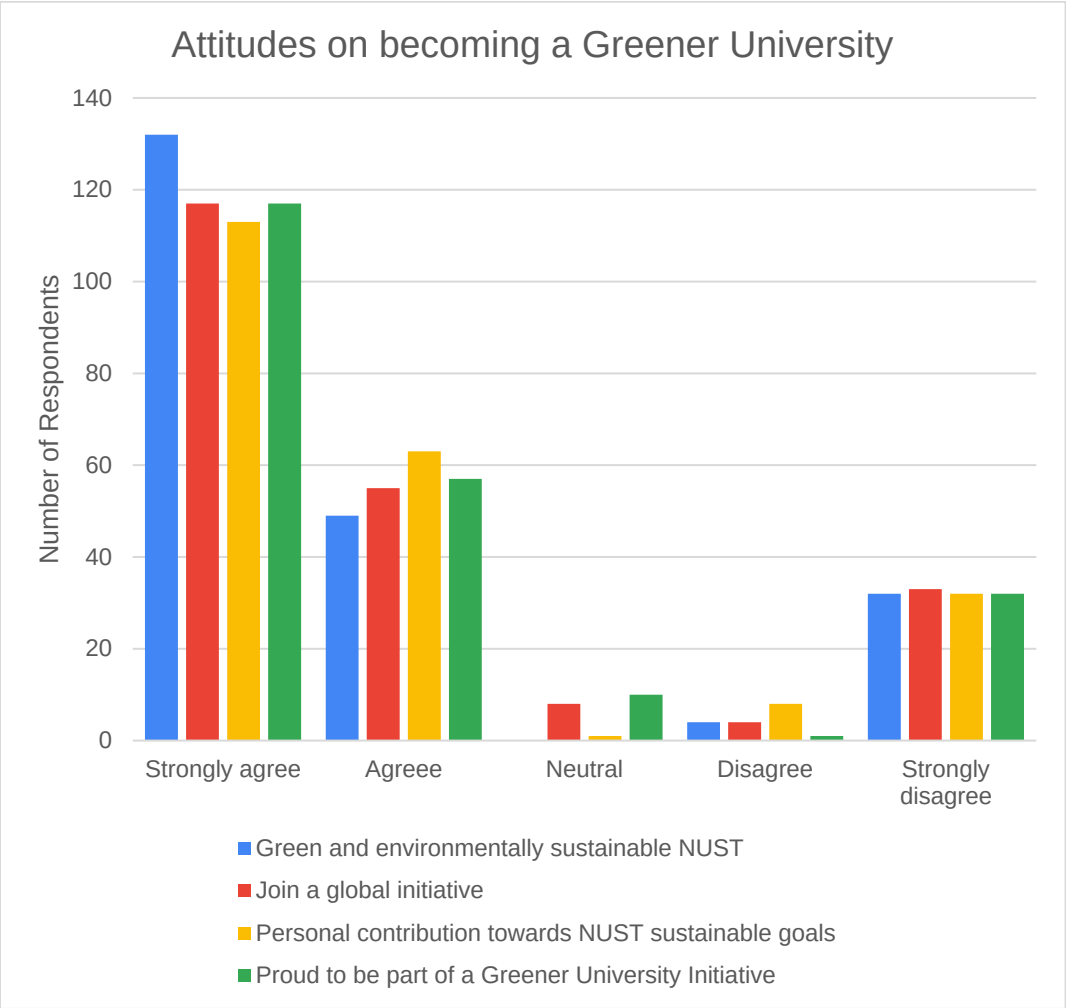

Figure 40: Impressions on NUST moving towards being a greener university.

3.2.7 : Expert external stakeholder engagement

Throughout the study stakeholder engagement was a key facet of the research. Various external stakeholders associated with water issues were approached for suggestions on how NUST could institute water savings based on their experiences elsewhere and asked for contributions to the development of the WMS for NUST.

The interpretation of a sustainable campus in this study focussed more on minimising environmental impacts and reducing costs of water consumption to enable investment of the savings elsewhere to enhance both environmental and economic sustainability at NUST. Discussions with stakeholders resulted

in suggestions for the NUST community to reduce water consumption, promote awareness and make use of appropriate water-saving technology. Interviews and discussions took place with stakeholders and experts from the City of Windhoek which provided data on NUST's water consumption and details on the CoW's approach to reducing consumption. Public talks at the Namibia Scientific Society by CoW, Namibia Hydrogeological Association, and NamWater gave a background to the critical water issues relating to supply and demand in Windhoek and Namibia. Meetings with Pearl Water regarding the water-efficient technology pilot project, discussions with InCharge, Smart Group Technologies and Artemesiot regarding smart meters as well as a tour of EMCON's 6-star rated Green Building contributed to the recommendations (Appendix 5). Approaches such as water-wise technology and smart meters as well as methods to sustain NUST's efforts in moving towards becoming a greener university including active monitoring and management of water resources, and investment in new and improved maintenance of old infrastructure were identified as having the potential for long-term impact.

Organisations with similar approaches, Namibia Environment and Wildlife Society (NEWS), Southern African Institute for Environmental Assessment (SAIEA), Eco-Awards, Gobabeb Research and Training Centre (GRTC) and NaDeet, offered suggestions and shared lessons and concepts that worked in their institutions and ideas of how NUST could become more water-wise and develop into a more environmentally sustainable University. The salient points include awareness raising and education using visual and factual displays; incorporation and integration of sustainable development into the curriculum; monitoring water use; removal of high consumption appliances; setting targets with incentives to achieve them; education of administrative staff to identify the trends and understand water consumption; channelling of runoff to water-wise gardens and installation of Advanced Metering Infrastructure (AMI), a digital metering system with communication and information management system providing real-time water usage data. They also involved electing champions as role models to promote sustainability and stewards to drive the greening programme; building a community of green people willing to make behavioural changes; and employing permanent staff to attain green status and assist in the development of an EMP. All the recommendations made by the stakeholders below support the findings of the literature review. A summary of the most applicable and easily implemented suggestions are contained in Table 5.

Table 5: Key suggestions shared by stakeholders during interviews in April and May 2020.

Key informants	**Question asked**	**Summary of suggestions given**
Victoria and Andreas Keding, NaDeet	From your experience at NaDeet, what do you suggest NUST does to save water?	Monitor water use and give rewards to low consumers.
John Pallet, SAIEA / NEWS	From your experience at SAIEA, what do you suggest NUST does to save water?	Develop monitoring and water conservation guidelines; erect public noticeboards displaying water consumption data; use water-wise gardening initiatives. Start in hostels raising awareness and educating. Screen midday movies. Give recognition to Enviro Club so it runs long-term. Change attitudes and show benefits in practical terms.
Gillian Maggs-Kolling, Gobabeb Research Centre	Are there any strategies or interventions concerning water that you find work well at Gobabeb in reducing water consumption?	Use videos with a short and punchy message. Posters and notices work well.
Hazel Milne, Eco-Awards	Are there any strategies or interventions concerning water that you find work well in reducing water consumption?	Explain the water situation and what appliances use. Competition for a water-saving plan for the campus, or an assignment.
Victoria and Andreas Keding, NaDeet	Are there any strategies or interventions concerning water that you find work well at NaDeet in reducing water consumption?	Familiarise administration staff with the consumption trends, and what is normal so problems can be identified. Employ a person dedicated to sustainability to take charge. The LIME GREEN (Less Impact More Education) programme audits participants but needs to monitor its staff too. NUST set the example.
Hazel Milne, Eco-awards	What do you suggest NUST does to save water?	Measure consumption, establish average use and set targets. Elect a champion in each faculty. Can use ordinary meters with a smart person employed to read them and given an incentive. Continuity is key. Install water flow

		reducers. Set a target usage. Channel run-off to trees and establish water-wise gardens. Remove baths in hostels and replace them with showers. Rewards could be credits towards a course or a free dinner for low use. Hold a competition between the hostels for per capita use.
Victoria and Andreas Keding, NaDeet	Is there anything NaDeet promotes or is intending to implement to save water that could be replicated at NUST?	Install smart digital meters - easier to read. Technical issues with manual reading, such as human error.
Hazel Milne, Eco-Awards	How does Eco-Awards measure the long-term impact of their measures and their success in encouraging saving water?	Key factors include targets, monitoring and reporting, evaluating successes and accountability.
Victoria and Andreas Keding, NaDeet	Do you have any systems and programmes from NaDeet that could be replicated at NUST?	NaDeet's Education for Sustainable Development resource material pack could be used during freshers' orientation.
Victoria and Andreas Keding, NaDeet	How could NUST and NaDeet collaborate and develop partnership activities?	Use Go Green funding to take tertiary students down to participate in the NaDeet programme, then work towards an awareness campaign at NUST upon return.
Gillian Maggs-Kolling, Gobabeb Research Centre	What do you suggest management, academic staff and students at NUST can do to help sustain their efforts for long-term success in becoming a greener University?	It takes motivated people to become a Greener University. Cooperation and buy-in of the staff and students must be gained.
Victoria and Andreas Keding, NaDeet	What do you suggest management, academic staff, and students at NUST can do to help sustain their efforts for long-term success	Appoint monitors and stewards to drive the greening programme - gain credits towards their course modules. Develop long-term awareness. Build monitoring into daily life. Percentage usage and trends published in a newsletter compiled by IT students. Make links

	in becoming a greener University?	with NEEN (Namibia Environmental Education Network).
Gillian Maggs-Kolling, Gobabeb Research Centre	More broadly what would your recommendations be to help move NUST towards becoming a greener campus?	Essential to have tangible, measurable outputs with recommendations to bring about real change.
Hazel Milne, Eco-awards	What can be done to help sustain efforts for long-term success in becoming a greener University?	Permanent staff employed to get green status. Encourage students to research the topic of greening. Greenness will become a branding for the University. Eco-awards can do an assessment.
Victoria and Andreas Keding, NaDeet	How can NUST achieve a green, environmentally friendly status	An EMP requires an integrated, cross-curricula approach with different expertise from each department employed to create a system and analyse data sets. Link to SDGs on clean water
Victoria and Andreas Keding, NaDeet	Can a NUST champions and stewards programme - replicate similar systems to NaDeet	Establish an environmental literacy system on the NUST website become for efficient updates.
John Pallet, SAIEA / NEWS	Do you feel that NEWS could contribute to finding a solution to the water problem at NUST or in helping it to achieve a green, environmentally friendly status	Submit a proposal to NEWS - N$12,000 available for awareness raising. EU could be approached to fund the installation of smart meters.

The findings of the interviews were in line with the findings of the lessons learnt in Australia (Patterson 2015), Cape Town (Ziervogel 2019), Botswana (M. Margolis personal communication, 21 Oct 2021) and Windhoek (D. Tolke, personal communication, 22 Oct 2021).

3.2.8 : Educating for Sustainable Development

In addition to suggestions from key stakeholders' introductory meetings were held with occupants of the three campus study sites to discuss the water situation and the best approach to raise awareness and

inform. The participants proposed that education for sustainable development could be incorporated into the Institutional Core Courses (ICC) (Figure 41), as well as in modules on Sustainable Development being made applicable to the different disciplines. Currently, the course syllabus shows that it covers renewable energy with no focus on sustainable water use. This could be used as a platform to educate incoming NUST students about water-wise measures and behaviour. These departmental representatives and environmental champions were supportive of placing more focus on environmental sustainability in their courses and are committed to the long-term greening of NUST.

Course Content	The course will cover the following integrated issues**:** **UNIT 1: Sustainable development** 1. Sustainability vs sustainable development 2. Sustainable development goals 3. Approaches and implementation of sustainable development 4. Environmental sustainability, health and waste management 5. Energy Management 6. Gender and sustainable development 7. Developmental designs

Figure 41: Sustainability and Development Syllabus SYD611S.

Currently, no mention is made of sustainable water use, or energy, during Freshers' orientation however the NUST Environmental Club leaders planned a water awareness campaign around campus as their first environmental project in 2020 in collaboration with CoW (A. Nangula personal communication, 15 Sep 2020). This did not take place due to the Covid-19 pandemic. A Memorandum of Understanding (MoU) was signed between NUST and the City of Windhoek in early 2019. The Water Marshal Training Programme at CoW, therefore, offers another opportunity to train people, staff, water marshals and Environmental Club members.

Further ideas on increasing knowledge, understanding and our environmental impact put forward during the study involved external stakeholders such as NEWS, NamWater, CoW and the Hydrogeological Association presenting workshops and conferences on a wide range of water-related topics, and the

acquisition of materials from other training and support organisations such as NaDeet and CoW to support these educational initiatives whilst NEWS could provide funding for materials.

3.3 : Results Objective 3:

Examples of best practices, adaptations and interventions made elsewhere, both in Namibia and abroad, were examined for successful approaches that could be applied to NUST to help it move towards becoming a greener, more water-wise and sustainable campus. Recommendations were drawn from these examples to aid the development of a WMS for NUST.

Table 6 summarises identified interventions which will be suitable for NUST to implement.

Table 6: Interventions and their sources.

Area of intervention	**Detail**	**Source**
1. Interventions to increase sustainability		
Strengthening institutional response	Systems approach to build adaptive capacity. Small-city approach applying lessons on a university scale. Strengthen governance. Recognise and adopt change. Integrate and actively manage the water supply system from the social, ecological, and physical perspectives. Institutionalise sustainability by practising and exemplifying it.	Ziervogel 2018, Shoup 2005, Too and Bajracharya 2015, Ziervogel 2018, United Nations 1993 Kosta 2017
Engagement at every level	Attain sustainable water management by building the capacity for learning at all levels from students to top management.	Crews 2010, Kosta 2017,
Ensuring successful implementation	Guidance from WEF-ISCN and Gulf Universities reports on how to establish strategies and the most successful approaches. UCT adopted a Green Campus Policy Framework and a Green Campus Action Plan addressing operational issues. UCT's model: Properties and Services Department were made responsible for implementing their charter. ISCN Charter three Principles 1.	ISCN 2917 Rippon 2013 Rippon 2013

	Sustainable Performance of Buildings on Campus. 2. Campus-wide Master Planning and Target Setting. UCT Environmental Management Working Group and a student movement, the Green Campus Initiative (GCL) ensure the strategy ensure strategy carried out and integrated into programmes and courses. 3. Integration of Facilities Research and Education to create a 'living laboratory' for sustainability across all faculties, relating policies to operational issues. The African Climate and Development Initiative (ACDI) supports innovative research and helped UCT accomplish its strategic goal of addressing the climate and development challenges of Africa. Green forums can be established to oversee implementation and adherence to strategies.	Rippon 2013 Bekessy *et al*. 2007
Addressing water conservation	UCT investigated digital water sub-metering technologies in 2013 and a Tridion smart building management system. Water-efficient sanitary fittings were retrofitted and established specifications for all new buildings were. Dams and water harvesting for irrigation, permeable paving and stormwater swales were instituted to promote infiltration and attenuation. Replacement of old pipelines and maintenance of water infrastructure and pipelines were recommended in Cape Town. Water monitoring and management. Waterwise technology reduced water costs in Spelman College, Atlanta.	ISCN 2013 Ziervogel 2019 Ziervogel 2018 Flho *et al*. 2015
Feedback and communication	Targeted communication strategy to impart technical information, facts and figures. Real-time digital and informative feedback effectively reduced water use in student dormitories in the USA. Set targets to promote efficient use.	Patterson 2015 Petersen *et al*. 2005 Patterson 2015, Ziervogel 2018

Active and decisive action in time	The UCT Sustainable Campus Charter Report predicted water scarcity, restrictions and tariff increases would stimulate a response. Mitigating action is needed before a crisis is experienced.	ISCN 2013 Rippon 2013
2. Developing a community of change agents		
Education for sustainable development	ISCN Sustainable Campus Best Practices report emphasises education underlies behavioural and operational adaptation. Recognition of the role's HEI's play in evolving into a sustainable society. The University of Exeter educates students to lead a resource-efficient socially responsible future. World Business Council for Sustainable Development emphasises the role of academia in achieving the goals of a sustainable society. Corporate responsibility drives employers to improve environmental profiles so seek environmentally educated graduates.	ISCN 2017 Lozano and Lozano 2014, UNESCO n.d. University of Exeter 2012 Lozano and Lozano 2014 Kosta 2015
Motives for incorporating SD into the curriculum	Forum for the Future encourages environmental education to create change agents to ease the transition to future sustainability. Fridays for Future is driven by students interested in the preservation of natural resources. UK Teaching Excellence Framework assesses the success of universities in equipping students with the required skills. Increased understanding leads to more sustainable consumption practices. Students should be equipped with knowledge for a sustainable future. Changing attitudes is essential, not just upgrading infrastructure. New degrees should build an understanding of environmental issues. Include more in the NUST curriculum to enhance understanding. Integrate ESD across the curriculum.	Forum for the Future (n.d.) Fridays for Future n.d. Petersen *et al*. 2005, Ziervogel 2018 Petersen *et al*. 2005, Lozano and Lozano 2014 and Kosta 2017 Petersen *et al*. 2005 Kambura 2019, ISCN 2017
Encouraging sustainability	Pro-environmental behaviour requires deeper understanding.	Fu *et al*. 2017 Wymer *et al*. 2014

	Outline methods on how to conserve not only providing feedback on use. A barrier to implementing SD into the curriculum in the UK is not being included in the institutional strategy.	Kosta 2017
3. Strategies for implementing sustainability		
Join green initiatives	Sustainability strategies with targets and aims. Guidance on best practices and most successful approaches to establishing strategies. Outline of measures to undertake and provision of networking opportunities. The Association of University Leaders for a Sustainable Future (ULSF) guide, the Sustainable Campus Charter (Appendix 6), assists in the development of a personalised charter or strategy for members. An outline of measures is provided and a network for sharing ideas and best practices Talloires Declaration 10-point action plan (Appendix 7) to ensure progress towards sustainability goals. Signing pledges encourage a greater commitment to realise goals. Progress must be regularly reviewed.	Kosta 2015 ISCN 2017 USLF n.d. ULSF n.d. ULSF n.d, ISCN 2017 Bekessy *et al*. 2007
Use best practice guides	Organisations that provide toolkits and guides to support the adoption of strategies include the ISCN Educating for Sustainability programme, the Blueprint for a Green Campus, the UNEP Greening Universities Programme, the UNESCO Global Action Programme, and the National Union of Students Green Impact accreditation programme. The Green Impact toolkit aligns with the University's ISO14001.	ISCN 2017, Stoss 1998, UNEP 2014, UNESCO n.d., Green Impact n.d,
Share experiences and ideas with other universities	Networking with other universities to share ideas as well as ISCN, Global Universities Partnership for Environment and Sustainability (GUPES), WRI and the Association of University Leaders for a Sustainable Future (USLF).	Too and Bajracharya 2015, ISCN 2017,
4. Greening NUST		

Integrated approach	A holistic trans-disciplinary approach is promoted and practised at universities such as De Montfort, UK. The World Green Building Council's (WGBC) criteria and goals ensure buildings are developed sustainably. The principles and strategies can be used for new developments and retroactively applied to existing buildings to achieve sustainability. Engage green experts in collaborative stakeholder-based master planning.	ISCN 2016 WGBC n.d. ISCN 2014
Measuring greenness	UI Greenmetrics World University Ranking Network (UIGWURN) provides indicators to measure the greenness of a university and its environmental impact using a ranking system and a baseline for the development of a strategy. One of the six criteria is water. Need to track performance and report to internal and external stakeholders to ensure accountability and progress.	UI Greenmetrics 2020 Filho *et al* 2015, Bekessy *et al*. 2007
5. Creating an enabling environment		
Seek out support structures	The UNEP programme 'Sustainability 2.0' and the GUPES partnership help universities pave the way for change. The Higher Education and Research for Sustainable Development (HESD) initiative strives towards sustainable development goals and can strengthen global partnerships. Ensure commitment, not just pledges so change is maintained beyond the expiry of declarations and charters. Evaluation by external parties. Full, visible and tangible support from management is essential for success. Make sustainable living part of the university ethos.	UNEP 2014 UNEP 2014 Bekessy *et al*. 2007 Bekessy *et al*. 2007 Ramisioa *et al*. 2019
Learn from best practices	Learn lessons from other cities and establish mechanisms to embed learning before the situation is critical.	Ziervogel 2019, CoW 2019c

Chapter 4 : Discussion

Sustainable water management was defined as using water without compromising ecological, social, and economic needs in the future. (Water Foundation 2020).

The 1992 United Nations Earth Summit Conference on Environment and Development in Rio de Janeiro adopted three main pillars of sustainable development which were economic, social (also including culture), and environmental sustainability (United Nations 1993) that incorporate approaches, programmes, actions, and initiatives, aimed at the long-term safeguarding of resources. Behavioural studies (Wymer *et al*. 2014, Lozano and Lozano 2014, McGibbon and van Belle 2015) suggest environmental knowledge influences sustainable behaviour. This study focused on environmental and economic sustainability which requires education, knowledge, and skills development, that relate to social sustainability. Even though NUST is a training institution and has a some programmes directly relating to sustainable development and natural resource management, they are not cross-curricula and there are only a few ad-hoc activities which address the universities' adherence to environmental sustainability. This is not only a shortcoming in compliance with the EMA (2007) but also misses out on opportunities for substantial financial savings.

4.1 : Discussion Objective 1:

The focus of objective 1 was to assess sustainable and unsustainable approaches and behaviour in relation to water consumption on the NUST Campus. Statistics from CoW indicate NUST was amongst the top 40 water users in Windhoek in 2019 (D. Tolke personal communication, 3 Oct 2019), and an analysis of historical municipal water bills signifies the scale of unsustainable resource-use practices at the university. High water consumption periods are largely attributable to leaks, burst pipes and problems with sanitary ware which can be addressed. A more recent analysis in October 2021 of the 84 highest water consumers in Windhoek, D. Tolke (personal communication, 22 Oct 2021), did not contain NUST on the list. The closure of the University for parts of 2020 and 2021 due to the Covid-19 pandemic could explain the improved consumption rates. In addition, the survey which was done within this Master's resulted in increased awareness through the water audits and meter readings, together with the new more proactive approach to maintenance by the Facilities Department. This could all have partially contributed to the improvement and more sustainable use of water. Just monitoring water use has been found to have a profound effect on water use in studies by Gilley *et al*. (2006), Nehemia (2017) and Ndinoshiho (2019).

The results of the observational information, metering data collection and the survey allowed for a qualitative comparison of perceptions and water use behaviour. Positive attitudes towards responsibility and environmental and economically sustainable solutions were noted. Willingness to be involved in implementing plans, educating, and devising techniques and technology that would monitor and curb water consumption was taken to indicate a readiness of some to change behaviour and encourage good behaviour in others. However, the willingness and concern for water loss expressed in the survey did not always correspond directly with water management or water conservation practices observed. There was evidence of significant water wastage incurred by leaks and burst pipes, through carelessness and a lack of proactive maintenance. Only at the Hotel School, were there clear management practices and behavioural correlations. Wymer *et al*. (2014) found that changing behaviour is often difficult, even if there is a willingness to do so, practical examples of how to do it need to be provided. Particularly in water management, even when water levels are critically low, people do not react accordingly (Ziervogel 2019).

4.1.1 : Unsustainable practices

The Portuguese experience described in a study on water efficiency in buildings concludes that efficient use of water should be an environmental priority in all countries because the availability of water could be significantly reduced in future (Silva-Alfonso and Pimentel-Rodrigues 2011 p. 23). This is validated by the need for compliance with the Environmental Management Act (GRN 2007) in Namibia to have an Environmental Management Plan. Since the beginning of 2021, more focused monitoring of water costs at NUST has led to investigations into a more sustainable and holistic approach to its management. Active water management and monitoring are what ISCN (2017), WRI (2019) and CoW as well as studies conducted at NUST and by NUST students elsewhere have concluded are essential (Nehemia 2017 and Ndinoshiho 2019). Knowing the consumption and managing the water provision and payment systems, allows for control, proactive maintenance, and improvements to be made (Filho *et al*. (2015).

4.1.2 : Flow rates and leaks

Water reticulation plans are not available for much of the campus. Plans are required for proactive maintenance, repairs, and renewal of the infrastructure, and the development of an infrastructure maintenance plan. The current system requires shutting off the whole campus to fix a leak or burst pipe, which the installation shut-off valves would avoid. Ndinoshiho (2019) references the Integrated Water

Resource Management Plan (IWRM) of 2010 saying water losses through the water reticulation system are seen as one of the biggest challenges of water resource management in Namibia. The City of Cape Town replaces 60km of old pipeline a year as part of a water reticulation system maintenance and rehabilitation programme (Sinclair-Smith and Winter 2018). Pipe replacements reduce water loss and save on costs. Older pipelines tend to have more leaks and burst more easily (Sinclair-Smith and Winter 2018). Despite water being scarce in Namibia, it appears NUST underinvests in ageing pipelines and sanitary fittings and rarely maintains or replaces them. Leaks were often fixed but if they occur underground or during the holidays, they could go undetected (S. Katurota personal communication, 7 Dec 2021). Actions and measures to control and reduce consumption can be assisted by lowering the water pressure in the system as was done in Cape Town as part of their 2007 water conservation and water demand management programme in response to climate change (Sinclair-Smith and Winter 2018). Reducing pressure also reduces the likelihood of burst pipes. The high consumption in January 2017 at Lower Campus and January 2019 at the Hotel School, was postulated to be as a result of the sudden surge in water volumes and release in pipe pressure after the December break resulting in burst pipes. The Hotel School Manager confirmed it was an annual event, however, nothing had been done to reduce the sudden flow after the long period of closure (L. Liebenberg personal communication, 27 Oct 2021). A mitigation strategy identified during the study was to introduce a pressure-reducing valve to lower water pressure and to stagger the start of the semester in January to prevent the surges in water volumes from creating a pressure build-up (L. Liebenberg personal communication, 27 Oct 2021). No emergency maintenance team is appointed to attend to leaks and plumbing problems during periods of closure such as in December 2021 thus leaks went unattended until the University opened. The outcome was frequent costly leaks and burst pipes during the holiday periods. Provision could be made for this with a plumber on standby for emergency callouts since several of the major leaks identified during this study occurred when no one was on hand to fix them.

The charges on the municipal invoices were not questioned in the past, despite the fluctuating and overall high-cost utility bills. However, by checking the flow rate on meters, leaks are discovered. When no one is on campus a moving meter is a clear indication of a burst pipe or leak. This is particularly apparent at night so checking night flows can reveal problems Gilley *et al*. (2006) found in their study on water conservation in Windhoek schools. This was confirmed by studies conducted by two NUST students at two schools in Windhoek and Gobabeb Research Centre respectively (Nehemia 2017 and Ndinoshiho 2019). The recommendation of the water demand management study at Gobabeb, (Ndinoshiho 2019) was daily

monitoring of water consumption. Gilley *et al*. (2006) found that fixing leaks promptly reduced water consumption by 40% per year on average. This is the same amount that CoW calculated they saved in its own water management programme, (D. Tolke personal communication, 22 Oct 2021). These studies demonstrate the value of self-metering and monitoring water on a regular, preferably daily, basis.

4.1.3 : Broken meters

Daily monitoring and being watchful of night flows, not only enables the immediate identification of faults and leaks and the avoidance of wastage but also helps identify broken and faulty meters. Many analogue meters found on internal water supply lines within the campuses at NUST were defective so they cannot be used to check flow rates. Ageing and broken meters went unrepaired for over 1.5 years and arrears, stuck charges and interest paid on the CoW municipal bills, were accepted and paid without any apparent investigation of the reason for it according to O. Quarmby (personal communication, 28 Oct 2021). The results of water consumption analysis and data manually captured by staff members at UCT demonstrate the unreliability of the data drawn from municipal bills where estimates and billing reversals were common. This was enhanced by faulty and broken municipal meters that often went undetected for long periods. The Charter report concludes that until digital metering and monitoring is implemented, management of potable water consumption at UCT is likely to remain a challenge (Rippon 2013).

4.1.4 : Consumption patterns

A pertinent study of the water and energy consumption at NUST derived from 2015 to 2018 municipal bills by Kambura (2019) concluded that more accurate metering and readings were required to improve the reliability of water consumption data. Kambura (2019) deduced that annual water consumption patterns were erratic and, in his analysis, were non-linear and thus followed no continuous trends. He also assumed that some inexplicable consumption peaks in 2016 and 2017, could only have been explained by unattended leaks on a supply pipeline or poor water use. He determined that, with the exception of years with extreme peaks, NUST consumption patterns varied with changes in campus activities and student population. The assumption throughout this study is that water consumption fluctuates between weekdays and weekends, times when the University is open and closed, and between practicals and lecture periods. The results of this study corroborate the earlier findings and show that use continues to be non-linear. It also indicates that the lack of explanation for high use and lack of interpretation of water use patterns by NUST staff is a long-term issue. Despite the recommendations, no

ongoing analysis was initiated as a result of Kambura's (2019) study so the ensuing peaks in use remain inexplicable at times when DICT plumbing reports did not indicate a leak or were not available.

4.1.5 : Targets

At NUST no targets are set for daily and monthly consumption indicating what is acceptable use and no alert procedures are in place. There are no follow-ups made on heavy use so no one is aware of the overuse nor encouraged to do anything about it.

Targets help set a maximum acceptable water consumption level so departments can review and monitor their success and therefore strive to remain within the acceptable limit as was found by Ziervogel (2019). A measure of accountability with assessments performed by the Facilities Department would help future sustainability. Departments at NUST can be incentivised through funding for green projects if savings targets are met. Barometers such as those used during the Day Zero campaign in Cape Town (Ziervogel 2019), introduced an element of competition as well as alerting the population to the seriousness of the situation and progress made towards averting the crisis. Without maximum daily water consumption targets NUST cannot monitor the impact of their water conservation efforts. An average per capita consumption estimate would assist in target setting. Targets need to be adapted according to the predicted demand of different departments and displayed to encourage the NUST population to reach the targets with red-flag alerts raised when daily consumption is exceeded. Target setting for reduced use was found by Ziervogel (2019) and (Patterson 2015) to be an effective measure in reducing water use. Information from a smart meter can be sent via a cell phone or computer to Heads of Departments who then take responsibility for their departments' water consumption, thus promoting some accountability. Measures must be set in place to ensure that they are met to adhere to the CoW recommended daily limit (CoW 20). Currently, there are no repercussions for incurring excessive water use other than those implemented by CoW with higher kilolitre (kl) costs.

4.1.6 : DICT reporting system

The accuracy of the maintenance reports submitted to DICT on the ITS Service Desk system has some shortcomings for data analysis. It also requires manual sorting. Improvements in data capturing would allow the generation of graphs and reports that highlight the most common problem areas to be addressed by the maintenance team. Some refinements were suggested such as modifications to the

interface, and improvements in the reporting system so problems are collated under categories (Appendix 8). Modifications will then highlight hot spots and problem areas that require maintenance or replacement of infrastructure. DICT problem reports allow narrative descriptions. Ticking a drop-down checklist facilitates more efficient analysis. Immediate completion of the online reports after repairs are completed will indicate the time between reporting, response and resolution of the problem by the maintenance team and help ensure repairs are enacted as quickly as possible to reduce water loss. The Facilities Director O. Quarmby (personal communication Oct 2021) indicated that the resolution time is often completed in bulk at the end of the month rather than after each problem is resolved so outstanding issues are obvious on the system. Use of a mobile device would enable real-time reporting and ease the completion of the DICT report process. Overdue and outstanding plumbing issues would become easily identifiable by the maintenance team and would serve to inform those who reported the problem if they have been addressed. By streamlining the data collection and data storage system the use of the DICT Service Desk problem reporting system would be broadened to become a tool for the management of the University Campus infrastructure and facilities.

4.1.7 : Hot spots

Comments in the survey and analysis of the DICT Service Desk problem reports revealed that excessive water wastage is more often closely linked to decaying infrastructure than misuse, except for the hostels where anecdotal evidence from matrons and cleaners in June 2019 revealed that students enjoy full baths and take long showers exhibiting poor water-wise behaviour. The plumbing problem reports revealed what problems occur most frequently and in which buildings. The priority areas were the showers in the men's hostels, replacing old pipes, installing new water-efficient sanitary ware in the hostels, Science and Technology building and the Library and Resource Centre first, followed by upgrading of facilities in the old Engineering building, Poly Heights block and the Hotel School. The study conducted at Botho University by M. Margolis (personal communication, 21 Oct 2021) and at the University of Wisconsin-Madison (Uelmen *et al*. 2020) substantiates the suggestions for infrastructure upgrades to generate savings.

The unstudied buildings and infrastructure on the Lower Campus are older, with the exception of the Library and Information Services building which, DICT reports indicate, is highly susceptible to burst pipes, leakages or fitted with inefficient water use appliances. This could serve as an explanation for the

inconsistency and minimal proportional use between the two Lower Campus buildings, Architecture and Engineering, and the Lower Campus as a whole.

4.1.8 : Water marshals

This study demonstrated the inaccuracies of manual reading which are subject to human error, particularly when undertaken by untrained personnel. The CoW Water Marshal Programme assists water meter readers to provide a useful monitoring and leak detection function until digital systems are installed in all buildings. Inaccuracies of manual metering experienced during the study period nevertheless validate the suggestion that smart meters provide more accurate and reliable data therefore should be installed. This confirms Rippon's (2017) expectations that replacing manual data collection with automated metering resulted in increases in accuracy. Many litres of water could have been saved during lockdown and periods when the University was closed such as in December 2020 and December 2021 had smart meter remote shut-off valves been in place. However, CoW has not indicated any intention to digitalise their system thus the analogue main meters will remain emphasising the need for alternative methods to cross-check CoW readings. On a smaller institutional scale, it is also appropriate for NUST to consider digital solutions since consumption patterns are not monitored, nor is information on use provided to users. By optimising and automating the NUST water provision and monitoring systems water consumption can be more carefully controlled, targets set, and demand met without wastage and therefore savings made.

A major shortcoming found in this study was that no person or persons are dedicated to environmental management or sustainability at NUST. The Greening Universities Toolkit (UNEP 2013) and the UCT Green Campus Action Plan (Rippon 2008) indicate the value of having a person dedicated to environmental sustainability whose position can be covered by the savings from the more sustainable use of resources at the university. Environmental stewards assigned to receive the signals and data from the smart meter and report leaks when the system raises alerts could increase sustainability at NUST. Electricity can be monitored in the same way and share the AMI system reducing the costs of regular maintenance and administration over time O. Quarmby (personal communication, 28 Oct 2021).

Sustainability could be improved if active water management, monitoring and maintenance is undertaken. By allocating the responsibility of monitoring and analysing usage presented on the AMI

system to environmental stewards, overseen by environmental champions, and examining the trends high-water use buildings will be pinpointed. The problem areas and hot spots highlighted through the monitoring system can be cross-referenced with the DICT reports and the situation addressed with maintenance and replacement of old infrastructure.

An *Assessment of Future Water Efficiency Measures in the State of Victoria in Australia* concluded that digital metering with its monitoring and control functions and the capability to address demand management, provide consumption data and evaluate the impacts of water optimisation activities will be a fundamental need in the future (Liu *et al*. 2017).

4.1.9 : AMI and smart meters

The pilot project initiated by this study using smart meters installed by Artemesiot at the new Engineering building and the Architecture building predicted substantial water-savings as a result of the AMI technology.

Consumption was unpredictable during the study period however, leaks in the two buildings were detected more rapidly and reported. A big leak underground in February 2021 took a few days to detect and repair as it was not picked up on the manual readings according to S. Katurota (personal communication, 7 Dec 21). The very high consumption, 7175 units was, therefore, the loss was assigned to a leak on the second fire meter measured by CoW. Smart meters negate the need to physically survey the campus for leaks and would enable more accurate identification of where the fault lies as was found in a campaign, Smart Water Meter Challenge, in Cape Town where Dropula smart meters were installed in 196 schools (Booysen *et al*. 2019). The automated feedback alerts the recipient to peaks in use and consumption that do not comply with the usual consumption patterns. Constant monitoring, as recommended by CoW in 2019, can result in reduced water consumption since awareness of how much is being used is more overt in turn prompting more sustainable behaviour whilst encouraging the attainment of goals if consumption is visually displayed and targets publicised (Abrahamse *et al*. 2007). The online AMI customer Utility Portal provides consumption information indicating weekly, monthly and annual usage patterns which enables target setting. The frequency of the readings on the AMI system can be altered to suit the circumstances and can be calibrated to activate the alert system after the target usage limit is exceeded. The data collected can assist in the targeting of efforts to curb overuse and

manage water more sustainably. Similar monitoring has resulted in significant improvements in water use as found by Gilley *et al*. 2006 and Nehemia 2017.

Over the past few years, the CoW has encouraged the submission of own water and electricity meter readings on a monthly basis. This provides the user with a measure of control since manual meters must be physically read and readings texted to the municipality. Smart meters can reduce the margin for errors in readings. Since the beginning of 2021, the Facilities Department scrutinises water charges more closely. Measuring water use and self-metering enable monitoring, management and control of use and water costs by the University. Cross-checking units used with CoW invoices help ensure the correct amounts are being billed for enabling budgeting for water and sewerage payments. The data provided by the smart meters were more accurate and reliable water consumption information than that collected from manual meter readings and CoW invoices. In addition, it also raised alerts if leaks occurred, or the meter malfunctioned. The advantages of smart meters with a live dashboard are borne out in their consistency and non-reliance upon human intervention with its associated human errors. Manual meter reading involved time-consuming inputting and plotting of results and is prone to errors.

The use of smart meters, providing the option for advanced metering and monitoring, is becoming essential and will be used for demand management providing personalised water consumption data and helping optimise water systems (Liu *et al*. 2017). They are also becoming the norm in Windhoek where key institutions have installed them, such as hospitals, banks, Wernhill shopping Mall and MTC B. Chiwome (personal communication, 5 Nov 2020). The installation of additional meters would enable closer monitoring of water use and alerts to leakages and faulty meters resulting in cost savings, therefore, promoting not only environmental but also economic sustainability. A Tridion smart building management system is being investigated at NUST that will aid the management of electricity and can integrate water into it, O. Quarmby (personal communication Oct 2021). This will promote the more integrated management of resources.

Refurbishment and replacement of old pipelines and water infrastructure would enable the installation of smart water meters on supply lines to individual buildings. The smart meters help track daily use, and consumption patterns, facilitate target creation, identify overuse or high consumption and pinpoint hot spots. Notification is also received automatically if the meters fail to aid fast corrective action B. Chiwome (personal communication, 5 Nov 2020).

Smart meters have been successfully installed in some household residences, institutions and companies in Namibia. They have demonstrated immediate positive effects on water consumption, and water management, and resulted in an overall reduction in expenditure on water according to B. Chiwome (personal communication, 5 Nov 2020). The AMI system's leak alert function is based on an algorithm that provides the option to shut off the valve remotely in an emergency thus making it easier to prioritise maintenance. A study in households in the USA found convincing evidence for the value of leak detection analytics and alerts in minimising water loss and damage caused by leaks (Schultz *et al*. 2018). Water consumption in the two focus buildings was read remotely during the study, and leaks such as those in December 2021 were detected immediately. If needed the water shut-off valve can be activated from a computer B. Chiwome (personal communication, 5 Nov 2020). Data, units used, and graphs were all automatically generated in user-friendly digital formats that could be downloaded and analysed. Smart meters provide instant, easily interpreted, reliable data and analysis was more time and energy efficient than the analogue variety. In the 2014-2015 Campus Charter report UCT noted water consumption units drawn from municipal accounts were unreliable, leading to inconsistent performance data and recognised digital water sub-metering technologies were needed to address the issue (University of Cape Town n.d.). Based on the results of the study leak detection and response were easier using the AMI system, and due to its digitalised nature, flow rates were easier to monitor.

4.1.10 :Water-efficient technology

The University of Wisconsin-Madison Office of Sustainability manages a Green Fund intended to reduce operational costs and the environmental footprint of the facilities (Uelmen *et al*. 2020). Students design, propose, and implement projects. A proposal from one student involved the upgrading of toilets in halls of residence on campus to assess the impact and potential for further upgrades resulted in substantial savings.

The retrofitting of water-efficient technology has demonstrated substantial water savings elsewhere. Water conservation was partially addressed at UCT with the retrofitting of water-efficient sanitary fittings. All new buildings at UCT must adhere to these specifications. Waterless urinals were piloted in 2012/13 and found to save water though maintenance costs did not allow for any economic gains (Rippon 2011). Though difficult to measure at NUST, at smaller organisations where the meters have been installed and consumption monitored there is indisputable proof that the new appliances result in a reduction in water

consumption, M. Margolis (personal communication, 21 Oct 2021). This was supported by D. Tolke (personal communication, 22 Oct 2021) and Gilley *et al*. (2006).

Old toilets and sanitary fittings at NUST are associated with leakages that could amount to large volumes of water lost (D. Tolke, personal communication, 22 Oct 2021). In an effort to reduce water consumption through water-efficient technology, the City of Windhoek Bulk Water and Wastewater Division installed waterwise taps, and toilets in their building and achieved a 40% reduction in water consumption according to Tolke (2021). Through further active management and daily monitoring of consumption and addressing leakages effectively they achieved an additional 50% reduction in water use. Leaking toilets alone account for one-quarter of household water losses (>10kl/day) (D. Tolke, personal communication, 22 Oct 2021). This process has an estimated a cost recovery period of less than three years if water-efficient appliances are adopted. In addition to the installation of water-efficient equipment at Pupkewitz Megabuild, the CoW ran one of its water marshal training programmes there in 2020. The training had a dramatic effect that reduced water consumption by 50% (D. Tolke, personal communication, 22 Oct 2021). Similarly, at the Namibia Qualifications Association, the water marshal trained under the programme reported a decrease of more than 19% in water use in just four months as a result of awareness-raising and monitoring efforts (Rasmeni 2017). Water demand management at UCT was partially addressed through the retrofitting of water-efficient sanitary fittings and installation in all new buildings (Rippon 2013).

Sanitary fittings at NUST do not comply with CoW recommendations for businesses of reduced cistern capacity (<6l) and low-flow taps (<2l per minute). The Portuguese experience emphasises that greater attention must be given to the use of water-efficient products as they identified that toilet flushing cisterns are one of the biggest water consumers (Silva-Alfonso and Pimentel-Rodrigues 2011). Water-wise technology and bathroom appliances have been shown to dramatically reduce water consumption. Pearl Water-free technology reported savings of over 75% made at Botho University in Botswana as a result of the installation of water-efficient appliances M. Margolis (personal communication, 21 Oct 2021). Water-efficient technology is proven to reduce water consumption, (Uelmen *et al*. 2020). The technology has been pilot tested at NUST. The 2020 pandemic and University closure, combined with the inability to isolate and independently meter the lecture building where the appliances were installed meant a drop in consumption, and therefore the result of this pilot project could not be determined. However, Pearl Water has proved these methods of reducing water use to be effective in many other institutions in Namibia M. Margolis (personal communication, 21 Oct 2021). Margolis recommends low-flow taps, mist

and tap aerators, shower regulators, toilet blocks reducing the capacity of the cistern, smaller cisterns and waterless urinals. All indications from successful instalments elsewhere such as in Windhoek schools (Gilley *et al*. 2006) suggest that the rolling out of the current pilot project would be beneficial both for environmental and economic sustainability at NUST. Research by Gilley *et al*. (2006) revealed that 16% of taps and 19% of toilets leaked in schools and that the cost of repairs to them could be recouped from water saved within just 9 days from taps and 85 days on toilets. This is a strong incentive to repair and retrofit more water-efficient infrastructure (Gilley *et al.* 2006). Retrofitting water-efficient technology would result in significant economic returns, as identified by Silva-Alfonso and Pimentel-Rodrigues (2011), but a delay can result in gross waste of water, which is not compliant with requests from the CoW to use water sparingly. Upgrades at NUST could result in significant financial and water savings thereby also improving resilience to droughts.

Interventions required to increase sustainability in the future would include replacing old reticulation infrastructure and pipelines, and the installation of water-efficient technology throughout the campus (Ziervogel 2018). According to Filho *et al*. (2015) Spelman College in Atlanta, USA saved roughly US$200,000 in utility costs by reducing water use and energy consumption in a year. The investment cost for changes was estimated to be US$150,000, thus the cost of investment was recouped in less than a year. This illustrates how decreasing wasteful practices and reducing consumption through green measures can save money as well as conserve resources. Arguably this scenario could be mirrored at NUST through water-savings by utilising water-efficient technology in addition to smart meters with real-time wireless AMI data monitoring systems that identify leaks immediately and give frequent updates on water consumption.

Survey results in this study indicated support for installing water-efficient technology. However, change cannot be made in isolation but implemented in combination with the upgrading of the water reticulation infrastructure, and improved management of water consumption and, importantly, education such as was done at the two universities in South Africa (Rippon 2013 and SU 2018). Consumers need to be reminded to use less water. Setting targets for water use and making them public as it is accepted that information encourages more sustainable behaviour (Patterson 2015). Leaks from burst pipes and careless use can outweigh what is saved with water-wise technology. Water-wise technology reduces the demand for water resulting in greater sustainability and will effect a change before water awareness and education instils a behavioural change (D. Tolke personal communication, 3 Oct 2019). This in turn reduces the stress

on water supplies in the city. Ideally, however, an understanding and appreciation for the water situation and the need for the technology should be increased to have a more substantial impact and to lead to a situation of smart technology and smart people.

4.1.11 : Recycle, reuse

Pro-environmental measures such as reducing the demand, recycling and reusing water have been adopted and found effective in universities such as Stellenbosch (2018). These waste recycling principles can also be applied to efficient water management in a building to reduce consumption and loss of water (Silva-Alfonso and Pimentel-Rodrigues 2011).

The WRI Aqueduct study (WRI 2019) outlines three basic measures that can be taken to reduce water stress. Two of the three, investing in grey and green infrastructure, and treating, reusing, and recycling water can be applied at NUST on a smaller scale to both provide an additional supply and reduce the amount consumed. Effective recycling of grey water for use in toilets was done at Stellenbosch University (SUFMPS 2015). Rainwater is harvested from the roof at UCT and stored in tanks below the building, saving 300 m^3 of potable water per annum (Rippon 2013). In addition, other successful water-saving methods employed at Universities in South Africa as part of ecologically sustainable (SUFMPS 2015) and green campus initiatives (Hall and Murray 2008) include rainwater harvesting for building, car washing and laboratory purposes, capturing, diverting, and channelling rainwater onto plants and vegetated areas to save on irrigation. Permeable paving replaced the impenetrable top surface layer at Stellenbosch University (SUFMPS 2015) and ditches and swales flanked by ridges promoting infiltration were created to capture and divert excess water for use on vegetated areas. Similarly, permeable paving and stormwater swales were created as part of the UCT Green Campus Action Plan to promote stormwater infiltration and attenuation and irrigation of gardens (Rippon 2011). Combining waterwise technology, reusing wastewater and recycling rainwater and redirecting it for irrigation, use in toilets and laboratories reduces the amount of water used before it is recycled and reused. In so doing this helps reduce the overall demand for water.

4.1.12 : Reducing municipal costs

The Hotel School has made significant steps to save water not only because they are personally concerned about their environmental impact, but also to ensure greater economic sustainability of its entity. As a

commercial enterprise, the Hotel School is responsible for covering its own costs. A survey conducted by Peterson *et al.* (2005) on water used in dormitories in the state of Indiana in the USA found that consumers not personally responsible for paying the bills are not as incentivised to conserve water as there are no 'personal' savings to be made. This case highlights that at the other departments and faculties at NUST, the value of saving water resources needs to be 'personalised' in order to motivate water-saving actions. Potential benefits of their actions such as meeting targets could result in increased effort.

Fire-pipeline meters

The results of the investigation established that the combination meter functions are currently combined but could be split into fire and non-domestic use, and the fire meter and larger water pipelines associated with them used for emergencies only at a much lower monthly basic charge (D. Tolke personal communication, 22 Oct 2021). Basic water tariffs increase as per the diameter of the offtake pipe. Any line >80mm such as the fire meter supply line used regularly carries the highest basic monthly municipal basic water tariffs of N$18,713.84. These are currently being used unnecessarily. If these combination meters were split, the charges would be significantly reduced with the fire meter basic water tariff at N$2,100.00 a month and basic charges of N$2,338.93 for a 50mm meter for non-domestic consumption rate. The fire meter also only reads kilolitres so more accurate usage, and smaller leaks, cannot be monitored. Further savings can be made as it is only a provisional supply requiring less maintenance. Savings recouped from CoW, for unnecessary water loss and use of fire meters could be reinvested in smart meters to improve long-term monitoring capabilities suggested O. Quarmby (personal communication, 28 Oct 2021). This not only promotes greater economic sustainability but frees up funds from operational costs for capital investments such as water-efficient technology for long-term sustainability.

Sewerage charges

The CoW bills for actual water consumption volume in kilolitre units. A sewer volume is also charged calculated at 85% of the water consumed. A positive move towards reducing water consumption on campus has a dual financial impact by reducing the amount paid to the City of Windhoek monthly for water and the related sewerage services thereby facilitating the investment in further green technologies and building both economic and environmental sustainability. It will also have a positive effect on water-savings for the city in addition to encouraging greater commitment to sustainability amongst the NUST population. Efforts made by large institutions will help build the city's resilience to droughts in the future

and help with preparedness so a crisis response, such as that experience in Cape Town with Day Zero and the near miss of the same situation in Windhoek in 2019, can be avoided.

4.1.13 : Towards more sustainable management

UNESCO (2020) states it is our social responsibility to preserve resources for future generations and to acknowledge that what we do can have an impact on others, thus, we have a duty, recognised by the Namibian Government, to use resources wisely now.

Since 2019 was a year of severe water scarcity (CoW 2019b), it was a time when the CoW undertook many drought awareness campaigns (CoW 2019b). However, it does not appear to have had any effect on reducing water use at NUST's Upper Campus where consumption was higher than the previous two years. Despite acknowledging in the survey Namibia is an arid country prone to droughts, water conservation behaviour is not wholly borne out by the statistics. The Hotel School is an exception where it had a higher occupancy but lower per capita usage. As previously mentioned, since water use is related to the financial sustainability of the Hotel School, a concerted effort was made to manage and reduce water consumption, and this was successful.

Awareness raising has changed behaviours at the Hotel School confirmed by the Manager in several face-to-face interviews in 2020 and 2021. Awareness was promoted through visual materials, talks and workshops encouraging pro-environmental behaviour. Additional mitigating actions such as monitoring the water consumption, water-saving measures implemented in the guest bathrooms, and the fire line blocked off strengthened the drive to reduce consumption. These efforts and the impact they have had indicate that pro-conservation knowledge in the Hotel School goes hand in hand with pro-environmental behaviour. This corresponds with findings from a study in the Netherlands that confirmed that people must understand their needs and the significance of their behaviour before they will act (Abrahamse *et al*. 2007).

The study of water use and water management on campus revealed that efforts were made by individuals but there was no integrated approach to monitoring and managing water use by management. As a result, there was little knowledge regarding consumption or costs. The integration of water-efficient strategies is partially reliant upon improved economic sustainability to make it affordable. More cost-effective

decisions will result in savings. Active metering and monitoring of water use are recommended by CoW; however, it is the responsibility of consumers to do this (CoW 2019a). This requires active management, maintenance, and systems in place to ensure it is done effectively. The baths still present in the hostels, taps and toilets left running, no visible attempts made to recycle and reuse water, incomplete knowledge of the water reticulation system, delayed responses to leaks and plumbing issues, dysfunctional meters, reactive rather than proactive maintenance, no monitoring of water use, lack of scrutiny of the municipal utility bills and no targets set for maximum use indicates a lack of appreciation for the impact of water loss and long-term availability of water in the city. The results of the investigation give solid grounds for the development of a WMS, not only to become more environmentally sustainable but to take a step towards the formation of a broader EMP in compliance with the Environmental Management Act (GRN 2007). A holistic and integrated systems approach, as inferred by the Act (GRN 2007), is required to collectively manage water in a coordinated and informed manner, and, equally as important, to promote resource use in a more economically sustainable manner. The outcome of more sustainable water use will be a move towards a greener campus.

4.2 : Discussion Objective 2:

This section of the study aimed to determine the attitudes and perceptions of the water-related environmental issues at NUST and support and suggestions for sustainable green campus initiatives using an online survey and semi-structured interviews.

Ham *et al*. (2016) describe environmental awareness as an attitude concerning the environmental consequences of human behaviour. They propose that awareness may precede the behaviour, however, pro-environmental behaviour is not necessarily a consequence of awareness which often needs more motivation or knowledge. Likewise, pro-environmental actions do not necessarily emanate from an appreciation of the environment (Ham *et al*. 2016). Knowledge of the impact of behaviour on the environment appears to be a precursor of pro-environmental behaviour. Therefore, in relation to NUST evidence or observation is a more reliable indication of pro-environmental behaviour than expressions of support or descriptions of environmental behaviour in the survey and online DICT reports. However, this relies on the behaviour being overt and relevant. In this survey no instrument was included to measure understanding thus environmental awareness was assumed to be the same amongst all respondents and it accepted respondents' classifications of knowledge and support with no examination of the depth.

There were some limits on the amount of information gathered during the survey, but it provided sufficient data to discern people's attitudes towards the water situation and their interest in knowing more. Examining the level of environmental awareness could form the basis of future research.

4.2.1 : Relationship between attitudes and actions

The survey was available online for any NUST staff and students to complete. It did not contain itself to the two focus buildings and Hotel School whose water consumption was more closely monitored. Had it been possible to determine the occupancy and frequency of building entries before, during and after the study period differences in water use after the survey was conducted could have been measured. Wymer *et al.* (2014) surmised that their final questionnaire run after a period of awareness raising and monitoring of the impact was completed had the effect of passive awareness which prompted an active behavioural response after the study period was over though that had not been the intention. It was an inadvertent consequence of the questionnaire, and indeed, had the NUST survey not been conducted during the lockdown a similar effect on water consumption might have become evident.

The survey conducted for this thesis indicated that 96% of the people felt they all have a responsibility to solve the water crisis which would indicate that they have a strong personal commitment and willingness towards changing wasteful behaviours, reducing water use, devising new technology, and promoting awareness. Comments drawn from these DICT reports corroborate this and indicate people on campus are genuinely concerned about the loss of water when leaks occur. The water marshals and departmental staff who participated in data collection activities displayed a keenness to report wastage as did those who competed and submitted water audit log sheets. Irritation expressed in the descriptive section of the DICT Service Desk reporting system inferred that some of the NUST population are careless and laissez-faire in their water use. Survey proposals, such as offering to check bathrooms before leaving the building at night and behavioural observations indicated that care is not taken to ensure taps are turned off and cisterns are not left running. Others complain that the problems are not attended to with enough urgency, demonstrating concern for water loss, and pro-water conservation thinking. Nevertheless, insufficient, or inefficient efforts to prevent or resolve plumbing problems show a poor attitude in certain sectors towards the protection of the scarce resource. The initiatives taken at the Hotel School provide an example of what can be done by departments on campus that take responsibility for their impact on both economic and environmental sustainability. Awareness on this site is more closely reflected in their behaviour.

The responses to questions probing people's attitudes and understanding of water-related environmental issues at NUST indicated that there was a high degree of concern about water use at NUST. Only 25% were neutral, not concerned or did not know how concerned they were about the water situation in Windhoek as a whole. At the Hotel School, where there are more efforts made to inform students, staff and guests and measures taken to reduce water consumption, a greater level of concern was expressed.

Knowledge and an understanding of the consequences of behaviour influence behaviour (Too and Bajracharya 2015). Environmental knowledge has been found to encourage pro-environmental behaviour though other factors, such as attitudes and satisfying emotional needs, also influence behaviour (Hartmann *et al*. 2016). Greater knowledge about the water situation, dam levels, where Windhoek's water comes from, and the impact of lower rainfall and extraction from aquifers could inform people's decision-making and encourage more sound practices since it is proposed that cognitive factors such as knowledge of the environment, influence affective factors such as environmentally conditioned decisions (Hartmann *et al*. 2006). Wanting to know more about the water situation was cited as important by 73% of the NUST survey participants, almost equally split between men and women. The aim of the International Decade for Action: Water for Sustainable Development is to inspire action to achieve the particularly water-related SDGs, by easing access to knowledge and the exchange of good practices (UNHLPW 2018).

Evidence that awareness raising and ESD were necessary came from the lack of understanding of the climate and long-term impact of drought years. The urgency to save water in Windhoek could be influenced by origins. Personal experience of the weather in home regions appeared to affect the climatic classification of the whole country. People from wetter areas didn't perceive the country as an arid one therefore they could be less likely to conserve water as carefully as those from the south who were more conscious of its aridity.

However, assuming there was a clear understanding of what a Green University is the support expressed for sustainable green campus initiatives in both the survey and discussions indicated NUST could hope for commitment from its staff and students in creating a more environmentally friendly campus. Positive comments and suggestions implied support for water-wise behaviour and pro-environmental thinking and the high proportion (87%) of respondents who considered that it would be useful for water-saving efforts if NUST joined a Worldwide Green University initiative confirms this. Though it gained support it would be

necessary to establish why the greening of the campus propositions were opposed by some respondents in order to design a WMS strategy that will have the greatest impact on water consumption.

4.2.2 : Level of awareness

The reductions in water consumption that resulted from the combined efforts of residents and businesses in Cape Town when Day Zero was looming potentially alerted people to what individuals can attain if they work together (Ziervogel 2018). The NUST attitudes survey revealed that teamwork was considered as important as the feeling of personal responsibility to address the water situation. Offers from respondents to incorporate discussions on water issues and Sustainable Development (SD) into the curriculum indicate a high level of support for raising awareness and greening the campus. Some staff indicated they would need to educate themselves first or lacked the confidence to teach others, indicating a sense of responsibility. Overall Lower Campus academic staff and students were less concerned about the seriousness of the water situation after the good rainfall of early 2020. This indicates greater efforts should be placed on assisting these categories to gain more information on the water situation and including materials into the curriculum whilst raising more awareness amongst the lecturing staff.

When staff can influence from a position of knowledge then real changes are more likely to occur. Awareness programmes broadening knowledge and providing examples of how sustainable resource use can be incorporated into subjects and integrated into all aspects of university life and teachings will facilitate change (Lozano and Lozano 2014). A training programme and information would raise confidence levels amongst people and make education for sustainable development more effective. Staff's confidence in their ability to educate others and their level of current knowledge could form part of a preliminary survey assessing how departments can integrate sustainable development into their curriculum and how they suggest doing it.

The water crisis had just reached a peak shortly before the survey was conducted (Remmert 2017) so a general awareness of the shortage of water that faced the residents of Windhoek existed. However, little information was openly available to educate people beyond the basics that were described in the Windhoek Municipalities Aloe newsletters, flyers and on billboards and in the media. Studies found consumers need to know what efforts are being made and should be able to identify these actions on the ground. Silva-Alfonso and Pimentel-Rodrigues (2011) recommend labelling devices and appliances with explanations about their water efficiency. The lesson learned from Cape Town (Ziervogel 2019) also

identified the need to inform consumers about the effects that behaviour, both positive and negative, is having on the environment and availability of water in a visible and informative way. This was also supported by the findings of Petersen *et al*. (2005) at Ball State University, and by Patterson (2015) at the University of Melbourne where empirical information displayed with facts and figures compelled people to act. Similarly, the Cape Town experience was that more information resulted in improved water-saving behaviours (Ziervogel 2018).

The multiplier effect (Lozano *et al*. 2013) of working with a large group of young students will ensure that environmental education and awareness and building a culture of environmentally friendly habits within the University community, as part of the WMS, will spread far beyond the confines of the university campus. Many NUST students will progress into influential positions, thus building knowledge and understanding of the environment now could have a positive approach to sustainability in the future. Thus, the potential to foster a positive approach to environmental matters, in particular, the use of natural resources, amongst the 12,500-strong student body is immeasurable. Heightened awareness will also ease the implementation of an EMP at NUST.

4.2.3 : Initiating behavioural change

The survey participants made many useful suggestions on how excessive water use could be mitigated akin to the findings of best practices from other universities including UCT (ISCN 2015), Stellenbosch (ISCN 2020), Wisconsin-Madison (Uelmen *et al*. 2020) and the University of Melbourne (Patterson 2015) such as informing and educating, training maintenance staff, setting targets and maximum quotas and offering rewards, supported by the establishment of a water forum to drive green initiatives. Several of the other actions suggested during interviews were also established at these universities such as an environmental stewardship programme, water and sustainability audits and assessment, harvesting water and implementing water-wise technology. All the commitments and willingness shown to implement solutions, shown in the DICT reports and survey and in actions taken to stop water loss, suggest that future efforts to implement a WMS will have favourable results.

For many of these actions to be effective dedicated role models are required to oversee and promote best practices. Active water management, monitoring and maintenance needs to take place to improve sustainability. Allocating responsibility to environmental stewards, overseen by environmental

champions, for monitoring and analysing data on usage and examining the trends will pinpoint high-water use buildings and raise alerts to wasteful practices.

The participation of role models such as these in the study can be considered an indication of a positive attitude backed by positive behaviour. De Montfort University in the UK (Green Impact n.d.) assigned Environmental Champions in each faculty and department of the University providing a network through which to disseminate information on current environmental projects and initiatives. The champions receive information on how to get involved and encourage colleagues to adopt greener habits in their workplace. Training management and administrative staff to become role models will help establish systems and develop a WMS. These role models, demonstrating and promoting sustainable resource use, would support and initiate corrective action to turn the University into one that can lead by example and ensure that future generations take pro-environmental behaviour into the workplace.

4.2.4 : Effective approaches to change behaviour

Raising awareness

Suggestions of techniques and approaches to change behaviour in the survey overlapped with examples of best practices, adaptations, interventions, and mitigation measures implemented in other environmentally conscious organisations were found in Namibia, South Africa and in universities worldwide. This study compared measures taken in Windhoek during the 2019 drought and in Cape Town during the 2017/2018 drought and found that awareness-raising was common in both cases. Cape Town's notices were more prominent and public such as visual display screens on freeways informing people of the number of days of water left in the dam (Ziervogel 2019), websites displaying current dam and consumption levels (Parks *et al*. 2019) whilst Windhoek's were in the form of flyers, media releases and notifications (D. Tolke, personal communication, 22 Oct 2021). The high volume of media coverage plus the discussions on social media regarding the Cape Town Water Map contributed greatly to awareness whilst communication campaigns across various media contributed to changing social norms around water use in Cape Town (Parks *et al*. 2019). In addition, tariff hikes were used as a form of penalty in both countries. Windhoek implemented the tariffs on a graduated scale according to units consumed, whilst the prices of water in Cape Town increased over the subsequent two years (Chambers 2018). Cape Town saw a reduction of 50% of pre-drought usage (Ziervogel 2019). The CoW's efforts to curb water use were

less successful with January and March 2019 Windhoek's consumption exceeding the weekly water use reduction targets (D. Tolke, personal communication, 22 Oct 2021).

The approaches to change behaviour corresponded with findings of other studies such as Petersen *et al*. (2005) who found that the most effective way to raise awareness and maintain water conservation in dormitories in Indiana was to give high-resolution real-time digital and online feedback on a continual loop with visual displays around campus on consumption and its environmental and economic costs. This involved detail on use, financial and environmental consequences so that use could be contextualised. It enhanced the connection between behaviour and the environmental consequences of it. This was found to be more successful than the low-resolution monthly feedback that gave basic information from utility bills. Petersen *et al.* (2005) also noted that awareness raising was more effective amongst first-year students who are more flexible and compliant so behaviour can be entrenched whilst change in older students is harder to enact. Pro-environmental awareness and behaviour were studied on Tianjin Campus in China and revealed that group pressure can cause people to abandon their pro-environmental behaviour in order to fit in (Fu *et al*. 2017). The behaviour of peers is very influential when living in hostel accommodation on campus. This supports the suggestion made in the survey that education and positive influencing should start at fresher's week and should be included in the first-year core courses.

In Melbourne-Australia analysis found broadcasting reservoir levels on electronic billboards during their drought period was very effective (Grant 2015). Patterson (2015) reported that everyone was very roused by the electronic displays, being very literal in depicting what would happen if they ran out of water in Melbourne (Patterson 2015). This approach was used equally effectively in Cape Town, along with the Water Dashboard, Water Maps and the City's Think Water website, where the threat of a Day Zero when the municipal water supply was shut off was publicised (Ziervogel 2019). This technique of raising awareness works in conjunction with empirical information that is backed by facts and figures, not just emotional pleas (Petersen *et al.* 2005, Stern, 2018). Though there were many communication tools used in the Cape including various written materials and digital media none seemed to explain the drought or its severity, particularly related to climate variability, and what the city of Cape Town was doing in response reports Ziervogel (2019) who also purports that reactions to the need to save water would have been faster had the messages been more explanatory. Many staff and students at NUST acknowledged that they needed more information and education on the water situation.

Melbourne-Australia showed the enduring impact of its water conservation efforts that moved on from water scarcity to developing drought resilience through systemic change. Recognition was given to the environmental benefits of continuing water conservation habits learned during the drought (Patterson 2015). Once the situation is made clear a sense of urgency is created to which people will react and make changes to their behaviour (Grant 2015). Patterson (2015) recognises that making efforts to encourage behaviour change incurs the costs of policy changes but has long-term benefits. Though these approaches were taken at a city level they can be applied at an institutional level as well. Becoming more water-wise not only mitigates against future droughts but also contributes towards becoming a greener campus.

In their study on the most effective awareness tools for water use efficiency, Wymer *et al*. (2014) noted that where residents are not paying for their actual water usage, other means to promote water conservation behaviour become necessary. Though many survey respondents appeared to understand how critical the water situation is in Windhoek the examples given of large baths being enjoyed in the hostel bathrooms, taps being left dripping and toilets running support this notion that if you are not personally responsible for the bill it is more difficult to change behaviour. Nevertheless, this same study found that knowledge informs behaviour and greater knowledge results in an improvement in water conservation, particularly when education is done in an interactive way with concrete examples of how one can personally make a difference.

Many studies reviewed by this study and Petersen *et al*. (2005) confirmed feedback to be effective in reducing resource use among people who are already environmentally concerned. Thus, it was found that behavioural changes are more likely to be successful if people understand why it is necessary and what the impact of the behaviour is. Using social science theories to generate environmental sustainability Stern (2018) summarises Ikujiro Nonanka's theory of Organisational Knowledge Creation that suggests that there is a need to internalise transformation by combining easily articulated facts, figures, principles and instructions, with tacit or more experiential knowledge. Building explicit knowledge provides a more complete understanding and as it is worked with it is internalised it becomes tacit practice, routine and ingrained. This supports the theory that awareness-raising must be supported by reasoning and details which will result in a deeper understanding before behavioural change takes place. For behaviour to change people require more than emotional pleas or threats, it needs to become habitual as a result of reasoning and understanding.

Incorporating sustainable development into the curriculum

The ISCN (2017) report promotes integrating sustainability across the curriculum as it provides channels through which students' behaviour can be directly influenced. They provide examples of universities that are capitalising on these opportunities by focusing integration of sustainability issues into specific disciplines and through broader degree programmes.

In the study '*Turning Minds on and Faucets Off*' Middlestadt *et al*. (2001) concluded that behavioural changes were demonstrated after exposure to water conservation issues incorporated into the curriculum, however, they were effective only shortly after awareness. Vickers (1999) noted the diminishing effect of awareness on water use and conservation if it is not continuous and stressed the need to repeatedly remind consumers about saving water to avoid reverting to wasteful water use. In the results of this study, section 3.2.1, 24% of respondents felt less concerned about the water crisis after the good rainfall experienced in 2020, and 17% felt the situation was no longer critical despite a falling annual average rainfall since 2012. Extrapolated for the whole of the city this attitude could result in a water shortage in subsequent years. Parks *et al* (2019) noted that once the reservoirs in the Cape had returned to non-critical levels it was still important to maintain conservative water use practices. In order to be responsible citizens and understand the impact of individual behaviour on the overall water supply it is necessary to continue educating people in non-drought periods as well to ensure wise behaviour use becomes entrenched and a habit whilst living in an arid country. Thus, in non-drought years awareness raising is necessary so that the knowledge is pre-existing, and water conservation methods are regularly practised. This supports the suggestions to include ESD in the curriculum. In their Transtheoretical model of the early 1980s, Prochaska and DiClemente (1983) state that there are five stages of behaviour change: pre-contemplation, contemplation, preparation, action, maintenance and suggest that it takes six months for an individual to exhibit new behaviour consistently, reinforcing that long term adaptations require continual input before they become ingrained.

A BJ behaviour model developed by Fogg (2009) suggests that behaviour change is comprised of three factors: motivation, ability, and triggers. Survey respondents identified that rewards, understanding and targets would promote action. Stern (2018) summarises Maslow's Theories of Hierarchy of Needs and cites that a shared vision for desired outcomes, shared ground rules, use of community talents and capacity building, enhancing perceptions of the importance of the tasks and having transparent goals all have a positive impact on a successful outcome. Thus, the impact of a WMS will depend upon how NUST

can develop capacity, establish an enabling environment and communicate their intentions to the NUST community and support behavioural change techniques that will lead to environmental sustainability.

4.2.5 : Positive reinforcement

Incentives for changing behaviour and positive reinforcement were recognised by Skinner (1954) and proved to be more motivating than punishments (Gilley *et al*. 2006). More recently positive reinforcement of wise use and recognition of performance was found effective in reducing consumption (Abrahamse *et al*. 2007, Bekessy *et al*. 2007), thus determining a suitable reward for departments or faculties saving the most water could encourage pro-environmental behaviour. Rewards or recognition in the form of articles on performance or winners of a monthly best practice published in a university publication, on social media or NUST FM, or support given for a green project were suggested as effective ways to encourage efforts. Green projects initiated can in turn gain recognition for the university if registered with Green Impact (n.d.), ISCN and similar international programmes.

Setting targets and a goal to aim for, combined with good reasoning and explanation, inspires consumers to act accordingly as was found in Cape Town in 2017/18. In the approaching Day Zero campaign the incentive was simply still having water on tap. This everyone desired so great effort was put into cutting down water consumption during the drought. In Windhoek, the years of poor rainfall when the water resources were becoming increasingly scarce leading up to the drought in 2019 could have resulted in the same scenario (Rensberg and Tortajada 2021). Outlining the benefits of efforts made now can help mitigate this scenario in the future.

Skinner (1954) theorised that individuals learn by duplicating behaviours they observe in others and that rewards are essential to ensuring the repetition of desirable behaviour. As each simple behaviour is established through imitation and subsequent reinforcement, then complex behaviour develops. To establish the imitation required at NUST one must work with a group of key influencers who can demonstrate more sustainable practices, starting with simple measures and building upon them over time until the best practices are achieved whilst outlining the rewards and communicating the benefits of adapting behaviour.

Much of Cialdini's (2007) discussion on persuasion also relates to mimicry, replicating the behaviour of others and compliance. Staff and students at NUST could be influenced to change their attitude towards

water usage if well-respected champions and environmental stewards are engaged in promoting and modelling positive behaviour change. This approach successfully turned around the Cape Town crisis when a prominent figure, the mayor, issued a press statement regarding people's lack of concern for the crisis (Ziervogel 2019). Having an influential person championing the cause made the difference and shifted viewpoints and behaviour.

4.2.6 : Sustaining behavioural change

Lessons highlighted in the analysis of the drought response in Cape Town (Ziervogel 2019) emphasised the importance of collaboration to tackle the multi-faceted aspects of the drought and reach everyone. Some of the assumptions in Cape Town's Water Resilience Plan included not being confined by resources and not relying on the National Government (Ziervogel 2019). A similar approach using a combination of techniques to change water use and management could be crucial to improving the effectiveness of the behaviour change interventions at NUST.

Though much has been done to learn about how long-lasting changes in behaviour can be achieved and lessons can be taken from the methodology and assessment of prior practices nothing has been found with specific reference to changing water use practices through awareness raising in universities in Namibia. Ascertaining the determining factors of an effective environmental awareness campaign in a Namibian setting could be an opportunity for further research. The City of Windhoek's water use management campaign offers references, as well as the MoU between NUST and the CoW which is aimed at bringing about synergies and a focused approach to the development of areas of common interest. This will provide a platform for cooperation and support feedback on practices and techniques that were most effective in the 2016 and 2019 campaigns for incorporation into a WMS. The Cape Town 'Think Water-wise' (Ziervogel 2019) campaign provides good examples of what works and what does not in a Southern African city, including setting and publicising daily limits, multimedia awareness raising, preventing overuse if the limit is exceeded, reducing toilet flushing, using hand sanitisers and reusing grey water. The most successful approach to change behaviour will require the identification of common and distinctive techniques to suit Namibian circumstances and an evaluation of each intervention to determine which had the greatest effect on reduction. This could be the subject of further research.

The success and impact of ESD and awareness-raising activities at NUST will be evident from the long-term positive changes in personal behaviour observed around the campus and in a reduction in water

consumption revealed from the water meter readings. Tracking success will be necessary, whilst it could also become the focus of a more intensive longitudinal research project.

4.3 : Discussion Objective 3:

Primary and secondary research identified the impacts of current behaviour and aspects that can be controlled and which, more sustainable approaches, could be adopted to reduce water consumption on the campus. The review allowed for the recommendations to be drawn up based on best practices and lessons learned elsewhere. Proposed adaptations and interventions could be drawn from these to form the basis of an integrated WMS for NUST. However, sustainability and being green are more than just the wise use of resources (ISCN 2017). Adaptations and interventions must address economic and social sustainability as well as environmental sustainability (United Nations 1993). At NUST these must be integrated into a WMS that will feed into an EMP addressing the wise use of all resources. Financial resources must be managed sustainably in order to support social and environmental efforts and contribute towards becoming a greener campus.

4.3.1 : Interventions to increase sustainability

In a report outlining lessons learned from the drought in Cape Town Ziervogel (2019) states that building a water-sensitive city requires a holistic understanding of the system and an ability to adapt at a variety of scales in a range of ways. Reflecting on the drought, preparedness, the strength of institutional response and actions during the water crisis and how Cape Town managed to avoid Day Zero (Ziervogel 2018) provides an opportunity to examine how cities could manage the situation better in future. Universities are likened to small cities, with many duplicate facilities found within them thus lessons drawn at a city level can be applied at the University scale (Shoup 2005). Cape Town's lessons are equally applicable on an institutional level since institutions, companies and service providers in Windhoek together consume approximately 40% of the water Tolke (personal communication, 22 Oct 2021). Experience gained from the Cape Town drought of 2017/18 was distilled in the Climate Resilience Briefing Note (Ziervogel 2018) and provides lessons that can be adapted to assist NUST with the development of their own WMS. They had four focus areas relating to drought mitigation and the promotion of sustainable use of water.

The first focus area of the lessons learned identified the need to strengthen governance which requires shared obligations, and a coordinated approach across all departments making each department equally responsible and accountable whilst taking a systems approach to building adaptive capacity in data expertise and communication, in order to develop a water-sensitive city (Ziervogel 2018). Too and Bajracharya (2015) emphasise the importance of an effective governance framework addressing the environmental, economic and social outcomes to make the necessary adaptations towards improved sustainable practices. Adaptive systems and relationships, within NUST, together with research and partner institutions need to be developed to support this through a culture of trusted leadership and collaboration.

Focus area two of the Briefing Note (Ziervogel 2018) recommended effective communication of technical information to aid wise choices facilitated through professional training. The water infrastructure, reticulation plan and management systems need to be understood and made accessible whilst analysis of data, information on water use and targets should be publicised using the most effective communication techniques to improve understanding of the need for implementation of plans. A targeted communication strategy aimed at stakeholders on campus should be developed based on their influence on water use. Sharing technical information in an easily understandable format influences and changes behaviour as was found by Patterson (2015). Experts and students from a wide range of backgrounds should be engaged to assess and review plans through the development of a working group or forum such as that was created by the Royal Melbourne Institute of Technology (RMIT) greening team (Bekessy *et al*. 2007). The enthusiasm the stakeholders showed at NUST could be turned into proactive behaviour with positive sustainable effects.

The third area focussed on taking a systems approach to actively manage the water system, detect flaws in the current water provision and provide water effectively whilst sustainably meeting the needs of the university population (Ziervogel 2018). The steps should include an upgrade of the infrastructure to reduce the possibility of leaks and put controls and targets in place to keep within a budgeted amount for water use. Likewise, funds saved in NUST's monthly operational costs from improved management and monitoring systems can be reinvested in water and money-saving infrastructure.

The final focus area Ziervogel (2018) referred to as building the adaptive capacity of leadership to ensure it is strengthened to facilitate sound decision-making. This aids the development of a water-sensitive

management plan integrated with climate change and SDG goals. The priorities for intervention must be identified and the adaptive capacity of the university to react when the time arises assessed, followed by the establishment of a long-term strategy with realisable goals that are based upon the available resources.

The conclusion of the report (Ziervogel 2018), based on the Cape Town Municipality experience, was that recognising and adopting change helps build an adaptive water-sensitive urban system (Ziervogel 2018 p. 7). Therefore, an effective water system, holistically addressing diverse needs, must be actively managed and integrated to create a robust water supply system while keeping within the financial limitations that exist. The lessons derived from the drought in Cape Town (Ziervogel 2018) indicate that NUST needs to take active and decisive action to improve its environmental sustainability.

In 2008, before the severe drought, the UCT adopted a Green Campus Policy Framework, and a Green Campus Action Plan (Rippon 2008) drawing together environmental initiatives predominantly relating to operational issues. The Action Plan was implemented through the University's Properties and Services Department responsible for building maintenance, environmental management and sustainability of facilities and services. The UCT Environmental Management Working Group (EMWG) are responsible for reporting in terms of the ISCN-GULF Charter signed in 2012 to bring a policy to the University that integrates sustainability in education, research and outreach, strategic planning and operations (Rippon 2013). The EMWG, and a student movement, the Green Campus Initiative (GCI), ensure the strategy is carried out and determine the extent to which sustainability principles and issues have been integrated into programmes and courses. The EMWG report on the three principles of the Charter. Principle 1 is the Sustainability Performance of Buildings on Campus with sustainability playing an integral role in planning, construction, renovation, and operation of buildings at UCT and Principle 2 is Campus-wide Master Planning and Target Setting that includes social and environmental goals (Rippon 2013).

Principle 3 of the ISCN Charter, Integration of Facilities Research and Education to create a 'living laboratory' for sustainability, brought together policies relating to operational issues with sustainability in education and research across all faculties. It involves research groups in community-based projects, the UCT Global Citizenship Programme, which encourages voluntary service. An annual Green Week and Sustainability Month provide platforms for awareness raising, and the GCI Sustainability Awards launched in 2010 inspire innovative work in green initiatives. In addition, they have courses with an emphasis on

sustainability using participatory and project-based training, and several behavioural programmes aimed at encouraging more sustainable actions by students, staff, or external community members. UCT's vision is 'to produce graduates who are not only well-educated but also aware of the responsibilities of democratic citizenship' (ISCN 2013). The African Climate and Development Initiative (ACDI) was established in 2011 to support innovative research and help UCT accomplish its strategic goal of addressing the climate and development challenges of Africa (Rippon 2013).

The Sustainable Campus Charter Report (ISCN 2013) predicted that water conservation would receive more attention in future, with water scarcity, water restrictions and tariff increases imposed at the water supply level that would drive this change. Investigations into digital water sub-metering technologies were underway at UCT in 2013 intending to phase in the implementation of water metering once the energy meters had been installed (Rippon 2013). Indeed in 2017/18, the drought stimulated many city-wide response measures in Cape Town. Being prepared and attempting to mitigate the situation would have been preferable to a crisis response.

Transformation to a sustainable campus as Rippon (2008) recognises will require institutional change and policy interventions to provide the necessary stimulus at NUST.

4.3.2 : Developing a community of change agents

The ISCN Sustainable Campus Best Practices report of 2017 emphasises that education underpins the transformation of our society toward a more suitable future (ISCN 2017). Never is this more critical whilst Namibia is making climate change adaptations. Experts estimate in the next 20 years rainfall in Namibia will decrease by 7 per cent and mean annual temperatures will rise by 2.7 degrees causing more frequent droughts, heatwaves, and floods (Chemonics 2021). Droughts will exacerbate water shortages in Namibia. McGibbon and van Belle (2015) note the indications that increased droughts and floods intensify the urgency with which Africa needs to deal with climate change, and one way in which that can be tackled is to include environmental education and sustainable development in the curriculum.

As early as 1972 the Stockholm Conference on Education for Sustainable Development recognised the need for education about and for the environment and sustainable development (Lozano and Lozano 2014). It has been shown that an increased understanding of the water situation leads to more favourable

consumption practices (Petersen *et al*. 2005, Ziervogel 2018). The United Nations defined the years 2005 to 2014 as the Decade of Education for Sustainable Development (UNESCO n.d.) which resulted in Higher Education Institutions including SD in their curricula, policies, and practices. The goal was to integrate the principles, values, and practices of sustainable development into all aspects of research, education, and learning, as well as campus operations, outreach, reporting and assessments. The initiative hoped to encourage changes in behaviour and build environmental sensitivity to create a more sustainable future. HEIs attempted to include sustainability in their curricula, policies and practice. Kosta (2015) cited Sterling (2011) who said greening the campus and the curriculum is driven not only by Government policies but also by environmentally sensitive students and employers needing to protect their corporate social responsibility profiles. As a result, the University of Exeter (2012) in the UK committed to giving all its students an opportunity to equip themselves with the knowledge and skill required for a green economy. Kosta (2017) refers to the UK Teaching Excellence Framework which assesses the quality, environment, and outcomes of teaching in universities and colleges in the UK for awards as having one indicator which is equipping students to allow them to make a strong contribution to society, economy, and the environment. The need identified is to equip students with sustainability skills. This applies in a Namibian environment as equally as it does in the UK.

The University of Exeter in the UK assisted its students to become agents of change when it launched its new Education Strategy in 2019 (Kosta 2015). Optional sustainability modules are offered across all subjects with a common focus on the core challenge of achieving a sustainable future for humanity on Earth. Two hundred staff members undertook environment sustainability research spanning the natural and social sciences, humanities, and arts in support of the movement. A review of the research led to the development of The University of Exeter's Environment and Sustainability Strategy 2010-2015. The strategy has annual achievable targets and overall aims for the 5-year period. One aim is to provide all students with access to education for and about sustainability, and another is to reduce the environmental impact of their operational activities and make a positive contribution to the local environment, through the management of their estate.

Other universities such as Stellenbosch and the Royal Melbourne Institute of Technology, took measures to implement becoming greener), as well as the inclusion of green matters and education for sustainable development in the curriculum (Bekessy *et al*. 2007, SUFMPS 2015). They found support in programmes such as the ISCN Educating for Sustainability programme, the Heinz family foundation’s Blueprint for a

Green Campus, and the UNESCO Global Action Programme. The United Nations Environment Programme (UNEP) Greening Universities Education Initiative actively promoted the objectives of greening universities by launching GUPES (Global Universities Partnership for Environment and Sustainability). This partnership provided institutional support between universities. Global communities such as Future's School of System Change (n.d.) and The Fridays for Future (n.d.) a worldwide movement already active in Namibia also help facilitate and promote pro-environmental change.

The motto of the Forum for the Future's School of System Change (n.d.) is 'growing a global community of change agents is our best chance to accelerate a transition to a sustainable future'. This approach echoes the approach in the UK that promotes preparing students for sustainability. The Fridays for Future (n.d.) is driven predominantly by students and the youth, who are adamant that change needs to be made to protect natural resources for the future. These approaches have a common theme, that environmental education should be incorporated into all curricula, starting at the tertiary level, but, in time, in schools as well. It must be made applicable to all faculties so general awareness and cognisance of the issues around living in tune with the environment and using natural resources sustainably are developed amongst all staff and students.

The University of Hong Kong maps its Common Core courses against the 17 SDG's providing a framework for trans-disciplinary and holistic learning offering credit-earning components in an Introduction to Sustainability course that blended diverse perspectives across eight different faculties (ISCN 2017). Sustainability classes were made mandatory at Nanyang Technological University, Singapore in 2014 for first-year students and exposure is continued through each department's curriculum. At the National Institute of Education at Nanyang University all primary and secondary education students incorporate sustainability in classes ensuring is taught from a young age in school (ISCN 2017).

Lozano and Lozano (2014) report that, in general, there have been four approaches for incorporating sustainable development (SD) into higher education curricula:

1. Some coverage of environmental issues and material in an existing module or course.
2. A specific SD course.
3. SD intertwined as a concept in regular disciplinary courses tailored to the nature of each specific case.
4. SD as a possibility for specialisation within the framework of each faculty.

They note that the World Business Council for Sustainable Development advise that it is becoming increasingly necessary to prepare graduates with a background in ESD and that Higher Education Institutions (HEIs) should recognise the important role academics play in accommodating and incorporating cross-curricula courses that can lead to help achieve the goals of sustainable societies. In a further study looking into integrating environmental sustainability into the curriculum McGibbon and van Belle (2015) argued that the practice was still in a nascent stage in Africa.

Greening the campus and the curriculum is not without its challenges Fu *et al.* (2017) recognise, as first people must understand the need for pro-environmental behaviour and the significance of it. Despite awareness being raised in other ways Lozano and Lozano (2014) found limited research on how to include SD in the curricula. They promoted the development of a curriculum for a bachelor's degree in Engineering for Sustainable Development. Lozano and Lozano (2014) are amongst many proponents who advocate incorporating SD into the curricula as a catalyst for transformation into sustainable societies. Based on these findings NUST needs to take steps towards incorporating SD into its curriculum in a holistic and integrated way, developing a new SD course or specialisation in order both to encourage pro-environmental and sustainable thinking and also to keep up with trends in universities internationally.

Awareness and understanding of the water situation, and environmental sustainability, must be built, combined with practical suggestions of what individuals can personally do to improve it. The Wymer *et al*. (2014) study in SE England in Halls of Residence cited evidence that water conservation was more successful through teaching methods of reducing consumption rather than solely giving feedback on how much was used. Petersen *et al*. (2005) postulate that changes in attitude and lifestyles are essential to solving environmental problems rather than just installing technologies aimed at reducing resource use. Ignorance and unfamiliarity with resource flows contribute to an unsustainable relationship between people and the environment. Petersen *et al*. (2005) propose that the employment of smart technology to control behaviour is only part of the solution. Building a university population of conservation-minded, environmentally smart people able to engage in resource management planning and personal water use decisions is the key to success when faced with "environmentally and technologically dumb buildings" (Petersen *et al*. 2005 p.12). Focussing only on smart technology without education the opposite is likely to occur, they conclude that smarter buildings may lead to environmentally dumber people since the occupants are only passively engaged and not involved in decision-making regarding resource conservation. (Petersen *et al*. 2005).

Kambaru (2019) concluded his research assessing water and energy consumption at NUST by recommending that to be a sustainable campus NUST should enhance the curriculum and build an understanding of environmental issues through the development of new degrees that focus on renewable energy (RE), RE economics and public policy. Whilst suggestions were made to include more into the NUST curricula and a willingness to teach it was indicated, ESD should not just be restricted to specialist courses but holistically integrated across all disciplines (ISCN 2017) and courses at NUST to ensure that all students leave university with greater knowledge of the environment and sustainable living as Petersen *et al*. (2005), Lozano and Lozano (2014) and Kosta (2017) recognise.

However, simply including SD in the curriculum is not sufficient to have a positive impact if it is not systemic and incorporated as part of the institutional strategy. Kosta (2017) looked at the Sustainability Curriculum in UK Universities and noted that embedding sustainability in the curriculum is often viewed as more difficult than greening the campus, an area which has seen good progress in the UK. One of the biggest barriers to the implementation of SD into the curriculum is its absence from the institutional strategy. Kosta (2017) proposes that if the curriculum is included as part of the agenda in the institutional strategy, it is more likely to be prioritised and promoted.

4.3.3 : Strategies for implementing sustainability

Kosta (2017) recognises the challenges of institutionalising sustainability. It is not sufficient to teach about sustainability, it must be practised and exemplified by the institution. The implementation of strategies and approaches requires the buy-in of management, staff, and students at the university to effect change that will reduce the consumption of water. In an article on strategies for implementing sustainability Crews (2010) identifies the need for the engagement of every member of an organisation and to build the capacity for learning at all levels to attain sustainability.

Green Impact is a sustainability engagement accreditation programme developed by the National Union of Students in the UK in partnership with the UNESCO Global Action Programme on Education for Sustainable Development. The programme, run by Students Organising for Sustainability United Kingdom (SOS-UK) is designed to support environmentally and socially sustainable practices in organisations (Green Impact n.d.). Green Impact reports that many Universities in the UK, Australia and around the world have improved their skills and made a lasting change in their organisations as a result of the programme. The

Environmental and Sustainability Officer at De Montfort University in the UK describes the Green Impact Programme as a well-structured programme for encouraging behaviour change (Green Impact n.d.).

The Green Impact toolkit aims to create an effective approach to sustainable development aligned with the University's ISO14001 environmental management system, objectives, and targets. The programme encourages engaging activities, improving environmental performance based on a set of easy criteria, and promoting sustainability at the University, whilst giving recognition for efforts and their impact. One of the outcomes of the programme is that the negative impacts the University has on the environment are reduced, and the positives increased. The online toolkit provides a framework for encouraging discussion on sustainability and social responsibility that helps the University become more integrated and encourages departments to broaden their perspectives and share ideas and knowledge. The actions are simple and based on seven areas of sustainability, one of which is water.

WEF-ISCN and Gulf Universities reports provide guidance on how to establish strategies and the best and most successful approaches to employ (ISCN 2017). Associations such as the Association of University Leaders for a Sustainable Future (ULSF) provide an outline of measures that can be taken to members and a network for sharing ideas and best practices. The ULSF leaders from all over the world developed the Sustainable Campus Charter (Appendix 6) and Talloires Declaration 10-point action plan in 1990 (ULSF n.d.) (Appendix 7). By signing the Talloires Declaration universities agree to:

- Take action to increase awareness of environmentally sustainable development.
- Create an institutional culture of sustainability.
- Educate for environmentally responsible citizenship.
- Foster environmental literacy for all.
- Practice institutional ecology.
- Involve all stakeholders and collaborate for interdisciplinary approaches.

Signing pledges such as the Talloires Declaration of 1990, though non-binding as Bekessy *et al*. (2007) note, encourages greater commitment by universities to realising the goals and targets set if progress towards goals is regularly reviewed.

Many other initiatives such as the ISCN Educating for Sustainability programme, the Blueprint for a Green Campus (Stoss 1998), the UNEP Greening Universities Programme (UNEP 2013), and the UNESCO Global Action Programme (n.d.), provide guides and toolkits for the development and adaptation of curriculums

to incorporate green issues. Networking with other universities to share their approaches to sustainability is considered an important part of establishing a sustainable university (Too and Bajracharya 2015). Connections with other universities such as UCT and the University of Exeter where Green Campus initiatives are underway and SD incorporated into the curriculum, as well as organisations and representative bodies such as ISCN, GUPES, WRI and the Association of University Leaders for a Sustainable Future (USLF) facilitate the sharing of ideas and best practices with NUST for implementation of an education programme.

In their research Filho *et al*. (2015) found that several studies including the ISCN (2013) suggest that universities can become living laboratories for sustainability initiatives and develop the knowledge and capacity of students to bring about deeper and wider-reaching change as well as becoming a showcase for sustainability projects and approaches. As a University of Science and Technology, many opportunities and capabilities lie within NUST that could be promoted and enabled through campus greening activities.

The ISCN (2017) report gives examples of how other Universities have embraced sustainability such as Anglia Ruskin University where sustainability is a required part of every degree programme and is integrated into library resources, student art exhibitions, and volunteer programmes. Similarly, De La Salle University in the Philippines believes that educating for sustainability should not be confined to the classrooms or the curriculum (ISCN 2017). Integrating sustainability into the University's practices and processes increases the understanding of its applicability and reinforces that through participation and collaboration, it is feasible and achievable. ISCN (2017) urges the academic community to rethink and redefine its role in society and make sustainable development a key theme of its mission and aim to reach the SDG's acknowledging that changes will be required in operations, teaching, and research. In addition, by including sustainable development in the strategic goals for all their activities, universities promote a more holistic education for all. UCT, through its Green Campus Policy Framework (Hall and Murray 2008), integrated sustainability and practice into a holistic approach incorporating teaching, outreach, strategic planning and operations.

A holistic approach is required to engage the support indicated for water conservation and greening up NUST. The ability of NUST management to commit to adaptations must be long-term. Steps must be contained in a strategy to implement water management Ziervogel (2018) which should then be incorporated into an EMP and broader strategy for sustainability at the university. The Secretariat for

signatories to the Talloires Declaration of 1990, recognises the role that universities play role in education, research, policy formation, and information exchange. HEIs around the world can sign up for declarations and charters for sustainability to ratify their commitment to sustainable development. These include the:

- Talloires Declaration of 1990 declaring a commitment to incorporating sustainability and environmental literacy in all aspects of higher education.
- Swansea Declaration (ACU 1993) signed by commonwealth universities seeking ways to preserve the balance between people and the environment.
- Barcelona Declaration (EESD 2004).

After the Talloires Declaration, the Blueprint for a Green Campus was established at the Campus Earth Summit at Yale University in 1994. Based on the principle that since students in the United States pay a high price for their education, they can demand a greener, more environmentally responsible campus and curriculum. Academic staff carry great influence and can foster pro-environmental attitudes and behaviour and have the opportunity to develop good moral and ethical values. Stoss (1998) claims in the Counterpoise Journal that universities and colleges train the majority of people who run institutions later in life and train the teachers who educate children, thus he states, 'it becomes clear that transforming campuses into catalysts for environmental sustainability is a good first step toward changing the world'. (Stoss 1998 p. 12). This view is also expressed by Svanström *et al*. (2008), UNESCO (2012) and ULSF (n.d.) who state that the education process needs to be addressed more holistically.

4.3.4 : Greening NUST

It is evident from research and previous international movements and initiatives backed by UN institutions that tertiary institutions must strive to integrate sustainable development holistically and lead the way by improving their environmental sustainability records. Schwarzenbach and Schmidt-Traub (ISCN 2017) suggest that the global higher education sector has a tremendous opportunity to lead the world in sustainable development research, promotion of solutions, and implementation support (ISCN 2017). There are opportunities for NUST, as a research institution, to start leading the way in Namibia, if not Southern Africa.

To date, ISCN universities' support for sustainable development has primarily focused on campus design and operations. Less attention has been given to solutions-oriented research, policy changes, or the practical education of students. Holistic, cross-disciplinary initiatives are needed to link academic and operational practices to create a sustainable learning environment and experience (ISCN 2016). Solutions-oriented sustainability research requires inter- and trans-disciplinary approaches. Integrating approaches between faculties and moving away from working in isolation by considering broader the environmental, social, and economic dimensions. This could lead to greater sustainability at NUST. In this integrated approach, Filho *et al.* (2015) recognise, one of the most challenging aspects that may inhibit its success is aligning stakeholders, academic staff, students, and management, with different perceptions and working across institutional structures.

Filho *et al.* (2015) note that after the first wave of enthusiasm generated by the Talloires Declaration in 1990 many programmes were developed such as the Green Impact Programme and the Blueprint for a Green Campus, which document steps towards greening the campus to ensure accountability. The integrated approach can be implemented at NUST using the Green Impact toolkit and the UNESCO Global Action Programme on Education for Sustainable Development. These programmes, with the participation of NUST students, can be tailored to the Namibian situation to facilitate successful water management and a cross-curricula sustainable development programme and help the university take steps towards recognised targets and awards. Too and Bajracharya (2015) recognised that these toolkits provide an opportunity for the development of an awareness programme that brings about behavioural change not only at the university but beyond its borders as well as fostering pro-environmental mindsets of future leaders.

The World Green Building Council (WGBC n.d.) defines a 'green' building as a building one where its design, construction, or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. Green buildings differ in characteristics between countries and regions as they should respond to climatic conditions, environmental, economic, and social priorities, cultures, traditions, building types and age. The WGBC (n.d.) established criteria and goals to ensure buildings are developed sustainably. The principles and strategies can be used for new developments and retroactively applied to existing buildings to achieve sustainability. There are several features which can make a building 'green' (WGBC). Amongst them, and relevant to this study is the efficient use of water and other resources which can be implemented retroactively and ensured that

future developments include green technology and structures. An example of this is Botho University in Botswana which partnered with Pearl Water-free Technologies in December 2018 in a water-saving programme. The University managed to reduce water consumption by 75% immediately after the installation of water-efficient technology such as waterless urinals and low-flow taps in 2019 and saved P110,000/mth (approximately N$147,000/mth, (Oanda Currency Converter, 4 Jan 2022). Comparing month-on-month use a year before installation and the same month of the year immediately afterwards the average water consumption savings were 80% (M. Margolis personal communication, 21 Oct 2021). A study at the University of Wisconsin-Madison (Uelmen *et al*. 2020) in which the university Green Fund was used to retrofit low-flow toilets resulted in a reduction of water consumption by 54% and a saving of US$2,380 in utility costs on each toilet, an annual saving of roughly N$37,600 per toilet (Oanda Currency Converter, 4 Jan 2022). The USA are already ahead of Southern Africa in encouraging waterless urinals and low-flow toilets. Well accepted there, some water utilities give rebates to offset the installation costs if toilets are upgraded (Uelmen *et al*. 2020).

UI Greenmetrics World University Ranking Network (UIGWURN) was launched in 2010 to provide a measure of the greenness of a university using a ranking system (UI Greenmetrics 2020) and provide a baseline from which to measure its level of sustainability and environmental impact. The University of South Africa, Pretoria, the University of Kwazulu Natal, Durban and the University of Technology, Free State are among the member of the Greenmetric programme from 84 countries (UI Greenmetrics 2020).

Universities that participate in the UI Greenmetrics programme are given indicators that measure greenness and help establish where it is on the scale and what needs to be done to gain a good green rating. There are six criteria: setting and infrastructure; energy and climate change; waste; water; transportation and education and research. The Greenmetric water indicators intend to assist universities to decrease water usage, increase water conservation programmes, and protect their habitat.
The indicators are:

- Water conservation programme implementation.
- Water recycling programme implementation.
- The use of water-efficient appliances (water tap, toilet flush, etc).
- Treated water consumed.

The UI Greenmetric education and research criteria are based on the belief that universities have an important role in fostering a generation of individuals concerned about sustainability issues. In addition to the water indicators to determine greenness, they use indicators to measure active involvement in sustainability issues that include the ratio of sustainability courses towards total courses/subjects and research funding compared to total research funding, as well as the number of scholarly publications, events and student organisations related to environment and sustainability. They also consider the existence of a university-run sustainability website and publication of sustainability reports. Further studies could involve measuring the greenness of NUST using the UI Greenmetrics criteria to provide a baseline from which to develop initially a WMS and in the future a green campus strategy.

Filho *et al*. (2015) view campus greening as an educational response to the world's economic, ecological, and educational challenges. Universities can be effective change agents as they have the potential to influence how people think and act and can shape the leaders and decision-makers of the future a concept recognised by Svanström *et al*. (2008) and Too and Bajracharya (2015). ISCN recognise that to achieve successful greening experts should be engaged to assess and review plans through the development of a working group or forum for students, staff and university partners to engage in collaborative stakeholder-based master planning. Involving a wide range of representatives from different sections of the campus will promote leadership and the impact of the programme (ISCN 2014). To establish the effectiveness of water management as well as a future greening strategy regular monitoring and evaluation of effectiveness is required as identified by Bekessy *et al*. (2007). Programmes and toolkits discussed above provide assessment schemes to do this and offer an opportunity to gain international recognition for green projects initiated.

In time, once strategies to save money using more efficient infrastructure and effective management are in place and operational costs are reduced, monitoring and evaluating campus sustainability using criteria such as the Greenmetrics ranking criteria and sustainable development milestones will assist NUST to keep on track. As was found in Cape Town (Ziervogel (2018) a systems approach would help ensure environmental and economic sustainability and instil sustainable development practices holistically around campus thereby ensuring environmentally responsible behaviour becomes habitual.

4.3.5 : Creating an enabling environment

Strategies alone will not have an impact (Bekessy *et al.* 2007). Proclamations of what is planned will not improve water sustainability, action must be taken, and approaches changed.

The UNEP programme and GUPES partnership promotes the greening of university infrastructure, facilities and operations and supports students and alumni participating in sustainability activities. In addition, the toolkit developed in collaboration with university leaders in 2011 inspired and aided positive change (UNEP 2014) that can be adopted at NUST. The Talloires Declaration provide guides to becoming greener and more sustainable. (ULSF n.d.). In order to meet these objectives broad-scale changes that are required in university practice should be set out in the plan.

Making a significant contribution to sustainability, initially, sustainable water use at NUST, requires a transformative strategy providing exemplary environmental best practices and mainstreaming sustainable initiatives rather than small-scale activities. Consequently, Bekessy *et al*. (2007) surmise, the Talloires declaration is calling for systemic change, rather than simply implementing isolated projects. Universities have a wide sphere of influence and can become the catalyst for greener communities beyond the campus walls. GUPES, UNESCO, and UNEP are amongst other institutions part of the Higher Education and Research for Sustainable Development (HESD) initiative which strive to reach the Sustainable Development Goals 4, 12, 16 and 17 relating to inclusive and quality education; sustainable consumption and production systems; promoting sustainable development through accountability; and strengthening global partnerships for sustainable development. This SD era was referred to as 'Sustainability 2.0' (UNEP 2014).

The RMIT University in Australia signed the Talloires declaration in 1995 and ran a greening RMIT programme from 1998 to 2004. The principle was that direct cultural change could be the catalyst for institutional transformation to sustainability (Bekessy *et al.* 2007). Students on the Greening RMIT team generated ideas and innovations related to RMIT's academic environmental programmes so ensuring the initiatives and projects were more appropriate and relevant. However, after the SD 'era' was over Bekessy *et al*. (2007) examined why RMIT, like many other Universities, did not meet its sustainability goals and promises.

Bekessy *et al*. (2007) propose that simply becoming a signatory of a declaration such as Talloires and joining the Association of University Leaders for a Sustainable Future is not impactful enough to bring about change as there is little accountability or monitoring of progress towards sustainability. A genuine and serious effort must be made by the institution rather than merely signing the declarations. UCT's stimulus to enact the Talloires Declaration was the formation of a policy and subsequent action plan with evaluation criteria by a newly established Environmental Working Group (Rippon 2008). Filho *et al*. (2015) note that it is important to track performance measures and have targets clearly defined and adapted as time progresses and report to internal and external communities. Signing up for green initiatives does not change behaviours. A system of open accountability that monitors progress towards the goal of environmental sustainability is required. Methods and approaches must be continually tested, evaluated, and improved to ensure that the university is progressing towards greater sustainability (Bekessy, *et al*. (2007). In looking at facilities management and attaining a sustainable campus Saleh *et al*. (2011) report that legislation and regulations are becoming more stringent so to ensure action and compliance to pledges reports are required by stakeholders.

According to Ziervogel (2019), the capacity to learn and reflect is necessary both during and emerging from a crisis. It can be hard to institutionalise space for learning amid a crisis, so mechanisms must be set up beforehand to embed learning as part of the organizational culture. She cautions that the near miss of 'Day Zero' in Cape Town should serve as a lesson to other cities. (Ziervogel 2019). Windhoek was one step away from a Category E domestic water crisis with enforced water restrictions (CoW 2019b), indicating it is essential to act now and not enter a situation of crisis management.

If mainstreaming practices are to be initiated at NUST they need to support change as the process of changing is complex and requires a range of strategies integrated into all aspects of university life for success. Full, visible, and tangible support from the university management is critical to the success of sustainability strategies (Bekessy *et al*. 2007). Based on the findings of a nine-year study Ramisioa *et al*. (2019) also found the in implementation of sustainability strategies in higher education institutions change of the organisational culture was most significant when a combination of bottom-up and top-down approaches was used. Sustainable living needs to become part of the ethos of the institution and will be required to successfully implement the WMS at NUST and future environmental and SD plans.

Chapter 5 : Conclusion and Recommendations

This study provides new insight on how a multi-faceted approaches can address both technical and behavioural aspects to reduce water consumption improve management and increase awareness of water issues in the future (Sinclair-Smith and Winters 2018). The key points from this assessment of sustainable water management at NUST and lessons learned and best practices in similar institutions support the need for a WMS.

Water stress is an increasing concern in a time of climate change and taking personal responsibility for our own water use has important implications for CoW's ability to provide sufficient water for its residents in the future. This study highlighted areas of unsustainable practice in terms of water management at NUST with insufficient attempts to reduce losses, reduce water used, or reuse water. The lack of attention to water consumption and scrutiny of bills resulted in high water charges. Splitting the combination meter functions and retaining the fire pipelines for emergencies only would incur much lower monthly basic charges. NUST has clearly underinvested in the maintenance and replacement of decaying pipes and sanitary fittings. Large quantities of water are wasted due to old reticulation infrastructure and a lack of mitigating actions such as a maintenance and repair programme, water pressure management, and the installation of isolation valves. Improvements in the problem reporting system would make it more user friendly, provide more accurate data analysis and become a facility management tool. The installation of smart meters with leak detection capabilities and online shut-off valve piloted in this study already resulted in savings on water and sewerage bills. This led to positive steps being taken towards investigating a more effective and economically and environmentally sustainable water management approach. Strategies used by CoW and Cape Town municipality to encourage sustainability demonstrate how water demand management systems can successfully influence water use through awareness raising, the use of champions and increasing tariffs.

Pro-environmental actions and sustainable approaches taken at the Hotel School to monitor water use, read meters, prevent the use of fire pipelines and educate users were found to be effective. A general understanding of the severity of water scarcity among students and staff was particularly clearly demonstrated in comments regarding water loss in the Service Desk problem reports. However, a positive behavioural approach to water conservation was not observed equally at all levels of the campus

community, particularly obvious in the water left running in bathrooms, the use of baths and the response rate to leaks and burst pipes.

Awareness of, and attitudes towards water-related environmental issues at NUST were generally good. The results of the online survey and interviews confirm that over three-quarters of the respondents felt it is important that NUST becomes green and more environmentally sustainable and supported becoming part of a wider global initiative to develop into a greener university that they would be proud to be part of. The 1600 plumbing problems reported by staff members over 38 months are an indication of a community willing and interested in saving water. With an improved understanding of the water situation a positive relationship could be developed between the attitudes and water use behaviour. This bodes well for a campaign to use less water at NUST and should be taken forward into a strategy for overall environmental management and sustainable development.

The application of efficient and more sustainable technologies cannot replace the provision of information and examples of practical steps that can be taken to reduce use. Many practical ideas were provided by survey respondents, which have been summarised in Table 7 in the recommendations section below. To effectively support change in practice the introduction of concepts relating to environmental sustainability and sustainable development should be integrated across the curriculum and core courses with the provision of supporting data so sustainable practices become tacit and the long-term need for them is understood (Ham *et al*. 2016).

The research focused on drought responses in other countries and examined efforts to green up institutions of higher education and bring about environmental change such as becoming part of an international network of green universities. Sustainable approaches and action plans developed in other tertiary institutions provided good examples of what was found to be the most effective way of implementing change. These will inform and guide the development of a WMS for NUST. Signing the Talloires Declaration and the ISCN-GULF Sustainable Campus Charter will support efforts whilst global green initiatives provide toolkits that further encourage environmentally and socially sustainable practices.

This study is a forerunner to a WMS for NUST and sets a precedent for future investigations into other aspects that will contribute to the development of an EMP. The holistic approach required for

environmental sustainability throughout campus needs to focus on campus operations, management, maintenance and upgrading of infrastructure, research, SD education, awareness raising, monitoring and assessment, accountability, and reporting. A framework based on the three main components: management and monitoring systems, education and awareness, and evaluation and adaptation will be required to indicate how the WMS can be integrated into daily university life and will look more widely than just water management.

Sustainable environmental management can be achieved with a structured plan as was experienced at UCT (Rippon 2011). The successful implementation of a WMS, and the eventual EMP, will rely upon meeting milestones and targets and performance assessments. The concept of wise water use, sustainable development and green practices need to become accepted and embedded campus-wide in all procedures and processes, thinking and actions. Practices must be institutionalised within policies and daily operations with an environmental forum assisting with implementation and monitoring the progress of the university towards its sustainable goals. This should be under the scrutiny of the public, academic and corporate arena to ensure accountability and progress towards goals. Plans need some form of accountability, binding agreements, or consequences to ensure that efforts become actions and not just words (Bekessy *et al*. 2007). The appointment of someone to drive the sustainable development programme and oversee the sustainability programmes and projects will be essential for success. Investment now in environmental sustainability through integration, internalisation and institutionalisation of sustainable management practices will result in savings later and greater financial sustainability as well as increased environmental awareness.

There is potential to change attitudes and influence the behaviour of the more than 13,500 staff and students at NUST, the positive effects of which would stretch far beyond the borders of the university and can influence the leaders of the future to be more environmentally conscious. If HEIs worldwide were to take up the challenge to change behaviour, we would see some progress towards environmental sustainability and mitigate against climate change (Bekessy *et al*. 2007).

The study filled many gaps in existing knowledge regarding current water management practices and behaviour at NUST which prior to the completion of the study prompted action and measures to be put in place. It gained insights into attitudes towards sustainable water use which affects behaviour, and the broader support that exists for greening the campus. It uncovered an enthusiasm for initiating greener

practices and support for measures that would involve staff and student cooperation. As a result of the quantitative and qualitative findings, in combination with best practices and lessons learned from other universities and comparable situations, there is sufficient background data and information to compile a solid strategy to manage water at NUST and work towards the greening of the NUST campus.

Research points to alarming trends in water, which need immediate attention in the form of investing in better management for the benefit of the environment, economies, people and the planet (WRI 2019). Better management will help Windhoek avert a crisis in the future and as an institution with influence, NUST can provide a good example to its community and beyond of how working together can make an impact. We can all be agents of change and make sustainable and responsible behaviour a way of life. NUST should take the lead as a research institute to develop strategies and set practices in place to accelerate this transition.

5.1 : Recommendations for a WMS

NUST can begin its greener more sustainable campus journey by focusing on the severe scarcity of water, involving staff and students at all levels contributing ideas to promote behavioural transformation and the development of management, monitoring and IT systems to support it. As an organ of the state, it must be compliant with the Environmental Management Act (GRN 2007) and should be modelling exemplary behaviour by greening up its act as well as demonstrating its commitment to mitigating the impact of climate change. Research and implementation of sustainable technology, operational procedures and approaches could both put NUST at the forefront of sustainable living in Namibia in the long term, and in the short-term increase both economic and environmental sustainability through the reduction in water consumption and therefore operational costs.

Campus greening at NUST should start with water management and expand in steps to include energy and waste, as priority areas. In order to effect change a whole systems approach, regarded by the ISCN as the most effective way to become more sustainable (ISCN 2020), must be taken at NUST. This approach involves working on three components simultaneously: the development of more effective management and water monitoring systems including the installation of water-efficient and time-efficient technology; education and awareness raising to promote behaviour change and continual assessments and appraisals

of the success of the new systems and approach. The institution must endorse its commitment to environmental sustainability through environmental plans and strategies.

A strategy or blueprint providing a road map for the implementation of sustainable practices at NUST is essential to take NUST closer to becoming a Green University. Figure 42 summarises the steps that should be incorporated into a WMS, and the support and adaptations required. The steps fall into two broad categories, education and awareness, and management and monitoring, with oversight and evaluation to allow for adaptation and improvement of efforts.

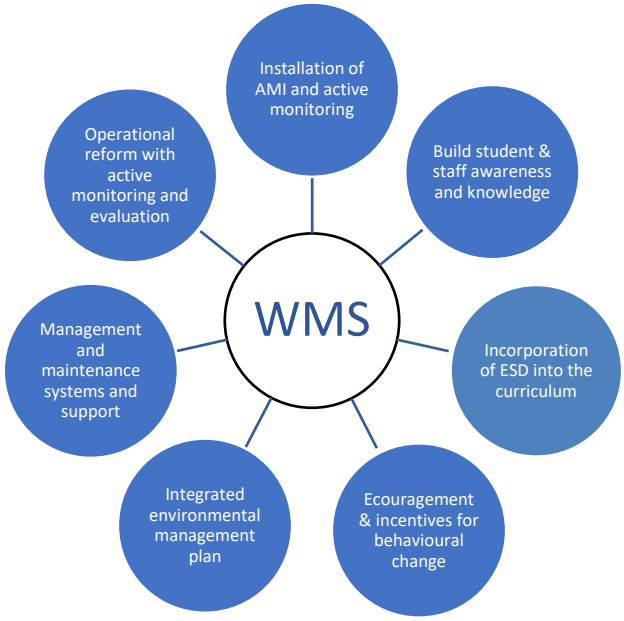

Figure 42: Water management strategy development.

(Adapted from *A Model for Sustainable Change*) Source: Harrington *et al*. (2015)

The steps outlined in Figure 42 for the suggested WMS design and development framework allow for:

- Improved organisational and metering capacity to measure the impact and effect of improvements to the water management system.
- Ongoing training and collaboration with institutions such as the City of Windhoek and NaDeet.
- Integration of assessment and learning into systems.
- Improvement of processes and effective management thereof.
- Constant reflection on, monitoring and modification of systems and processes.
- Continual upgrading and improving sustainability.

Access to assessment methods and tools to evaluate responses to the strategy encourages more accountability and greater assurance that the impact of efforts will become apparent through further studies.

A summary of what can be incorporated into a strategy to facilitate and institutionalised systemic change that, in the longer term, can be applied more widely to the use and management of and demand for other resources such as energy and waste on the NUST Campus is contained in Table 7 below. Recommendations and best sustainable and green practices used in other universities described in section 4.3 should be evaluated for their relevance and applicability to Windhoek and NUST when developing a WMS and the subsequent EMP for the University. Suggestions for future research to gain a more detailed picture of what water-saving strategies can be employed at NUST are also included.

Development of the approach falls into three categories:

1. Active management and monitoring
2. Education and awareness raising
3. Assessment and evaluation

Active management and monitoring involve the implementation of the WMS and EMP and practical ways of improving environmental and water-efficient performance including metering and overseeing consumption, charges and the state of the infrastructure. Education and awareness raising develops knowledge and promotes environmentally sustainable behaviour. It includes role models acting as cultural and environmental ambassadors engaging in and promoting activities and stimulating innovation, discussions and sustainable approaches in which students can engage. Assessment and evaluation involve the appraisal of the impact of actions and approaches using metrics, indicators and milestones and gauging the short and long-term impacts on behaviour and management. It includes modification of activities for greater effect.

Table 7: Summary of recommendations to initiate a greener water-wise campus at NUST.

Goal	**Actions**
Active management and monitoring	
Functional problem reporting system with improved feedback and alert capacity and a more user-friendly interface with greater interpretation and analytical capacity	The Service Desk software requires an annual licence to use it to organise, manage, and respond to maintenance requests, problems reported, and facility-related issues submitted by NUST staff. Ensure licences are automatically renewed for core systems such as this so maintenance requests can be made and responded to timeously.
	Redesign the DICT Service Desk reporting format to facilitate exactness in submission. Create an alert after 24, 48 and 36 hours to improve response time to a maximum of three days for reported water problems such as burst pipes and water leaks. Complete the report log as soon as the problem is resolved to make water losses and response times easier to determine. Include the response success rate in performance reviews and task-related work plans of the maintenance team.
	Improve the Service Desk system interface to streamline reports through the use of drop-down lists to tick, limiting descriptive sections and allowing a restricted number of characters to keep comments focused to facilitate a user-friendly extraction of useful data for additional uses. The online report form could highlight incomplete sections. By only allowing submission of the report when the form is fully completed, and all subject lines ticked it increases the detail and accuracy of the data captured. Improve functions so the report can be used as more than a problem reporting system such as facility management.
	Analyse the proportion of plumbing problems reported versus electrical and infrastructure issues to ascertain where the most effort is required in terms of maintenance and upgrading of infrastructure, and where resources should be focused for improvements.
	Investigate a client–operator dashboard or App which will reduce the burden of administration in the maintenance process and will greatly improve upon the current Service Desk ITS system.
	Analyse the Services Desk reports and reliable historical records in detail to establish where the University water hot spots are and develop a maintenance and renovation plan.
	Alternatively create an online real-time database, developed by the NUST IT department to replace the Service Desk system so NUST has its own tailor-made system, free of charge and that it is not reliant upon licence renewal. This will provide easy access to information regarding water use, as well as energy, by

	department, or by floor of each building. This could also store all plumbing, and other maintenance problem reports. Ensure accountability is created to update it daily with actions taken, so enabling the analysis and addressing of maintenance issues.
Understanding of consumption patterns to set targets and monitor water use against	Scrutinise bills and compile a month-by-month spreadsheet linked to a graph enabling excessively high bills to be identified immediately and addressed.
	Assess departmental water use activities. Establish a baseline against which progress and achievements such as reductions in water use, reporting and response times can be measured. Investigate potential rewards for best practices.
	Enter water meter readings onto a mobile device to ease the burden of transferring manual readings into a digital format and facilitate the compilation and analysis of data. Detect abnormal usage by cross-checking daily metering with occupancy and time of day. This provides an opportunity to manage water use more efficiently and exert controls when spikes in use are observed.
	Set targets, both a per capita and departmental quota and water use indicators for reducing water consumption. A quota of 20l/person/day for a full day and 15l/person for a half day based on the CoW should be used as guidance. Publicise them around campus using large visual targets, consumption barometers or dashboards, on social media, using NUST FM and on calendars to remind people of the quote to aim for that week.
	Decide on the repercussions for not meeting targets or for wasteful use or misuse of water and rewards for meeting targets.
	Monitor and measure the effects of water-saving efforts
Identification of hot spots for the renovation of infrastructure	Establish if the original site plans are available from the municipality otherwise have new ones drawn up mapping the water infrastructure and reticulation system.
	Determine what proportion of the maintenance budget, and reinvestment of savings from operational costs (reduced water bills), can be allocated to the replacement of water infrastructure and mitigating actions such as finding or re-creating the water pipeline plans for the University and identifying.
	Map high water usage areas and problem hot spots in a graphic format monthly so trends are apparent, and information is used as a management tool.
	Upgrade, renovate and replace old water infrastructure, pipelines and ablution facilities, standardising them where possible, so simplifying maintenance. Stop cocks should be installed in every building, and isolation valves, preferably on every

	floor, so water to specific areas can be shut off and leaks isolated without cutting off water to the entire campus.
	Develop a maintenance plan so that rather than making reactive or corrective repairs schedules preventative action and maintenance to prevent the occurrence of problems in the future.
Save water through the installation of water-wise technology	Install water-wise technology such as tap aerators, or low-flow regulators. Install eco-flush toilets or dual flush toilets with smaller 4.5-litre cisterns when they need to be replaced and place bricks into cisterns to reduce water flushed and fit waterless urinals campus-wide. Insert pressure valves into shower heads in the hostel bathrooms and insert hex plugs into the bathtub taps to prevent the use of the baths until they can be removed. Reinvest savings from the installation of water-wise technology in a cyclical manner.
	Put checks and restrictions in place such as shower timers that limit the length of showers in the hostels to protect against excessive use of water.
	Manage and reduce the water pressure, in particular to facilities that are high water consumers and prone to burst pipes
Reuse and recycle water to reduce overall water consumption	Reduce consumption of water; reduce loss and wasted water from leaks; install instant hot water devices to reduce water runoff wasted whilst showering; recycle filtered greywater for plumbing, use in laboratories, particularly in heavy-use bindings such as the Hotel School and Hostel and. for waterwise gardens. Harvest rainwater from the gutters. divert it into toilets and reuse it for cleaning floors, washing University vehicles, and building maintenance. Invest in greywater treatment infrastructure and green infrastructure such as rainwater butts. The application of more efficient systems to reduce, recycle and reuse water will certainly result in cost savings for the institution.
	Use students to design a wastewater recycling system to capture and re-use laboratory water such as in the Mining laboratories.
	Actively engage NUST students in the design of water-saving infrastructure for example water harvesting and management systems for example design a rooftop rainwater harvesting system as a supplementary water source for toilet flushing and use in some laboratories.
	Integrate permeable paving and vegetated swales and berms on slopes around campus to capture rainwater runoff, remove pollutants and channel the water to gardens planted with indigenous trees and shrubs.

Use of an AMI smart meter system for more effective monitoring	Install smart meters at least in each building preferably on each floor to identify and trace leaks or burst pipes more efficiently and provide accurate data on daily water consumption whilst tracking and monitoring water use and providing more accurate billing. Facilitate cell phone notifications to give operators the ability to shut valves and close down areas during holiday or closed periods. Open up valves singly via the AMI system upon return to campus to reduce the pressure of water flowing through the pipes that causes them to burst.
	Consider the use of a Tridium building management system to monitor the smart meters. This uses an HTML software platform to connect and interface with other devices including cell phones to report problems using an App with a GeoTag, and systems such as electricity, security, and access as well in real-time. Data will be collected from all systems whilst providing services such as leak detection nonfictions, emergency shutoff valves, data management and compilation of reports so hot spots and common faults can be easily detected and monitored or replaced.
Correct charges and billing by CoW	Split the main municipal combination meters at Lower, Upper and Hotel Campus into non-domestic and emergency fire meters to save more than N$16,000/mth per meter. Check for other meters where the fire meter is being charged at the >80mm meter rate to reduce basic water tariffs. Invest the savings in smart meters.
	Ensure CoW municipal bills are cross-checked against meter readings and trends plotted to identify irregularities more easily.
Reinvestment of savings	Redirect water cost savings from the above adaptations into regular maintenance and upgrading of infrastructure and sanitary fittings, and the installation of greener water-efficient technology and AMI throughout the university.
Refer to the relevant WGBC safeguarding measures to ensure compliance	• Ensure infrastructure, such as drains, water pipelines and sewers are not put under undue pressure or prevented from doing their job. • Minimise water use in buildings. • Recycle and reuse laboratory water. • Harvest water for safe indoor use in innovative ways. • Water-smart landscaping involving drought-resistant plants. • Consider the impact of buildings and their surroundings on stormwater and drainage infrastructure. • Explore ways to improve drinking and waste-water efficiency and management.
Compliance with the Environmental	Undertake further investigations into other resource management aspects that will contribute to the development of an Environmental Management Plan then implement it to encourage energy and water-savings, as well as reduction of waste

Management Act (GRN 2007)	through more efficient and sustainable technologies, increased SD awareness, active monitoring and management.
Education and Awareness Raising	
Community on board with the green measures	Ensure staff, students, and the public and community in the vicinity of NUST are fully informed and on board with sustainable water use and the development of a green campus programme.
	Ensure that staff, students, and the public and community in the vicinity of NUST are aware of: • The institution's water management plans and strategies, as well as the University's commitment to environmental sustainability. • The impacts, environmental and consumptive, of individual activities. • Ways of improving environmental performance through water-wise initiatives.
Visual display of water consumption and facts on water availability	Inform people about the water crisis on notice boards in the bathrooms and cleaning storerooms, on social media with daily updates. Provide direct and immediate information on resource use and the environmental impact of the use. Jointly set targets for water use reduction with faculties and publicise them. Erect billboards or digital barometers displaying what has been used or use an inside-outside dashboard that is linked to a reward system for wiser water use and the benefits to the community at large. Derive investments and give rewards from cost savings on reduced water use and more efficient and effective management of water.
Integrate sustainable development across the curriculum and in courses and introduction to new students	Assess whether or not the institutional core courses, sustainability and development courses (SYD611S) and orientation initiatives related to environmental sustainability at NUST are effective and promote positive environmental attitudes and behaviour.
	Increase awareness further by incorporating more Education for Sustainable Development teachings during orientation and through ICC and then integrate it into all aspect's daily life and work. Environmental literacy is key to influencing attitudes and behaviour, however, perceptions differ among staff and students at NUST thus a programme that is integrated into all components of student life and learning is necessary to achieve a genuine green campus.
	Work with the curriculum designer on the structure of an SD course, and how SD can be incorporated across the curriculum in all disciplines. Refer to the different sections in the IUCN-WaterNet Postgraduate Training Module on Water Demand Management 2003 for how it can be incorporated into the different subjects.

Promote water awareness through the NUST Environmental Club	Involve students from the NUST Environmental Club initiative, in promoting awareness and wise use of natural resources to their peers through activities, talks, games, and lectures from guest speakers. Collaborate with other relevant external stakeholders and the COW on the provision of printed materials for the campaigns to educate new students during Freshers Week orientation.
Celebrate international climate and environment days	Add either a Sustainable Development or Innovation for Climate Change week to the academic year to encourage the development of innovative and practical applications and solutions. Observe other pertinent days such as World Water Day.
NUST becomes the leader in the environmental field	Hold annual sustainability conferences and workshops at NUST led by students with guest speakers with examples of what has been developed by researchers and students at NUST. Encourage students to take responsibility and place NUST at the forefront of sustainability in Namibia.
	Invite external stakeholders such as NEWS, NamWater, CoW and the Hydrogeological Association to present workshops and conferences to educate, impart more information and increase academic staff's confidence to teach about sustainable development in their respective subjects.
Security guards trained as water marshals	The National Save Water Campaign endorsed Water Marshal training programme recommends public and commercial buildings appoint a Water Marshal. Security guards and cleaning staff should undertake the CoW water marshal training programme to provide a useful monitoring and leak detection function until digital systems are installed in all buildings. The programme creates more awareness and gives clearer insights into their responsibilities regarding water and energy wastage and responsible behaviour. Attendance of such a programme allows for more active monitoring and generates a greater sense of purpose.
Publicise the Universities' efforts to inform all staff and students	The implementation of the EMP should include awareness programmes to ensure that staff, students, and the public and community in the vicinity of NUST are aware of the institution's plans and strategies, the environmental impacts of behaviour, ways to improve performance, roles and responsibilities and potential rewards for best practices. Greater awareness and understanding will inspire people to meet the targets.
Green Campus initiatives	
Definitions clearly outlined	Develop clear definitions, directly related and applicable to NUST set within the Namibian context and the SDGs, for concepts such as sustainability, green

for the Namibian context	university, and water demand management. The definitions of sustainability and sustainable use must be established that NUST adheres to and applicable solutions to it becoming environmentally sustainable defined in the institutional context.
Students taking the lead in green initiatives	NUST university management should consider involving students in the planning and implementation of sustainable practices on campus not only to build environmental literacy but also to illustrate how it can be practically implemented, whilst harnessing the energy and commitment of the youth to take the programme forward. Student bodies such as the Environmental Club could be given a forum to become advocates for the sustainable use of resources on campus and change agents to raise awareness and become activists promoting behaviour more favourable to the environment.
NUST Greenmetric rating established	Measure the greenness of NUST using the UI Greenmetrics criteria, - setting and landscape; energy and climate change; waste; water; transportation; education and research, to get a baseline for improvement (see UI Greenmetric criteria and indicators) and indicate the immediate areas of focus.
A Green Campus plan established and implemented	Connect departments and faculties to greater cross-fertilisation of ideas and working with a common goal. For instance, connect the Facilities and Architecture Departments with the Integrated Land Management Institute (ILMI at the Faculty of Natural Resources and Spatial Sciences (FNRSS) at NUST and foster working with their water and waste section to discuss better water management systems, employ new methods to monitor and promote wise usage and engage with experts to gain advice on greening up buildings. Establish a Green Campus Forum with representatives from all sectors of the university, in particular Management, Facilities, Administration, Finance, DICT and Natural Resource Departments to identify actions, operational procedures and a framework for initiatives and generate a master plan and how to implement it to reduce water and energy consumption, waste and reducing the impact on the environment whilst educating to improve understanding.
Integrated environmental planning	The forum should monitor progress and attainment of goals for implementing the WMS and the design and development of future environmental plans and integration into all aspects of university life at NUST. It could engage advice from experts and key partners and stakeholders in the environmental field.
Acknowledge the role staff and students can play in achieving the	Assess the role, level of participation and support student representatives/leaders can offer towards the implementation of sustainable practices in universities and seek willing position holders.
	Appoint environmental champions (departmental staff) in each faculty at NUST to drive the WMS programme, environmental stewards (students) to monitor water

green campus goal	consumption on a departmental scale and water marshals (security guards) to check the meters. Appoint these role models in each faculty on a rotational basis to share responsibility. Determine their roles and responsibilities.
	Ascertain the support that can be expected for the implementation of Green University initiatives and ways to harness that support by providing an enabling and incentivised (not necessarily financial) environment.
	Facilitate opportunities to allow students and staff to have an impactful influence on the greening up NUST.
	Follow the model of De Montfort University (Green Impact n.d.) and UCT (Rippon 2008) and create a position for a dedicated sustainable environmental development person to monitor and manage the programme and implementation of the WMS.
Join international green networks	Collaborate with other Universities through the ISCN GULF Universities network. Sign up for green initiatives that hold universities accountable to ensure progress and compliance and expand opportunities, share ideas, information and best practices and seek new perspectives on sustainability with other universities. Become the first ISCN member University in Namibia to join Universities in North and South America, Europe, Scandinavia, and Asia.

5.2 : Further research topics

A number of studies could follow on from the research conducted for this study and add to the body of knowledge to further inform the development of a WMS and in particular an EMP with the supporting actions and initiatives that must be taken to support its effective implementation. Suggestions for further research topics are listed below in Table 8.

Table 8: Suggestions of area for further research.

Further Research Topics	
Determining NUST's Greenmetrics rating	Measure the greenness of NUST using the UI Greenmetrics criteria to be used as a guide for the development of a green campus initiative.

Accurate target setting	Determine weekday and weekend consumption and analyse day and night use to provide deeper insights into water use trends
Identification of most consumptive sites on campus	Monitor weekly and monthly usage at all buildings on the campuses and how it varies to determine where most of the water is being consumed and identify actions that can be taken to reduce the consumption.
Metering of residential buildings	Install meters on the hostels, hostel kitchen and Poly Heights to compare water use on a per capita basis and monitor consumption at the residential sites.
Establish a baseline for further education	Ascertain SD knowledge and awareness, level of concern and determine what new students feel it is important to learn to incorporate it into ICC and freshers' orientation.
Development of an ESD campaign	Determine how to impart more facts and figures on resource use amongst staff and students at NUST through the provision of easily digestible and incorporation of it into the curriculum. Ascertain the determining factors of an effective environmental awareness campaign.
Development of materials for integration across the curricula	How to incorporate more sustainable natural resource use awareness across the curriculum at NUST, in combination with the provision of easily digestible facts and figures on resources to effect behavioural change.
Namibian-specific motivational techniques	Identify common and distinctive techniques to motivate people to save water, change attitudes and enhance sustainable thinking at NUST that work in a Namibian context. Evaluate each intervention to determine which is the most effective.
Measuring the effectiveness of an awareness campaign	Find out how attitudes influence behaviour at NUST through an awareness campaign and determine the specifics of how to effectively change attitudes or enhance sustainable thinking in the Namibian context. Further research can be carried out once behavioural changes take effect to measure the reduction in use from the current use to the new level of use and to estimate the continued reduction that could take place over time.
Measure the success of new efforts in reducing consumption	Post-implementation of pro-environmental approaches measure the reduction in use from the initial use to the new level and estimate the continued reduction that could take place over time. Develop a system of accountability that monitors progress towards the goal of environmental sustainability.
Determine the influence of	Ascertain the influence of demographics, personal backgrounds and rural or urban childhoods on environmental awareness, attitudes, and responsible

demographics on responsible behaviour	environmental behaviour in a Namibian environment to tailor make an educational programme that will be effective and achieve the goals to heighten environmental and ecological sensitivity to resource use.
Establish a viable system to recycle and reuse water	Investigate opportunities to recycle grey water at NUST and identify areas where water can be harvested, treated, and reused. Assess existing grey water harvesting, treatment and recycling systems in schools, that could be adapted and enhanced to suit NUST.
Establish the next steps to develop the EMP.	Based on this study undertake further investigations into other aspects that will further contribute to the development of an Environmental Management Plan
Establish an EMP at Eenhana NUST Campus	Undertake an assessment and establish an EMP based on the principles outlined above in order to set the foundations for an environmentally conscious approach to operations and resource management at the new northern campus.

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Appendices

Appendix 1: Water Meter Reading Log Sheet

WATER METER READINGS MAY 2020

NUST UPPER CAMPUS

WATER METER Number: 3050703-99

WATER READER Name: Abraham 0816060052 & Iita Immanuel

22 Security staff on site, two matrons and people living in PolyHeights.

Initial reading 17.00 30.4.20 059921 - Water meter not recording correctly.

Date	Am / Pm	Meter reading	Problems identified
1.5.20	7.30	059921	
1.5.20	16.30	059922	
2.5.20	7.30	059923	
2.5.20	16.30	059923	
3.5.20	7.30	059923	
3.5.20	16.30	059924	
4.5.20	7.30	059924	
4.5.20	16.30	059924	
5.5.20	7.30	059925	
5.5.20	16.30	059925	
6.5.20	7.30	059926	
6.5.20	16.30	059927	
7.5.20	7.30	059928	
7.5.20	16.30	059928	
8.5.20	7.30	059930	
8.5.20	16.30	059930	
9.5.20	7.30	059931	
9.5.20	16.30	059931	
10.5.20	7.30	059932	
10.5.20	16.30	059933	
11.5.20	7.30	059934	
11.5.20	16.30	059935	
12.5.20	7.30	059935	
12.5.20	16.30	059936	
13.5.20	7.30	059937	
13.5.20	16.30	059937	
14.5.20	7.30	059938	
14.5.20	16.30	059939	
15.5.20	7.30	059941	
15.5.20	16.30	059942	
16.5.20	7.30	059943	
16.5.20	16.30	059944	Geyser lacking behind boys hostel
17.5.20	7.30	059945	there is full of water inside
17.5.20	16.30	059946	Still water in site

WATER METER READINGS MAY 2020

NUST UPPER CAMPUS

WATER METER Number: 3050703-99

WATER READER Name: Abraham 0816060052 & Iita Immanuel

22 Security staff on site, two matrons at male and female hostels with families and people living in PolyHeights.

Initial reading 17.00 30.4.20 059921 - Water meter not recording correctly.

Date	Am / Pm	Morning reading	Evening reading	Total daily use	Total night use	Problems identified
1.5.20	7.30	59922		0		
1.5.20	16.30		59922		0	
2.5.20	7.30	59922		1		
2.5.20	16.30		59923		0	
3.5.20	7.30	59923		1		
3.5.20	16.30		59924		0	
4.5.20	7.30	59924		0		
4.5.20	16.30		59924		1	
5.5.20	7.30	59925		0		
5.5.20	16.30		59925		1	
6.5.20	7.30	59926		1		
6.5.20	16.30		59927		1	3.15 Verified reading 059927
7.5.20	7.30	59928		0		
7.5.20	16.30		59928		2	

Appendix 2: Examples of Water Audit Log Sheets

Environmental Scoping Study - HEALTH & APPLIED SCIENCE **Month: .....October 2020.....**

Water outlets by floor

		Taps, Basins, Toilets, Pipes, Fire extinguishers					Date problems reported	Notes
	Quantity	No water	Dripping	Running	Full on	Leaking pipe		
Basement (Health) F Student toilets	3							No problem
Basement (Health) F Student basins (taps)	2							No problem
Basement (Health) M Student toilets	2							No problem
Basement (Health) M Student urinals	2							No problem
Basement (Health) M Student basins (taps)	2							No problem
Basement business unit lab (taps)	12							No problem
Ground floor F Staff toilets	1							
Ground floor F Staff basins (taps)	1					1	23/10/2020	Water leak under basin when used
Ground floor M Staff toilets	1							
Ground floor M Staff basins (taps)	1							
Ground floor F Students toilets	3							
Ground floor F Students basins (taps)	2							
Ground floor M Students toilets	2							
Ground floor M Students urinal	2							
Ground floor M Students basins (taps)	2							
Disabled toilet + basin (taps)	1							
Water fountain in wall inside	0							
Staff kitchen	1							
Store cupboard / store room sinks	2							
Practicum Lab	1							
Floor 1 F Staff toilets	1	1					14/10/2020	No running water when flushing
Floor 1 F Staff basins (taps)	1							
Floor 1 M Staff toilets	1							
Floor 1 M Staff basins (taps)	1							
Floor 1 F Students toilets	3							
Floor 1 F Students basins (taps)	2							
Floor 1 M Students toilets	2							
Floor 1 M Students urinal	2							
Floor 1 M Students basins (taps)	2							
Disabled toilet + basin (taps)	1							
Water fountain in wall inside	?							
Staff kitchen	1							
Store cupboard / store room sinks	2							
Pollution Lab	4							
Occupational Health and Safety Lab	3							
Food Technology Lab	7							
Floor 2 F Staff toilets	1							N/A (no problems were reported to me)
Floor 2 F Staff basins (taps)	1							N/A (no problems were reported to me)
Floor 2 M Staff toilets	1							N/A (no problems were reported to me)
Floor 2 M Staff urinal	0							N/A (no problems were reported to me)
Floor 2 M Staff basins (taps)	1							N/A (no problems were reported to me)
Floor 2 F Students toilets	3							N/A (no problems were reported to me)
Floor 2 F Students basins (taps)	2							N/A (no problems were reported to me)
Floor 2 M Students toilets	2							N/A (no problems were reported to me)
Floor 2 M Students urinal	2							N/A (no problems were reported to me)
Floor 2 M Students basins	2							N/A (no problems were reported to me)
Disabled toilet + basin (taps)	1							N/A (no problems were reported to me)
Water fountain in wall inside	?							N/A (no problems were reported to me)
Staff kitchens x2	2							N/A (no problems were reported to me)
Store cupboard / store room sinks	2							N/A (no problems were reported to me)
Physics Lab 1 (taps & eye wash unit)	16							N/A (no problems were reported to me)
Bio-Chemistry Lab (taps & eye wash unit)	16							N/A (no problems were reported to me)
Physics Lab 2 (taps & eye wash unit)	16							N/A (no problems were reported to me)
Floor 3 F Staff toilets	1							No problems noted
Floor 3 F Staff basins (taps)	1							No problems noted
Floor 3 M Staff toilets	1							No problems noted
Floor 3 M Staff basins (taps)	1							No problems noted
Floor 3 F Students toilets	3							No problems noted
Floor 3 F Students basins (taps)	2							No problems noted
Floor 3 M Students toilets	2							No problems noted
Floor 3 M Students urinals	2							No problems noted
Floor 3 M Students basins (taps)	2							No problems noted
Disabled toilet + basin (taps)	1							No problems noted
Water fountain in wall inside	?							n/a
Staff kitchen x2	2							No problems noted
Store cupboard / store room sinks	2							No problems noted
Biology Lab 1 (taps & eye wash unit)	16							No problems noted
Biology Lab 2 (taps & eye wash unit)	16							No problems noted
Chemistry Lab 1 (taps & eye wash unit)	16							No problems noted
Chemistry Lab 2 (taps & eye wash unit)	16							No problems noted
Floor 4 F Staff toilets	1							N/A (no problems were reported to me)
Floor 4 F Staff basins (taps)	1							N/A (no problems were reported to me)
Floor 4 M Staff toilets	1							N/A (no problems were reported to me)
Floor 4 M Staff basins (taps)	1							N/A (no problems were reported to me)
Floor 4 F Students toilets	3							N/A (no problems were reported to me)
Floor 4 F Students basins	2							N/A (no problems were reported to me)
Floor 4 M Students toilets	2							N/A (no problems were reported to me)
Floor 4 M Students urinals	2							N/A (no problems were reported to me)
Floor 4 M Students basins Taps)	2							N/A (no problems were reported to me)
Disabled toilet + basin (taps)	1							N/A (no problems were reported to me)
Staff kitchen	1							N/A (no problems were reported to me)
Board room and kitchen	2							N/A (no problems were reported to me)
Store cupboard / store room sinks	2							N/A (no problems were reported to me)
Weigh room (Media room)	1							N/A (no problems were reported to me)
Sterile room	1							N/A (no problems were reported to me)
Clean room	1							N/A (no problems were reported to me)
Microbiology Lab (taps & eye wash unit)	14							N/A (no problems were reported to me)
Molecular Biology Lab (taps & eye wash unit)	14							N/A (no problems were reported to me)
Sterile room	1							N/A (no problems were reported to me)
Chemical Pathology Lab (taps & eye wash unit)	14							N/A (no problems were reported to me)
Preparation room	1							N/A (no problems were reported to me)
Haematology Lab (taps & eye wash unit)	14							N/A (no problems were reported to me)
Garage EMC Bathrooms (Tap, toilet & shower)	6							
Kitchen	1							
Other (please describe)								
Outside water sprinklers								
Water fountains - free standing								

Water purification system in Health faculty
Note if leakage was reported, when and to whom

Obeserve inside & outside water status in any water appliances (on, off, dripping, leaking)

Contact: Annie Symonds annie.s@iway.na; 0812398829

Environmental Scoping Study - ARCHITECTURE **September 2020**

Water Audit: Water outlets by floor

	Quantity	Quantity	Quantity	Quantity
	Toilets/Urinals	Taps/Basins	Labs, Storeroms, Eyewash units	Kitchens, Storeroms, fountains, EMC showers
Ground floor F Staff toilets	0			
Ground floor F Staff basins		0		
Ground floor M Staff toilets	0			
Ground floor M Staff urinals	0			
Ground floor M Staff basins		0		
Ground floor F Students toilets	2			
Ground floor F Students basins		2		
Ground floor M Students toilets	1			
Ground floor M Students urinal	2			
Ground floor M Students basins		2		
Water fountain in wall inside				1
Staff kitchen				1
Store cupboard / store room sinks				1
Totals	**5**	**4**	**0**	**3**
Floor 1 F Staff toilets	1			
Floor 1 F Staff basins		1		
Floor 1 M Staff toilets	1			
Floor 1 M Staff urinal	0			
Floor 1 M Staff basins		1		
Floor 1 F Students toilets	2			
Floor 1 F Students basins		2		
Floor 1 M Students toilets	1			
Floor 1 M Students urinal	2			
Floor 1 M Students basins		2		
Disabled toilet + basin				
Water fountain in wall inside				1
Staff kitchen				1
Store cupboard / store room sinks				1
Totals	**7**	**6**	**0**	**3**
Floor 2 F Staff toilets	1			
Floor 2 F Staff basins		1		
Floor 2 M Staff toilets	1			
Floor 2 M Staff urinal	0			
Floor 2 M Staff basins		1		
Floor 2 F Students toilets	2			
Floor 2 F Students basins		2		
Floor 2 M Students toilets	1			
Floor 2 M Students urinal	2			
Floor 2 M Students basins		2		
Disabled toilet + basin	?	?		0
Water fountain in wall inside				1
Staff kitchen				1
Store cupboard / store room sinks				1
Totals	**7**	**6**	**0**	**3**
Floor 3 F Staff toilets	1			
Floor 3 F Staff basins		1		
Floor 3 M Staff toilets	1			
Floor 3 M Staff urinal	0			
Floor 3 M Staff basins		1		
Floor 3 F Students toilets	2			
Floor 3 F Students basins		2		
Floor 3 M Students toilets	1			
Floor 3 M Students urinal	2			
Floor 3 M Students basins		2		
Disabled toilet + basin				0
Water fountain in wall inside				1
Staff kitchen				1
Store cupboard / store room sinks				1
Totals	**7**	**6**	**0**	**3**
Other (please describe)				
Outside water sprinklers				
Water fountains - free standing				**3**
Water unit in the wall (Engineering)				
Totals				**3**
Architecture GRAND Totals	**26**	**22**	**0**	**15**

Please note if leakage was reported, when and to whom

Obeserve outside water status (on, off, dripping, leaking)

Appendix 3: NUST Staff and Student Awareness Survey 2020

Google Forms

NUST Staff and Student Water Awareness Survey

Biodiversity Research Centre

NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY | Biodiversity Research Centre

Towards a Green Campus: Assessment of Sustainable Water Management at NUST

The Department of Agriculture and Natural Resources Sciences at NUST is embarking on an exercise to develop an Environmental Management Plan (EMP) for NUST. This plan looks at reducing our negative impacts on the environment, as is required by the Environmental Management Act 7 of 2007.
I am one of two master's students who have been assigned to collect information regarding environmental awareness and water use. In future waste management, social impacts and energy will be focus areas to enable the development of an EMP.
The purpose of this survey is to determine the attitudes and understanding of water related environmental issues at NUST campus and the expectations in terms of instituting sustainable green initiatives. NUST staff and students are kindly requested to complete this questionnaire.
Your honest opinions are valued. It is an anonymous exercise. You will only be contacted if your suggestions require further detail.
The survey will only take 10 minutes of your time. Thank You
You are welcome to give us your email address. It will only be used to contact you if we feel you have an idea or suggestion regarding saving water that is useful and needs further elaboration.

Gender

- ( ) Female
- ( ) Male

What is your age? *

- ( ) 18 - 24 years
- ( ) 25 - 34 years
- ( ) 35 to 44 years
- ( ) 45 to 54 years
- ( ) 55 to 64 years
- ( ) 65+ years

Where did you grow up? *

- ( ) Erongo
- ( ) Hardap
- ( ) Karas
- ( ) Kavango East
- ( ) Kavango West

- ( ) Khomas
- ( ) Kunene
- ( ) Ohangwena
- ( ) Omaheke
- ( ) Omusati
- ( ) Oshana
- ( ) Oshikoto
- ( ) Otjozondjupa
- ( ) Zambezi
- ( ) Outside Namibia

Which department are you in? (Academic staff and students) *

- [ ] Computer Science Informatics
- [ ] Nam-German Centre for Logistics
- [ ] Civil and Environmental Engineering
- [ ] Dean Engineering
- [ ] Electrical and Computer Engineering
- [ ] Mechanical and Marine Engineering
- [ ] Mining and Process Engineering
- [ ] Health Sciences
- [ ] Mathematics and Statistics
- [ ] Natural and Applied Sciences
- [ ] Communication
- [ ] Education and Languages
- [ ] Social Sciences
- [ ] Accounting, Economics and Finance
- [ ] Hospitality and Tourism Management
- [ ] HP Graduate School of Business
- [ ] Management Studies
- [ ] Marketing and Logistics
- [ ] Nam Graduate School of Accounting
- [ ] Agriculture and Natural Resource Sciences
- [ ] Architecture and Spatial Planning
- [ ] Geo-spatial Sciences and Technology
- [ ] Land and Property Sciences
- [ ] Admin, Finance and Human Resources
- [ ] Information and Communication Technology
- [ ] Facilities (Inc. Security and Cleaners)
- [ ] Academic Affairs
- [ ] Teaching and Learning
- [ ] Other:

Academic year (Students only)

- ( ) First year
- ( ) Second year
- ( ) Third year
- ( ) Honours

- ( ) Masters
- ( ) PhD

Staff member category

- ( ) Academic
- ( ) Management
- ( ) Administration
- ( ) Technical

How many years have you been employed at NUST (staff)?

- ( ) < 1 years
- ( ) 1 - 2 years
- ( ) 3 - 5 years
- ( ) 6 - 10 years
- ( ) > 10 years

Where do you live? *

- ( ) On campus
- ( ) Off campus

Which classification would you say most accurately describes the climatic region Namibia falls into? *

- ( ) Tropical wet
- ( ) Tropical wet and dry
- ( ) Sub-tropical humid
- ( ) Semi-arid
- ( ) Arid

Please answer these questions *

	Yes	No	A little
Are you aware of the water crisis in Windhoek?	( )	( )	( )
Do you monitor the annual rainfall statistics?	( )	( )	( )
Now that it has rained is the water situation still critical?	( )	( )	( )

Namibia Central Area relies heavily on three dams to provide Windhoek with water, the Omatako, Swakoppoort and Von Bach dams. They are currently between 65%, 87% and 99% full respectively compared to 0%, 16% and 45% on 6 April 2019. In light of this is it still important to save water? *

	1	2	3	4	5	
Not important	( )	( )	( )	( )	( )	Very important

How concerned are you about the water situation? *

	1	2	3	4	5	
Very concerned	( )	( )	( )	( )	( )	I don't know enough to comment

How knowledgeable do you feel about the water situation in Windhoek? *

	1	2	3	4	5	
Very well informed	( )	( )	( )	( )	( )	I don't know anything

Do you feel you should know more? *

- ( ) Yes
- ( ) No
- ( ) Maybe

How do you keep informed about the water situation in Windhoek? (you may tick more than one answer) *

- [ ] Radio and/or television
- [ ] City of Windhoek publications
- [ ] Newspaper and written media
- [ ] Namibia Hydrological Services
- [ ] Other:

Please answer these questions *

	Yes	No	Maybe
Do you feel that you can contribute to finding a solution to the water situation?	( )	( )	( )
Do you feel that you can educate others about wise water use and sustainable approaches?	( )	( )	( )
Do you feel you have a personal responsibility to save water?	( )	( )	( )
Are you prepared to make lifestyle changes to ensure sustainable use of all our water?	( )	( )	( )

Whose responsibility do you feel it is to help resolve the water crisis in Windhoek? (you may tick more than one answer) *

- [ ] Mine
- [ ] Everyone's
- [ ] NUST's
- [ ] The City of Windhoek
- [ ] The Government
- [ ] Other please state:
- [ ] I don't know

Indicate how much you feel your personal efforts could contribute to an overall reduction in water consumption at NUST *

- ( ) We can only achieve a reduction if we all work towards the same goal
- ( ) One person cannot make a difference
- ( ) Every drop counts so I will save even if others don't
- ( ) I don't know

What do you suggest NUST does to save water?

Please indicate how important you think the actions below are to mitigate against overuse of water at NUST *

	Very important	Important	Indifferent	Less important	Not important	I don't know
Use less water for irrigation	( )	( )	( )	( )	( )	( )
Harvest water	( )	( )	( )	( )	( )	( )
Implement water wise technology in toilets, bathrooms and kitchen	( )	( )	( )	( )	( )	( )
Educate about the water crisis during Freshers Week	( )	( )	( )	( )	( )	( )
Include more about sustainable use in the curriculum	( )	( )	( )	( )	( )	( )
NUST joins a worldwide Green University initiative	( )	( )	( )	( )	( )	( )
NUST starts an environmental stewardship programme	( )	( )	( )	( )	( )	( )
Marshalls are appointed to monitor water use	( )	( )	( )	( )	( )	( )
Create an environmental group to do monitoring and advocacy work	( )	( )	( )	( )	( )	( )
Posters, fliers, visual media	( )	( )	( )	( )	( )	( )

Use social media to get the message across	( )	( )	( )	( )	( )	( )
Speakers and sustainability workshops and conferences	( )	( )	( )	( )	( )	( )
Water and sustainability audits and assessments	( )	( )	( )	( )	( )	( )
Water use targets are set for NUST's staff and students	( )	( )	( )	( )	( )	( )

If there are other actions you feel are important to mitigate against overuse of water that are not included above please state them here

What three significant contributions or actions would you personally be prepared to make to save water at NUST? Please answer in three concise points. *

If you were charged with informing / educating people at NUST about the water situation how would you do it?

Please indicate if you agree that these actions and approaches would motivate you to become more water-wise and ensure environmental sustainability *

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	I don't know
Being informed of water savings made	( )	( )	( )	( )	( )	( )
Being informed about costs saved	( )	( )	( )	( )	( )	( )
Being accountable to an environmental steward or water marshalls	( )	( )	( )	( )	( )	( )
Being given an incentive to save water	( )	( )	( )	( )	( )	( )

Having water restrictions if savings are not made	( )	( )	( )	( )	( )	( )
The sense of accomplishment from altruistic behaviour is satisfying	( )	( )	( )	( )	( )	( )
I am self motivated to achieve goals I set myself	( )	( )	( )	( )	( )	( )

If you have any other ways in which you would be motivated to save water not captured above please outline them here

Please indicate if you agree with these statements regarding NUST becoming a Greener University *

	Strongly disagree	Disagree	Agree	Strongly agree	I don't know
It is important that NUST becomes green and more environmentally sustainable	( )	( )	( )	( )	( )
NUST should become part of a wider global initiative to become a greener university	( )	( )	( )	( )	( )
I have a personal responsibility to try and ensure the University becomes more sustainable in its use of natural resources	( )	( )	( )	( )	( )
I would be proud to be part of a Greener University Initiative	( )	( )	( )	( )	( )

Appendix 4: Water Tariffs at the City of Windhoek

DEPARTMENT OF INFRASTRUCTURE, WATER & TECHNICAL SERVICES
DIVISION: BULK WATER & WASTEWATER

Annexure A

Each consumer shall pay, in addition to any other tariff payable in terms of any other paragraph of this Annexure, the following basic charge to the Council whether water was consumed or not, determined according to the diameter of the meter inlet:

1. WATER BASIC TARIFFS

	2019/2020		2020/2021						% Increase
BASIC CHARGE	TOTAL		TARIFF		VAT		TOTAL		
Diameter of meter inlet	Domestic	Non-Domestic	Domestic	Non-Domestic	Domestic	Non-Domestic	Domestic	Non-Domestic	
15 mm	45.15	51.92	45.15	45.15	-	6.77	45.15	51.92	0%
20 mm	108.15	124.37	108.15	108.15	-	16.22	108.15	124.37	0%
25 mm	176.40	202.86	176.40	176.40	-	26.46	176.40	202.86	0%
40 mm	1,155.00	1,328.25	1,155.00	1,155.00	-	173.25	1,155.00	1,328.25	0%
50 mm	2,033.85	2,338.93	2,033.85	2,033.85	-	305.08	2,033.85	2,338.93	0%
80 mm	6,665.40	7,665.21	6,665.40	6,665.40	-	999.81	6,665.40	7,665.21	0%
>80 mm	16,272.90	18,713.84	16,272.90	16,272.90	-	2,440.94	16,272.90	18,713.84	0%
Fire connections	1,848.00	2,125.20	1,848.00	1,848.00	-	277.20	1,848.00	2,125.20	0%

Appendix 5: Key Informants

	Experts from related institutions contacted	Contact method	Contact person	Date	Purpose
1	Environmental Trust and PASE Initiative UCT	Email	Merle Sowman	3 Feb 2019; 27 Feb 2019	Developing contacts in the field
2	NUST Hotel School	In person	Liesl Liebenberg	3 Apr 2019; 5 Apr 2019; 15 May 2019; 19 Feb 2020	Sustainable practices and green campus initiatives and initiatives taken at the Hotel School to save water
3	UCT Green Campus Initiative	Email	Sandra Rippon and David Gibbs	5 Apr 2019; 8 Apr 2019; 9 Apr 2019	UCT Green Campus Policy Framework and Action Plan
4	Cape Town Water Crisis Response team	Email	Gina Ziervogel	31 May 2019	Lessons learned from the Cape Town drought
5	Presentations at Namibia Scientific Society with NamWater, Namibia Hydrogeological Association, CoW	Public Talks	Andre Moster; Piet Heyns; Dieter Tolke; Mathew Margolis	2 May 2019; 4 Jul 2019; 6 Aug 2019; 17 Sep 2019; 24 Sep 2019	Broadening knowledge of the situation in Windhoek
6	DVC: A&F Facilities Directors	In-person	Mr Nawa; Oliver Quarmby	7 May 2019; 10 Feb 2020; 28 Oct 2021	Progress with meters and water technology installations
7	Environmental group meeting with Hotel School, Engineering and Architecture	In-person	Liesl Liebenberg; Jane Gold; Truddy Theron-Beukes;	9 Jun 2019; 5 Feb 2020	Discussing opportunities to Green NUST
8	Hotel School	In-person	Liesl Liebenberg	8 Jul 2019	Establishing a NUST Eco-Forum
9	Environmental Group Champions	In-person	Liesl Liebenberg; Jane Gold;	11 Nov 2019	Discussing ways to carry forward

			Truddy Theron-Beukes;		initiatives to Green NUST
10	Tour of Hostels to survey water installations	In-person	Donovan Zealand	15 Jul 2019	To assess the water provision infrastructure at the hostels
11	Smart Group Technologies	In-person	Cobus Blaauw	15 Jul 2019	Smart water meter quote, and a tour of Lower Campus
12	Tour of hostels	Tour	Eugene Brown; Cobus Blaauw	16 Jul 2019	To identify where meters could be installed
13	Maintenance team for NUST Lower Campus	Tour	Simon Haimbodi; Truddy Theron-Beukes	16 Jul 2019	Identify where water pipes run for water meter quote
14	Smart Group Technologies	Meeting	Cobus Blaauw; Mr Nawa; Franz Titus; Sean Katurota	16 Jul 2019	To introduce the concept of the smart meter
15	City of Windhoek - Bulk Water and Waste Division	In-person	Dieter Tolke; Julia Heimo (seconded to CoW from NUST)	10 Apr 2019 22 Jul 2019 3 Oct 2019	Collection of statistics and CoW's awareness approach
16	Civil Engineering Supervisor	In-person	Truddy Theron-Beukes	1 Aug 2019	Regarding an engineering student conducting water audit
17	Environmental group meeting	Meeting	Liesl Liebenberg; Jane Gold; Truddy Theron-Beukes;	7 Aug 2019	Further ways forward for greening NUST

18	Natural Resource Management Supervisor	In-person	Shirley Bethune	9 Aug 2019	Regarding student Juliet Mutyavaviri undertaking a water audit at NUST
19	DICT NUST and In-Charge	Meeting	Franco Bandlow; Truddy Theron-Beukes; Pieter Moller	9 Aug 2019	Regarding combining water monitoring with an energy monitoring system
20	In-Charge	Tour	Pieter Moller	16 Sep 2019	Tour of Lower Campus and hostels for a quote on smart meters
21	Rainwater Harvesting	In-person	Donovan Wagner	20 Sep 2019	Discussed Brad Lancaster visiting from the USA (rainwater harvesting specialist) in September 2020
22	Hanns Siedel Foundation	Conference		2 Oct 2019	The Current State of Sustainable Natural Resource Management in Namibia and Ways to Unlock its Bio-economy Potential
23	Pearl Water-free Technologies	Tour	Mathew Margolis; Leveenia Shigwedha	9 Oct 2019	Tour of water-saving installations NUST lecture block
24	EAPAN - NUST Hotel School	Mini-conference		15 Oct 2019	Best Practice EIA and Namibia Water Challenges
25	EMCON	Tour	Glenn Howard	24 Oct 2019	6-star rated Green Building
26	NUST plumber	Tour	Sean Katurota	13 Nov 2019; 5 Feb 2020	Water outlet mapping Lower Campus, Architecture,

					Engineering and Health buildings
27	Artemesiot	Tour	Bernard Chiwome and Clara Ahlenstorf	29 Oct 2021	Demonstration of Smart Meter capabilities at Krumhuk
28	Artemesiot	Meeting	Clara Ahlenstorf and Oliver Quarmby	6 Nov 2020	Presentation of smart meter pilot project in Architecture and Engineering Buildings
29	NUST DICT ITS system Technician	In-person	Sen Haikela	4 Mar 2020; 12 Mar 2021	Acquiring DICT Service Desk plumbing reports
30	Namibia Environment and Wildlife Society	Telephonic	John Pallet	28 Apr 2020	Sharing ideas and lessons learned
31	SAIEA	Telephonic	John Pallet	1 May 2020	Sharing ideas and lessons learned
32	NaDeet	Skype	Viktoria Keding	4 May 2020	Sharing ideas and lessons learned
33	Eco-Awards	Face-to-face	Hazel Milne	19 May 2020	Sharing ideas and lessons learned
34	GRTC	Telephonic	Gillian Maggs-Kolling	29 May 2020	Sharing ideas and lessons learned
35	City of Windhoek - Bulk Water and Waste Division	In-person	Dieter Tolke	22 Oct 2021	Updating knowledge on the situation in Windhoek

Appendix 6: ISCN-GULF Sustainable Campus Charter

A Summary of the ISCN-GULF Sustainable Campus Charter

The signatories of the ISCN-GULF Sustainable Campus Charter acknowledge that organizations of research and higher education have a unique role to play in developing the technologies, strategies, citizens, and leaders required for a more sustainable future. The signature of the present charter represents an organization's public commitment to aligning its operations, research, and teaching with the goal of sustainability. The signatories commit to:

- implement the three ISCN/GULF sustainable campus principles described below,
- set concrete and measurable goals for each of the three principles, and strive to achieve them,
- and report regularly and publicly on their organizations' performance in this regard.

Principle 1: To demonstrate respect for nature and society, sustainability considerations should be an integral part of planning, construction, renovation, and operation of buildings on campus.

A sustainable campus infrastructure is governed by respect for natural resources and social responsibility and embraces the principle of a low-carbon economy. Concrete goals embodied in individual buildings can include minimizing environmental impacts (such as energy and water consumption or waste), furthering equal access (such as non-discrimination of the disabled), and optimizing the integration of the built and natural environments. To ensure buildings on campus can meet these goals in the long term, and in a flexible manner, useful processes include participatory planning (integrating end-users such as faculty, staff, and students) and life-cycle costing (taking into account future cost-savings from sustainable construction).

Principle 2: To ensure long-term sustainable campus development, campus-wide master planning and target setting should include environmental and social goals.

Sustainable campus development needs to rely on forward-looking planning processes that consider the campus as a whole, and not just individual buildings. These processes can include comprehensive master planning with goals for impact management (for example, limiting the use of land and other natural resources and protecting ecosystems), responsible operation (for example encouraging environmentally compatible transport modes and efficiently managing urban flows), and social integration (ensuring user diversity, creating indoor and outdoor spaces for social exchange and shared learning, and supporting ease of access to commerce and services). Such integrated planning can profit from including users and neighbours and can be strengthened by organization-wide target setting (for example greenhouse gas emission goals).

Principle 3: To align the organization's core mission with sustainable development, facilities, research, and education should be linked to create a "living laboratory" for sustainability.

On a sustainable campus, the built environment, operational systems, research, scholarship, and education are linked as a “living laboratory” for sustainability. Users (such as students, faculty, and staff) have access to research, teaching, and learning opportunities on connections between environmental, social, and economic issues. Campus sustainability programs have concrete goals and can bring together campus residents with external partners, such as industry, government, or organized civil society. Beyond exploring a sustainable future in general, such programs can address issues pertinent to research and higher education (such as environmental impacts of research facilities, participatory teaching, or research that transcends disciplines). Institutional commitments (such as a sustainability policy) and dedicated resources (such as a person or team in the administration focused on this task) contribute to success.

As signatories to the ISCN-GULF Charter, we strive to share our goals and experiences on sustainable campus initiatives amongst our peers and other stakeholders. A key instrument for this is our regular reporting on progress under this Charter, which will be supported by the Charter stewardship (provided by the GULF group) and the Charter secretariat function (provided by the ISCN).

Appendix 7: The Tallories Declaration

10-Point Action Plan of the Association of University Leaders for a Sustainable Future

i. **Increase Awareness of Environmentally Sustainable Development**
Use every opportunity to raise public, government, industry, foundation, and university awareness by openly addressing the urgent need to move toward an environmentally sustainable future.

ii. **Create an Institutional Culture of Sustainability**
Encourage all universities to engage in education, research, policy formation, and information exchange on population, environment, and development to move toward global sustainability.

iii. **Educate for Environmentally Responsible Citizenship**
Establish programs to produce expertise in environmental management, sustainable economic development, population, and related fields to ensure that all university graduates are environmentally literate and have the awareness and understanding to be ecologically responsible citizens.

iv. **Foster Environmental Literacy for All**
Create programs to develop the capability of university faculty to teach environmental literacy to all undergraduate, graduate, and professional students.

v. **Practice Institutional Ecology**
Set an example of environmental responsibility by establishing institutional ecology policies and practices of resource conservation, recycling, waste reduction, and environmentally sound operations.

vi. **Involve All Stakeholders**
Encourage the involvement of government, foundations, and industry in supporting interdisciplinary research, education, policy formation, and information exchange in environmentally sustainable development. Expand work with community and nongovernmental organizations to assist in finding solutions to environmental problems.

vii. **Collaborate for Interdisciplinary Approaches**
Convene university faculty and administrators with environmental practitioners to develop interdisciplinary approaches to curricula, research initiatives, operations, and outreach activities that support an environmentally sustainable future.

viii. **Enhance Capacity of Primary and Secondary Schools**
Establish partnerships with primary and secondary schools to help develop the capacity for interdisciplinary teaching about population, environment, and sustainable development.

ix. Broaden Service and Outreach Nationally and Internationally
Work with national and international organizations to promote a worldwide university effort toward a sustainable future.

x. Maintain the Movement
Establish a Secretariat and a steering committee to continue this momentum, and to inform and support each other's efforts in carrying out this declaration.

Appendix 8: Example of DICT Problem reports

Department	Subject	Description	Service Category	Request Status	Created Time
2072970					
Health Sciences	Installation of Water Purification System	Dear Colleagues, Please assist us to install our water purification system in the Chemistry Laboratory, Room 4.349, Fourth Floor, Faculty of Health & Applied Sciences Building.	Plumbing	Closed / Completed	Aug 9, 2017 10:05 AM
Facilities	plumbing	Behind Poly- height where the people can hang their clothes there is a water pipe burst.	Plumbing	Closed / Completed	Nov 25, 2019 09:27 AM
Electrical & Computer Engineering	Blocked sink	Dear Sir/Madam, Kitchen sink is blocked, needs to be unblocked urgently	Plumbing	Closed / Completed	Jan 8, 2019 09:39 AM
Electrical & Computer Engineering	Block wahing hand basin	Regards, Kindly come and fix the washing hand basin in the bathroom. Please come urgently to fix the problem. Regards, Victor	Plumbing	Closed / Completed	Jul 31, 2018 07:12 PM
Dean Of Students	Plumbing	SHANGRILA 37	Plumbing	Closed / Completed	Oct 9, 2019 02:16 PM
Dean Of Students	SHANGRILA	Shower blocked SHANGRILA 22 Basin is blocked	Plumbing	Closed / Completed	Nov 5, 2019 12:26 PM
Accommodation & Food Services	plumbing	hop 7: washing basin blocked	Not Assigned	Closed / Completed	Feb 20, 2020 12:05 PM
Dean Of Students	HOPKER 13	HOPKER 13 Toilet pot cover off	Plumbing	Closed / Completed	Nov 7, 2019 09:12 AM
Accommodation & Food Services	Plumbing	Hopker out side: Drain in front Blocked	Plumbing	Closed / Completed	Mar 10, 2020 08:44 AM
Maintenance	Toilet out of order	At the Civil Engineering & Mining building the following needs to be fixed: 1. First floor - E/3/1.053 toilet pot leaking water under. 2. Third floor - E/3/3.133 toilet pot leaking water under.	Plumbing	Closed / Completed	Feb 12, 2018 08:22 AM
Maintenance	Toilet pot out of order	At Science & Technology building there is a toilet pot leaking in G 0.44 men's toilet	Plumbing	Closed / Completed	Feb 8, 2018 12: PM
Accommodation & Food Services	plumbing	hop 7: washing basin blocked	Not Assigned	Closed / Completed	Feb 20, 2020 12:05 PM
Dean Of Students	HOPKER 13	HOPKER 13 Toilet pot cover off	Plumbing	Closed / Completed	Nov 7, 2019 09:12 AM
Accommodation & Food Services	Plumbing	Hopker out side: Drain in front Blocked	Plumbing	Closed / Completed	Mar 10, 2020 08:44 AM