Investigating green initiatives at South African public universities

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ABSTRACT

Purpose: All institutions of higher learning including public universities in South Africa must participate in green programmes in order to be considered socially responsible. This requires a better understanding of the green environment and green initiatives. Hence, the primary objective is to identify and investigate the existing green initiatives implemented at South African universities.

Design/Methodology/Approach: The study investigated five key green initiatives: 1) Renewable energy generation and consumption. 2) Water-saving technology and consumption. 3) Waste management. 4) Sustainable buildings. 5) Personnel training and awareness creation. A five-point Likert scale collected data across 18 criteria measuring the five green initiatives. University managers completed and returned 149 questionnaires but only 144 were usable.

Findings: The data has marginal reliability (α=0.412), acceptable sample adequacy (KMO=0.531) and significance at the 95% confidence level ($p \leq 0.05$). The results show that universities implement 20-25% of their green initiatives. The exploratory factor analysis identified seven factors explaining a cumulative variance of 56.14%. They are: 1) Recovering natural resources and recycling. 2) Supportive infrastructure. 3) Reallocation of resources. 4) Conservation of natural resources. 5) Leadership involvement and improved communication. 6) Improved technology.7) Efficient use of financial resources.

Conclusion: This research contributes to the "going green at universities" of knowledge in South Africa. It is valuable to students, researchers, communities and the department of education in their pursuit to implement green initiatives at universities.

Keywords: *Awareness, Environment, Factors, Green initiatives, Role players, South Africa, Universities.*

1. INTRODUCTION

South Africa offers unique opportunities for some green initiatives already applied successfully elsewhere. Typically, the department of mineral resources and energy asserts that the abundance of more than 2,500 hours of annual sunlight and the average solar-radiation levels between 4.5 and 6.5kWh/m^2 per day provide opportunities for solar energy while the long coastline better suits wind energy generation (Department of Mineral Resources and Energy (DMRE), 2022). Several commercial enterprises are successfully operating in the photovoltaic market. A pilot programme was launched to allow private energy providers to sell excess energy onto the national electricity grid. Wind energy requires strong and steady winds while South Africa is a "fair wind" country. However, some parts of the coastline satisfy the requirements and the Western Cape province has two successful wind farms: Darling (5.2 MegaWatt with a load factor of 28%) and Klipheuwel (3.2 MegaWatt with a load factor of 20-30%) (Department of Mineral Resources and Energy (DMRE), 2022). The province of the Eastern Cape has also effectively used wind as a source of electricity and there are many wind turbines in operation along the coastline between Jeffrey's Bay and East London.

On the other hand, other worldwide success stories may not work locally. For example, South Africa does not have a high tide range (the height difference between high and low tides) of 2-2.5 meters, limiting the potential to use the changing levels in the sea tides as an energy source (Mejia-Olivares, Haigh, Angeloudis, Lewis, & Neill, 2020). The energy potential compares poorly to areas where the tidal range is between 5 and 8 meters or when compared to the Bay of Fundy in Nova Scotia with the world's highest tidal range at 14 meters (South African

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Weather Service, 2022). Globally, the trend in developing countries is to shift environmental awareness and education away from the public sector towards private sector role players and higher education institutions (Agyekum, Adinyira, Baiden, Ampratwum, & Duah, 2019). Agyekum et al. (2019) continue to attribute this trend to the government, thereby releasing awareness of the green initiative to educational institutions and private service providers. At the same time, the green business environment is also changing rapidly because of the mobility of global green competition and the entrance of green certification providers as competitors to the government. Yasir, Majid and Qudratullah (2020) assert that the government and South African universities (SAU) are experiencing significant challenges in such a green business environment. These challenges relate to changes in government regulations, the depletion of financial and natural resources, the cost of technology, environmental awareness and competition for students. The adverse effects of natural resource depletion on daily lifestyles also play a role. Universities are essential players in all these changes. Universities adhere to the demand for environmental awareness and training. Still, they are also heavily engaged in ecological research and offer innovative solutions to the government and industry. However, the fact that universities participate in green efforts and start green projects is not widely known about them.

2. PROBLEM STATEMENT

The Department of Forestry, Fisheries and Environment (DFFE) (2021) in South Africa regulates the quality education environment in accordance with the National Environment Management Act (No. 107 of 1998), the Specific Environment Management Act and the Environment Conservation Act (No. 73 of 1989). However, several researchers (Burdon & Sorour, 2020; Suleiman, Raimi, & Sawyerr, 2019) believe environmental education is over-regulated. Nonetheless, the government supports universities' responsibility in teaching South Africans despite the fact that these institutions continuously present challenges that they must overcome in order to remain competitive and compliant in the environmental awareness education region (Mawonde & Togo, 2019). In addition, the Department of Forestry, Fisheries and Environment acknowledges universities' role in attending to the need for environmental awareness education in SA. In this regard, the SA government should design an enabling regulatory platform for environmental awareness education that lures universities into the green education system while it remains the guardian of environmental awareness in South Africa (Department of Forestry Fisheries and Environment (DFFE), 2021). The government is not capable of accomplishing this objective.

Consequently, the solution to educating the people of South Africa and preparing them for the fifth industrial revolution involves higher education institutions such as universities (Haywood, Funke, Audouin, Musvoto, & Nahman, 2019). However, in a recently developed economy such as South Africa, these institutions must compete with other non-governmental organisations for funding in order to provide high-quality environmental awareness education These higher education institutions must be competitive (Sarkodie & Strezov, 2019). Various methods or models have been designed and applied to evaluate the implementation of green initiatives. Some have addressed the implementation progress of higher education institutions.

Moreover, most green implementation models focus on the government and non-governmental organisations considering the history of developing environmental awareness education in SA (Rigolon & Gibson, 2021). This exacerbates the challenge that higher education institutions face such as there is not adequate research done on the distinct performance indicators and challenges facing them if they want to assess the implementation of green initiatives in the SA higher education environment (Filho et al., 2019). This paper aims to evaluate the existing green initiatives at universities in SA.

3. RESEARCH QUESTIONS

A critical need exists to identify and analyse the factors impacting the implementation of green initiatives at SAU. The SAU must answer the following question with competitive green compliance as their goal:

- *RQ1: What potential green initiatives can South African universities implement?*
- *RQ2: Which green initiatives are being implemented at South African universities?*
- *RQ3: What are the perceptions of management at South African universities regarding green initiative implementation?*

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4. RESEARCH OBJECTIVES

This study identifies and investigates existing green initiatives implemented at universities in South Africa. The study objectives are as follows:

1 To identify potential green initiatives suitable for South African universities .
2 To determine to what extent green initiatives are being implemented at these universities.
3 To measure university 'managers' perceptions of green initiatives at their universities.
4 To identify any latent managerial factors of green initiatives at universities.

5. GREEN INITIATIVES AT SOUTH AFRICAN UNIVERSITIES

Currently, green initiatives at South African universities primarily focus on five key areas such as 1) Renewable energy 2) Water savings 3) Waste management 4) Sustainable buildings and 5) Personnel training and awareness (EL-Nwsany, Maarouf, & Abd el-Aal, 2019; Fuldauer, Ives, Adshead, Thacker, & Hall, 2019; Khan et al., 2019; Msengi et al., 2019). These initiatives serve as objectives 1 and 2 of the study.

5.1. Renewable Energy Generation and Consumption

Renewable energy is generated by natural sources such as the sun, tide differentials and wind. They are plentiful and replenished constantly (Güney, 2019). Environmental and economic benefits of renewable energy and consumption include:

- No greenhouse gas emissions result from renewable energy sources and reduces air pollution. On the other hand, fossil fuels emit greenhouse gases and pollute the air.
- It diversifies energy sources and reduces the country's dependence on coal and other fossil fuels such as diesel.
- Creates economic development and jobs in manufacturing, installation and maintenance.

Curtis and Lee (2019) assert that onsite power generation enables local governments to generate renewable energy directly and be less dependent on the national energy grid. Renewable energy generated locally through onsite projects can benefit municipalities financially while improving supply reliability and power quality. Local governments onsite generation could overcome potential financial, technical and regulatory challenges by identifying renewable generation opportunities within their municipal boundaries. They can also budget for the costs of renewable technologies by examining the aggregate costs and the benefits of onsite green power. This investigation should include assessing the requirements of the identified locations where green energy generation facilities could be sited, how to involve local stakeholders and the available financial sources.

South African universities are actively engaging in green initiatives. Typical examples are:

- The University of Pretoria (UP) invested in photovoltaic solar panels to provide supplementary green energy. Many of these solar panels were installed on the roofs of their technical services building . At the same time, some were also installed on the roof of the Merensky library on the main campus in Hatfield, Pretoria (University of Pretoria, 2021).
- The University of the Witwatersrand's green operations focus on infrastructure management (grounds and buildings). More specifically, this university manages their energy and water usage, waste and transport services. Several of this university's buildings on the Braamfontein campus have solar technology systems installed to produce electricity and heat the water. These systems primarily support office requirements such as office lights and laboratory equipment. Most of the university's offices have motion-sensor lights that switch off if no motion is detected. These sensors save electricity and bulbs (thereby also reducing maintenance and bulb replacement costs). The university also invested in supplementary gas heating technologies to prove a more stable energy supply when the solar panels are not operating efficiently (for example during a cloudy day) (University of Witwatersrand, 2023). These initiatives were implemented in 2018.
- Nelson Mandela University's main campus is situated in a wildlife reserve which has made it a unique location for rehabilitating wild animals. The university harvests sun and wind energy to ensure that innovative off-the-grid streetlights still come on at night even after days of rainy, sunless conditions. In line with international trends to embrace the benefits of renewable energy, the university offers four short courses on alternative energy. South Africa's second-largest battery testing laboratory is leading

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national research on batteries for stop-start vehicles, renewable energy traffic, streetlights and electric cars (Nelson Mandela University, 2022). It is also noteworthy that the NMU built a green, self-sustaining business school in Summerstand (the first green business school in the country).

- The University of the Western Cape's energy storage innovation lab focusses on industrial battery performance research. Storing electricity is a vital link in the energy chain for SA where load shedding has become a daily event. This university's green nanotechnology centre uses nanophysics, nano bioscience and nano-chemistry to create alternative energy, chemical sensors, biological sensors, new medical diagnostic and therapeutic agents, nanoscale robots and electronic materials (University of the Western Cape, 2021).

Universities also engage students and personnel in research projects on green initiatives. The energy storage innovation lab at the University of the Western Cape is an example of where post-graduate students are engaged in green initiative research.

5.2. Water-Saving Technology and Consumption

Water-saving technologies address all water-conserving methods by increasing the efficiency of water usage, eliminating water pollution and enhancing the capacity to retain runoff water (Guo, 2019). Some of the new and emerging water technologies that could preserve our planet and help alleviate the scarcity of fresh and clean water include:

- Nanotechnology in filtration: This technology kills bacteria, microbes and other matter in the water using composite nanoparticles. This process releases silver ions that eradicate contaminants (Madhura et al., 2019).
- Membrane chemistry: Water passes through membranes to be purified and filtered. This technology is popular for modern water treatment processing (Yusuf et al., 2020). Seawater is purified by membranes.
- Seawater desalination: One solution being explored worldwide is biomimicry. This biological process mimics mangrove plants and euryhaline fish to extract pure water from seawater using minimal energy. Another approach is to use aquaporin-enhanced biomimetic membranes. This method blocks the salts by selectively passing water in and out of cells (Pistocchi et al., 2020).
- Smart monitoring: Electronic instruments such as pressure and acoustic sensors are wirelessly connected in real-time to cloud-based and centralised monitoring systems allowing businesses to speedily detect and identify leaks (Ullo & Sinha, 2020).
- Intelligent irrigation: Applying an approach that is smarter to water management by employing accurate computer algorithms, irrigation systems and modelling has already benefited farmers in developed countries (Kamaruddin et al., 2019).
- Wastewater processing: New technologies such as sludge digesters and modular hybrid activated, presently remove the nutrients to use them as fertilizers reducing the energy needed for treatment (Aziz, Basheer, Sengar, Khan, & Farooqi, 2019).
- Mobile recycling facilities: This process entails reverse osmosis units enabling businesses to treat large amounts of water to extricate gas and administer it into the subsurface (Li, Hasson, Semiat, & Shemer, 2019).

South African universities also engage in water-saving activities. Typical examples are:

- The UP harvests rainwater and uses its registered boreholes on its campuses for irrigation. This reduces the university's consumption of municipal water. Advanced technologies are used to monitor electricity and water consumption in real-time. Universities can quickly identify faulty equipment and leaks and minimise water wastage (University of Pretoria, 2021).
- The era of having large green lawns has passed at the University of the Free State (UFS). This Bloemfontein-located university engaged in a "waterless gardens" initiative at some designated areas namely their two large traffic circles (at the George du Toit building and the Francois Retief building). Other landscape changes that save water are implemented in the gardens around the biotechnology building, the geography building, the Muller Potgieter building near the Thakanengbridge and the institute for groundwater studies and Engineering (University of the Free State, 2021). These water-saving strategies support an energy-efficient environment. Paving in these areas allows water to soak into the

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ground to irrigate more than 100 newly planted indigenous trees. Indigenous trees are more adaptive to local environmental conditions and use less water. Wood chips disseminate invasive trees as mulch in gardens; covering the soil saves water by limiting evaporation and stimulating healthy soil microbes. New student residences use a greywater system by collecting water from showers and basins. Rainwater harvesting systems have been fitted at all residences and academic buildings. The 19 tanks that have been installed have a storage capacity of 265 kilolitres. Other water-wise initiatives that have been implemented include installing waterless urinals in administrative and academic buildings, water retainers, pressure control systems that reduce water volume and push-button systems instead of taps (University of the Free State, 2021).

- At the North-West University's Potchefstroom campus, the fountains beneath the Economic and Management Sciences building are tapped and the water is stored in large tanks for consumption. These fountains were drained away for many years before the water became scarce (North-West University, 2021).
- The plant for borehole water purification at the University of the Western Cape (UWC) has achieved some form of self-sufficiency for the university. It can produce up to 500,000 litres of good quality drinking water (University of the Western Cape, 2021).

5.3. Waste Management

A system of waste management is a strategy used by organisations to reduce, dispose of, reuse and prevent waste. Multiple strategies and methods for waste management are available and they can be rearranged or combined to form a system of waste management that suits an organisation (Das et al., 2019).

- Waste prevention: The ideal alternative for waste management is to first prevent waste generation. Several technologies can be used throughout the manufacturing, consumption or after-use portions of the life cycles of the products to eradicate waste and reduce or prevent pollution (Zorpas, 2020).
- Waste minimization: Waste cannot be eliminated using various processes. However, strategies can be implemented to minimize or reduce the waste (Laovisutthichai, Lu, & Bao, 2022).
- Reducing, reusing and recycling: Modern waste management strategies focus on sustainability. It is also known as physical reprocessing. Recycling is suitable for inorganic waste disposals like glass, plastic and metals (Kabirifar, Mojtahedi, Wang, & Tam, 2020).
- Biological treatment: Numerous options have been found since landfilling does not provide the best option for management. Another option is to treat waste to enable biodegradable materials to be degraded. Then, the remaining fraction of inorganic waste also called residuals can be disposed of afterwards or used through anaerobic digestion (Kanaujiya, Paul, Sinharoy, & Pakshirajan, 2019).
- Composting is an ideal method of waste disposal as it transforms organic waste into fertilizers full of nutrients (Ayilara, Olanrewaju, Babalola, & Odeyemi, 2020).
- Incineration and waste degradation: Produce practical end-products that are solid, like compost and degrade by-products. It is also possible to use it as an alternative energy source (Zhang et al., 2021).
- Waste-to-energy: Processes involve converting non-recyclable waste into electricity, fuel or heat using renewable energy sources (Mayer, Bhandari, & Gäth, 2019).
- Plasma gasification: Strategies use a plasma-filled vessel that operates at high temperatures and low oxygen levels to convert hazardous waste into syngas (Munir, Mardon, Al-Zuhair, Shawabkeh, & Saqib, 2019).
- Bioremediation is another option for disposing of hazardous waste by using naturally occurring microorganisms or purposely introducing break down and consuming environmental pollutants (Ummalyma, Sahoo, & Pandey, 2021).

Local universities are also involved in waste management as a green initiative. Typical examples are:

- The UP focuses on recycling and a container for e-waste recycling is available at the Hatfield campus where cell phones, batteries, computers and other e-waste can be disposed of. The university also has a glass, paper and other waste recycling facility managed by a private contractor (University of Pretoria, 2021). The UP also produces bark chips and compost at its experimental farm. All the university's green waste is delivered to the farm and processed into compost used in the gardens and sports facilities. The

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UP has further introduced a programme for tree planting and has planted over 1,700 trees since 2014 (University of Pretoria, 2021).

- At Stellenbosch University (SUN), waste management includes using waste from the garden for composting, a three-bin approach on campus for sorting and recycling suitable waste and removing non-recyclable and recyclable waste to the appropriate facilities. The university further initiated the Bokashi project where microbes decompose waste from the kitchen resulting in heaps of compost (Stellenbosch University, 2021).

5.4. Sustainable Buildings

A sustainable building can be described as one with high energy consumption, materials and water efficiency that minimized environmental and health impacts because of its design, better siting, operation, construction and maintenance throughout its life cycle. Some of the more regular attributes of buildings that are green include:

- Energy efficiency is one of the ideal methods of reducing the loss of heat energy and of using the envelope of a high-performance building to minimize heat transfer between the interior and exterior of the building. Insulated envelopes are effective at preserving energy all year as they keep the heat out during the summer and winter (Belussi et al., 2019).
- Renewable energy generation refers to a building of high performance that contains energy-efficient supplemental systems for the generation of renewable energy and is likely to be considered a net zero-rated building (Ahmad, Zhang, & Yan, 2020).
- Water efficiency in green buildings conserves portable water through their operations by using low-flow water fixtures and taking advantage of alternative water sources such as rain or grey water (Zhao, Zuo, Wu, & Huang, 2019).
- Stormwater management is an attribute of a green building. It is the way stormwater is managed during heavy rains. During an increase in rainfall during the rainy seasons, numerous green buildings can capture the rainwater and use it or treat it as an alternative water source for cleaning or gardening (Rosenberger, Leandro, Pauleit, & Erlwein, 2021).
- A superior indoor environment is an outstanding design of many green buildings. It aims to improve the well-being and health of its inhabitants. Some attributes that contribute to the indoor environment encompass great acoustic performance, daylight, excellent indoor air quality and high-quality views (Kang, Yang, Yang, & Cheng, 2020).

South African universities successfully engage in sustainable building activities. In 2019, the University of Cape Town (UCT) began working on an air-conditioning policy to ensure that the university measures thermal comfort for staff and students according to international best practices. The Graduate School of Business Conference Centre was completed in 2019 and attained a 4-Star rating from the Green Building Council of South Africa (GBCSA). Over 100 energy and water meters across campus gather consolidated data on a remote metering dashboard. This system is being enhanced by adding additional meters to become a more helpful management and reporting tool (University of Cape Town, 2021).

The new NMU's R116 million business school is the first in SA to acquire an official rating of green design accreditation for an education and public building from the GBCSA. The rating of a four-star green design for the three-story building at the university's second avenue campus is the first of such buildings in port Elizabeth and the province of the Eastern Cape. The rating came after months of rigorous planning and implementation in the efficiency of materials, energy, water, indoor air quality, usage, ecology, transport and lighting to achieve stringent qualities (Nelson Mandela University, 2022).

5.5. Personnel Training and Awareness

Environmental awareness, training and education allow individuals to understand environmental issues better (Marpa, 2020). Education about nature and knowledge of environmental challenges improve attitudes, knowledge and the skills necessary to preserve natural resources. Informed individuals can make responsible decisions (Destek & Sinha, 2020). Environmental awareness, training and education benefit communities, youth, schools and teachers. When environmental awareness, training and education are integrated into the curriculum, students become zealous and passionate about engaging in learning. This advances student achievement in core

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academic areas. It also enables students to connect and apply their education in the real world to see the interconnectedness of ecological, social, cultural, economic and political matters (Danielraja, 2019). Environmental awareness, training and education encourage students to research complex environmental issues and assist in fostering a new generation of well-informed workers, consumers and decision-makers or policymakers. Integrated green initiative education includes aspects such as curriculum development and the history necessary to accomplish the required academic standards. Bringing nature indoors or holding classes outside provides an excellent background or setting for transdisciplinary learning (Torrejos & Israel, 2022). Exposing students to nature teaches them to appreciate and act sensitively towards the environment. It also assists students in understanding how their actions and decisions impact the environment and builds the knowledge and skills needed to address complex environmental issues. These measures help retain a healthy and sustainable environment for the future (Marpa, 2020).

South African "universities" have engaged in the following initiatives in terms of awareness and training:

- The University of Pretoria helps the neighbouring communities by undertaking clean-up projects involving local streams polluted by contaminants which may harm the operations of the local flora and fauna (University of Pretoria, 2021).
- The University of Johannesburg's (UJ) process, energy and environmental technology encourages the transfer of cross-disciplinary knowledge which promotes the development of the green economy by forming alliances between researchers and small and medium-sized enterprises. The energy, water and waste interaction at the institution is approached using a circular method. It fosters network developments between the university and the National System of Innovation (NSI) to ensure sustainable development (University of Johannesburg, 2021).
- The University of KwaZulu-Natal's Sustainable Living Student Organisation (SLSO) organized an event at the nursery on the Pietermaritzburg campus to teach students about beautifying the campus, improving their gardening skills and sustainable gardening. Numerous students joined the SLSO committee for 90 minutes to celebrate the spring season arrival through an assembly that contributed to achieving the 'university's objective of advancing the environmental awareness to which students are subjected and the factors impacting that environment including pollution, environmental degradation and climate change. They also watered the plants and removed litter from the area (University of KwaZulu-Natal, 2021).
- Rhodes University (RU) has committed to enhancing the environmental focal point of its education and research, decreasing its ecological footprint concerning the development of infrastructure and use of environmental goods and services, promoting more waste and water management, sustainable energy, usage strategies and actively involving its constituents to advance sustainability. Firstly, RU's senate approved their environmental policy obligating the university to expand its environmental research and programmes. Numerous institutes and departments at RU further commit to innumerable environmental matters (Rhodes University, 2021).
- University of the Western Cape students are involved in managing the university's nature reserve by exterminating alien vegetation and managing fire breakouts. The University of the Western Cape 's green campus initiative campus chapter of more than 2000 student volunteers actively participates in green debates, campus clean-ups and other green activities (University of the Western Cape, 2021).
- The University of the Witwatersrand offers a "Climate Change and Me" module. It was first presented in 2022 and quickly became the most popular module in the university's history. Climate change, a consequence of a system in a more extensive network was an ideal choice of subject as an intellectual activity shared by all first-year students regardless of their selected discipline. In 2022, over 7200 students enrolled in the “climate change and me” module which formed part of a compulsory and more extensive student life orientation and academic programme (University of Witwatersrand, 2023).

6. RESEARCH METHODOLOGY

This quantitative study used a five-point Likert questionnaire (ranging from 1 = strongly disagree to 5 = strongly agree). The population comprises executive directors, assistant directors, senior managers, senior lecturers and faculty deans at eight South African universities. A purposeful sample (based on their engagement in green initiatives as publicly outlined on their websites) selected eight universities for this study. Permission was obtained.

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The human resource departments served as mediators between the researcher and the respondents. The population received an email with the online Google Forms questionnaire from their human resource departments. The first page of the questionnaire contained a letter of consent explaining the study and requesting written permission (by ticking the appropriate box) to use the data for research and publication. Participation was voluntary and anonymous. This study was ethically approved and was issued an official ethics number (NWU-00588-22-A4).

The questionnaire consists of two sections: Section A: Demographics and Section B: Measuring criteria. Section A provides a demographic profile of the respondents while section B deals with five existing green initiative constructs and their respective measuring criteria.

7. RESULTS

The data analysis consists of three steps and coincides with the objectives. In step 1, the data is scrutinized for normality to ensure its suitability for analysis. Step 2 deals with the inferential statistics and measures the perceptions of university management towards implementing green initiatives (objective 3). Step 3 identifies the factors (latent perceptions).

7.1. Step 1: Suitability of the Data

The data's suitability consists of the data's normality (as represented by the skewness and kurtosis statistics), reliability (as per 'Cronbach's coefficient alpha) and the sample adequacy and sphericity.

Perfect normal data has kurtosis and skewness values of zero. Kurtosis refers to the 'data's "peakedness" and skewness refers to the data distribution. A positive skewness (see Table 1) indicates that most data points are located left of the normal bell curve (Pallant, 2016). The positive kurtosis in Table 1 indicates that the data is relatively "highly peaked" compared to the normal bell curve (Pallant, 2016). Table 1 shows the normality statistics.

Table 1 shows that the data is highly peaked and to the left of the normal bell curve. However, although it deviates from normality, Table 1 shows that all the data points have skewness (0.202) and kurtosis (0.401) values below the maximum acceptable value of 0.50. This means the data is suitable and within the margins of normality (Pallant, 2016). Therefore, the data is suitable for analysis (Field, 2013). Cronbach's alpha coefficient calculates the data's reliability and internal stability. Table 2 shows the reliability results.

Cronbach's alpha coefficient (α) determines the internal consistency or average relationship of items in a survey instrument to assess its reliability and the data's reliability (Wuensch, 2009). The results are outlined in Table 2. The alpha coefficient of the 18 criteria is 0.412. This is below the desired level of 0.70 (Field, 2013) and below the first minimum level of reliability (.57) (Field, 2013). However, the alpha coefficient is above the minimum usability level (0.30) established by Cortina (1993) in his seminal analysis of alpha coefficients. Cortina's research indicated that although the data has a lower order of reliability, it is still suitable for analysis when the alpha coefficient exceeds or equals 0.30. Furthermore, the lower reliability means that if the study were to be repeated, there is a 41.2% probability of reaching the same results. Therefore, reliability is an indicator of future consistency rather than a disqualifying metric for the current data (Sürücü & Maslakci, 2020).

7.2. Sample Adequacy and Sphericity

Testing the adequacy of the sample using the Kaiser Meyer-Olkin (KMO) method provides information regarding the number of respondents in the study. An ideal KMO value is .70 (Field, 2013), but a KMO value of 0.50 signifies a usable dataset (IBM SPSS Software, 2022). KMO values below 0.50 indicate that there may not be enough criteria loading on some factors if an exploratory factor analysis is conducted (IBM SPSS Software, 2022). In addition to the KMO value, Bartlett's test of spherity should be significant at the 95% confidence level ($p \leq .05$).

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Table 1. Normality of the data.

Descriptive statistics					
Measuring criteria	**N**	**Skewness**		**Kurtosis**	
	Statistic	**Statistic**	**Std. error**	**Statistic**	**Std. error**
q1.1 Only energy-rated equipment and appliances are used.	144	2.748	0.202	5.628	0.401
q1.2 There is a solar energy system in place to operate any or some of the buildings.	144	3.223	0.202	8.508	0.401
q1.3 There is a solar energy system in place to operate any or some of the buildings.	144	3.223	0.202	8.508	0.401
q2.1 There is a water reclamation system to ensure that used water is collected, recycled and reused.	144	3.223	0.202	8.508	0.401
q2.2 Uses an active system to detect and repair water leakage in toilets and shower heads.	144	3.653	0.202	11.504	0.401
q2.3 There is water waste technology that channels excess water to onsite irrigation.	144	3.922	0.202	13.567	0.401
q2.4 There is an efficient use of rainwater.	144	5.808	0.202	32.176	0.401
q2.5 There is an efficient rainwater harvesting system.	144	5.137	0.202	24.728	0.401
q3.1 There are marked bins to separate trash at every building.	144	4.636	0.202	19.764	0.401
q3.2 Cardboards, printer cartridges and papers are recycled.	144	4.636	0.202	19.764	0.401
q3.3 Uses environmentally friendly cleaning products.	144	4.636	0.202	19.764	0.401
q3.4 Practices paperless processes	144	5.137	0.202	24.728	0.401
q4.1 The university's buildings are classified as sustainable buildings.	144	4.636	0.202	19.764	0.401
q4.2 Printer rooms architecturally allow passive ventilation and space conditioning.	144	4.242	0.202	16.222	0.401
q4.3 All offices have access to daylight to expose occupants to natural light.	144	4.636	0.202	19.764	0.401
q5.1 There are systems in place to eliminate paper usage and aim for a paperless office.	144	4.242	0.202	16.222	0.401
q5.2 The university uses online storage instead of printing, scanning and paper filing.	144	4.242	0.202	16.222	0.401
q5.3 The university promotes and supports telecommuting instead of daily travelling.	144	4.242	0.202	16.222	0.401

Note: Valid N (listwise)=144.

Table 2. Reliability.

Cronbach's alpha	N of items
0.412	18

The results (see Table 3) show that Bartlett's test of sphericity is significant (p=.00). As a result, the data can be used in multivariate statistical analysis (Karosekali & Santoso, 2019). Exploratory factor analysis explored potential underlying variables (factors) in the 18 criteria. Table 5 shows the factor analysis results.

Table 3. Sample adequacy and sphericity.

Kaiser-Meyer-Olkin measure of sampling adequacy.		0.531
Bartlett's test of sphericity	Approx. chi-square	229.537
	Df	153
	Sig.	0.000

7.3. Step 2: Perceptions of Green Initiatives

Five initiatives have been identified from the literature and discussed above. These green initiatives are renewable energy generation, water consumption, waste management, sustainable buildings and personnel awareness

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creation and training. The managerial perceptions of these initiatives are shown in Table 4. Each initiative and its measuring criteria are scored on a five-point Likert scale. A low mean score (below the midpoint of 3.5) means that the managers rate this criterion as poor or unattended to while scores above the midpoint represent a positive perception towards the specific criterion. The secondary indicator was the standard deviation. Deviations greater than one indicate that the respondents disagreed and their scores differed. However, the results show that the managers were all in agreement. The standard deviations on all criteria were below 0.3 signifying consistency in the respondents' perceptions of the existing green initiatives at their universities.

NWTable 4. Personnel's perceptions of existing green initiatives at the university.

Criteria	Mean	Std. dev.
Renewable energy and consumption	1.09 (21.8%)	0.277
1.1 Only energy-rated equipment and appliances are used.	1.10	0.297
1.2 There is a solar energy system in place to operate any or some of the buildings.	1.08	0.267
1.3 Compact fluorescent bulbs or light emitting diodes are used.	1.08	0.267
1.4 Water-saving technology and consumption.	1.10 (22.0%)	0.297
2.1 A water reclamation system ensures that used water is collected, recycled and reused.	1.08	0.267
2.2 Uses an active system to detect and repair water leakage in toilets and shower heads.	1.06	0.243
2.3 There is water waste technology that channels excess water to onsite irrigation.	1.06	0.230
2.4 Efficient use of rainwater	1.03	0.165
2.5 Harvesting rainwater	1.03	0.184
Waste management	1.04 (20.8%)	0.197
3.1 There are marked bins to separate trash in every building.	1.04	0.201
3.2 Cardboards, printer cartridges and papers are recycled.	1.04	0.201
3.3 Uses environmentally friendly cleaning products.	1.04	0.201
3.4 Practices paperless processes	1.03	0.184
Sustainable buildings	1.04 (20.8%)	0.206
4.1 The university's buildings are classified as sustainable buildings.	1.04	0.201
4.2 Printer rooms architecturally allow passive ventilation and space conditioning.	1.05	0.216
4.3 All offices have access to daylight to expose occupants to natural light.	1.04	0.201
Personnel training and awareness creation:	1.05 (21.0%)	0.216
5.1 There are systems in place to eliminate paper usage and aim for a paperless office.	1.05	0.216
5.2 The university uses online storage instead of printing, scanning and paper filing .	1.05	0.216
5.3 The university promotes and supports telecommuting instead of daily travel.	1.05	0.216

Table 4 shows that most respondents strongly disagree with the statement that renewable energy systems are in place. They also disagree that water-saving technology is implemented, waste management is available, the universities' office buildings are classified as sustainable and personnel training and awareness creation exist. The table shows that SA universities have a long way to go in implementing green initiatives. The mean scores for each initiative are close to one (or 20%), signifying that most respondents opted for the minimum score on the scale.

7.4. Exploratory Factor Analysis

Exploratory factor analysis identified the factors or latent variables in the perceptual data. A total of seven variables were found to account for 56% of the variation.

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Table 5. Varimax rotated factor matrix.

Criteria	Component						
	1	**2**	**3**	**4**	**5**	**6**	**7**
q2.5 Harvesting rainwater	0.738						
q3.2 Cardboards, printer cartridges and papers are recycled.	0.579						
q4.2 Printer rooms architecturally allow passive ventilation and space conditioning.		0.657					
q1.2 There is a solar energy system in place to operate any or some of the buildings.		0.641					
q3.3 Uses environmentally friendly cleaning products.		0.506					
q5.1 There are systems in place to eliminate paper usage and aim for a paperless office.		0.496					
q1.1 Only energy-rated equipment and appliances are used.			0.728				
q2.3 There is water waste technology that channels excess water to onsite irrigation.			0.558				
q3.4 Practices paperless processes			-0.434				
q4.3 All offices have access to daylight to expose occupants to natural light.				0.753			
q3.1 There are marked bins to separate trash at every building.				0.369			
q5.3 The university promotes and supports telecommuting instead of daily travelling.					0.746		
q2.1 There is a water reclamation system to ensure that used water is collected, recycled and reused.					0.421		
q2.4 Efficient use of rainwater						0.785	
q5.2 The university uses online storage instead of printing, scanning and paper filing.						0.429	
q2.2 Uses an active system to detect and repair water leakage in toilets and shower heads.							0.698
q1.3 Compact fluorescent bulbs or light emitting diodes lighting is used.							0.426
% Var	9.397	9.214	8.326	8.272	7.353	7.051	6.529
% Cum var	9.397	18.611	26.937	35.209	42.563	49.613	56.142

Note: Extraction method: Principal component analysis.
Rotation method: Varimax with kaiser normalisation.
Rotation converged in 30 iterations.

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Exploratory factor analysis identified seven factors in an orthogonal Varimax rotation (Field, 2013). Factor loadings equal to and above 0.35 are significant and used in the analysis (Statistica, 2006). Table 5 shows that all 18 criteria were retained. Only Statement 4.1 (the university buildings are classified as sustainable) did not have a factor loading above the required 0.35 threshold and was discarded from the rotated factor matrix.
The seven components show a total of above 50%. This indicates a good relationship between the data (Field, 2013). All of the components have eigenvalues greater than one per the Kaiser criterion (Pallant, 2016). These factors are discussed in the next section.

Factor 1: Recovering natural resources and recycling
The first factor deals with recycling paper and capturing water that originate from natural resources. The reference to printer cartridges seems odd at first glance. However, refilling these cartridges do not require recycling because they are refilled and reused. The factor explains the most variance at 9.397%.

Factor 2: Supportive infrastructure
Factor 2 deals with issues such as passive ventilation, solar energy, paperless offices and using environmentally friendly products. These are all active decisions in creating and maintaining a more environmentally friendly building design. The factor explains 9.214% of the variance and is only marginally less important than factor one.

Factor 3: Reallocation of resources
Factor 3 deals with using runoff water for irrigation, using proven energy-saving equipment (so that saved energy can be redirected) and using paperless processes. Interestingly, the criterion dealing with paperless processes has a negative factor loading. According to the respondents, paperless operations are vital but universities do not use them (a negative loading). The factor explains 8.326% of the variance.

Factor 4: Conservation of natural resources
Factor 4 regards offices with daylight access and trash bin separators' availability. The criteria pertaining to these procedures show a negative factor loading indicating that the participants consider daylight and trash bin separators to be crucial. The universities have not adopted these processes explaining a negative loading of 8.272% of the variance.

Factor 5: Leadership involvement and improved communication
Factor 5 addresses water reclamation technologies to ensure that used water is collected, recycled and reused as well as telecommuting as an alternative to regular travel. These are all mutual decisions by management to promote greater flexibility in work schedules and save on water utility bills. The respondents view telecommuting and water reclamation as critical as indicated by the negative factor loading of both criteria. The universities have not implemented these initiatives which explains the negative loading of 7.353% of the variance.

Factor 6: Improved technology
Factor 6 deals with efficient rainwater usage and the utilisation of online data storage. The criterion dealing with these technology-enabled processes has a negative factor loading implying that the respondents regard them as crucial. The universities do not apply these processes explaining a negative loading of 7.051% of the variance.

Factor 7: Efficient use of financial resources
Factor 7 focuses on the active system to detect and repair water leakage and use compact fluorescent bulbs or light-emitting diodes. Management's financial decision is implementing the water leakage detecting systems and purchasing power-saving light bulbs. These criteria have a negative factor loading implying that the respondents regard this financial decision as paramount. However, the universities have not implemented these systems, hence a negative loading of 6.529% of the variance.

8. DISCUSSION OF RESULTS
Figure 1 summarises the results and shows the identified and latent variables (factors).

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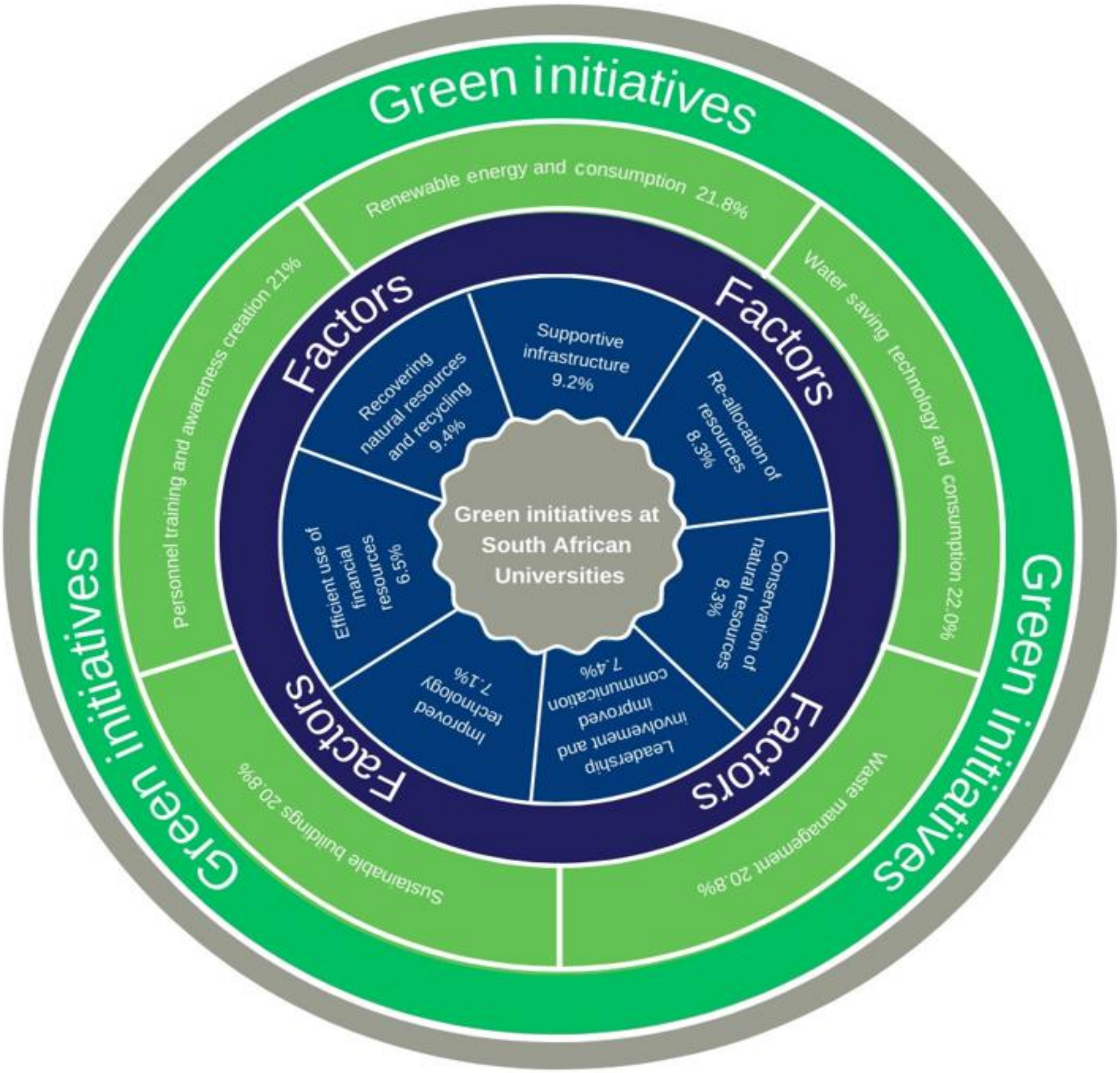

Figure 1. Green initiatives at South African universities.

Biodiversity which includes ecosystems and species is declining in South Africa and some environmentally unsustainable practices in urban expansion have the potential to eliminate some of the country's natural assets. At the same time, polluted ground and surface waters, land use and air quality are not improving (Bag, Pretorius, Gupta, & Dwivedi, 2021).

The production of wind and solar energy is the extent of South Africa's green initiative potential in terms of renewable energy. However, the country's long coastline has limited potential because of the low tide range. Universities and the government may both benefit from renewable energy as a possible green initiative. The SA economy heavily depends on the country's abundant coal reserves, steered largely by availability and low cost and the formal energy sector transformation is slow (Uhunamure & Shale, 2021). The poor performance of Eskom as the national energy supplier and continuous blackouts forced many businesses and consumers into alternative energy generation. Households and small businesses have installed 1,850,000 solar photovoltaic (PV) panel systems (backed up by battery storage) of less than 10kW and another 700,000 systems between 10 and 50kW since 2020 (Mordor Intelligence, 2023). Therefore, energy-efficient and renewable energy-related green

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technologies are being implemented by the private sector in South Africa setting the standard for the industry (Uhunamure & Shale, 2021). Universities are investigating ways to create clean coal together with the mining industry.

Water saving and consumption technology are critical as SA is water-scarce and cities like Cape Town and Port Elizabeth face extreme water shortages. Cape Town was the first modern city that almost ran completely dry on 11th May 2018 (Baker, 2018). On 7th March 2023, all five of the dams providing the city of Port Elizabeth had less than 12% water capacity (Sizani, 2023). Reusing rainwater collected from rooftops and other cities may be very helpful in ensuring access to clean water in cities and supplying sustainable water. Small-scale rooftop rainwater harvesting involves collecting, capturing and storing rainwater runoff for various productive purposes including drinking, irrigation and domestic use and is a viable alternative resource for water. This practice is becoming more common in rural regions across the nation especially with the government providing financial aid to low-income households to cover the cost of capital for the installation of rainwater tanks and related projects (Ndeketeya & Dundu, 2019). Unfortunately, Lebek and Krueger (2023) indicate that only 1% of rural households capture rainwater for domestic use. The typical round "rondavel-style" homes are also not conducive to capturing rainwater. Universities have successfully engaged in water-saving initiatives. The North-West university has redirected fountains on campus into large storage tanks. Nelson Mandela university captures waste water from its hostels in tanks and uses it to irrigate the campus gardens (AfricaLive, 2023; Nelson Mandela University, 2023).

8.1. Waste Management

In SA, in most developing countries, recycling is primarily steered by the informal waste sector. Landfills, unregulated disposal sites manage the majority of the country's production of general and hazardous trash. Statistics show that in January 2022, 46% of plastic, 70% of paper, 72% of beverage cans and 42% of glass were recycled in the country (Infrastructure News, 2022). However, SA waste technology solutions are still heavily reliant on landfilling. Municipalities are still relying very heavily on landfilling as the main solution for waste management (Dlamini, Simatele, & Serge Kubanza, 2019). The majority of campuses still lack systematic waste categorization or distinct containers for paper, glass and cans despite the fact that many universities legally recycle paper.

8.2. Sustainable Buildings

There is an extensive range of green technologies that are currently available globally. Nevertheless, most could still be regarded as 'fringe' technologies because they are unpopular in the building territory. SA is among the worldwide building markets where adoption rates are lower than those of Europe and America.

South Africa has approximately two million square metres of newly certified green buildings. These buildings remarkably decrease the carbon footprint of the construction sector. According to the developers of a study of 50 green building projects, their structures will save 76 million kilowatt hours of electricity annually or 5,300 households' annual electricity consumption. This signifies annual carbon emissions savings of 115 million kilogrammes, 28,000 fewer cars on the road or 124 million litres of water (enough to sustain 34,000 families) (International Trade Administration, 2022).

8.3. Personnel Training and Awareness Creation

Environmental awareness, training and education involve allowing individuals to traverse environmental concerns, participate in problem-solving and take action towards improving the environment (Marpa, 2020). It further assists students in understanding how their actions and decisions impact the environment, builds skills and knowledge needed to address complex environmental concerns and actions that can be undertaken to maintain a healthy and sustainable environment for the future (Marpa, 2020). Students who make the decision to learn more or take action to better their surroundings connect with local organizations and communities to promote discussion and comprehension about problems pertaining to the environment that affect their area.

According to a survey by master card covering 24 countries, 58% of adults maintain that they are more conscious of their environmental impact. In contrast, 85% claimed they would take personal action to tackle challenges in climate and sustainability in 2021. Moreover, 62% of respondents maintain that companies must behave more eco-friendly and sustainably (Mastercard, 2021).

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According to UNICEF (2022), people's attitudes towards taking personal responsibility for environmental protection are divided. This survey revealed that 46% of participants felt that taking personal responsibility for environmental and climate action is encouraged while 43% did not believe that individual actions can affect climate change. However, 90% of them think that schools should be in charge of offering environmental education and assisting students in understanding how their choices and actions affect the environment (UNICEF, 2022).
The Fujitsu group manages numerous environmental awareness and education activities based on the perception that "greater environmental awareness and proactive attempts among all personnel are significant in pursuing the management of the environment" (Fujitsu Group, 2021).

8.4. Universities' Role in Green Initiative Research

The University of South Africa (UNISA) established the Green Energy for Africa Research (GEAR) Centre. This centre is devoted to researching technologies suitable for renewable energy by converting under used resources and waste into electricity, fuel and jobs. The university also partners internationally to investigate ground-breaking energy innovations (University of South Africa, 2022). Although universities cannot implement these initiatives, they contribute to the green initiatives listed below because they research all these topics.
The primary mandate of the university of Johannesburg's process, energy and environmental technology is to improve the industry's competitiveness in the green economy. This mandate expands to policy-influencing and capacity-building initiatives in the green economy and promotes interaction between industry, academia and the public sector (University of Johannesburg, 2021).
At the University of Pretoria, the Clean Energy Research Group (CERG) is actively involved in the numerical and experimental transfer of heat research focused on clean energy applications. CERG is a world-class experimental facility centred on heat transfer that is part of the Department of Mechanical and Aeronautical Engineering (University of Pretoria, 2023).
Stellenbosch university has allocated R12 million for research into green hydrogen which the South African government has touted as an energy source that can help lower carbon emissions in sectors such as steel and aviation (Stellenbosch University, 2022).
At the University of Witwatersrand, the Sustainable Energy and Environment Research Unit (SEERU) aims to develop skills through teaching and research to address crucial processes for producing clean or renewable energy and a sustainable environment (University of Witwatersrand, 2023).

9. CONCLUSION

The listed green initiatives are insufficient compared to other universities worldwide. Building sustainable designs, hydration stations, locally grown food, green transportation, lighting renovation, behavioural modification, education and more awareness-raising activities are among the initiatives that SAU might explore immediately. SAU can start introducing rainwater harvesting, telecommuting, sanitation, conservation agriculture, green information and communication technology and a mandatory environmental sustainability module for all undergraduate students despite the obstacles of time, effort, money and infrastructure. These might assist in combating the problems of an increased number of vehicles on the roads, degradation of land, air pollution, water wastage, deforestation and the usage of fossil fuels. Instead, energy and water saving, waste reduction, preservation of natural resources, reduction in deforestation, less air pollution, energy transition processes, sustainable ways of living and green tax incentives will be attained.
As a result, there is an opportunity for SAU to favourably impact the nation's economic expansion and green requirements. SAU can start by outlining what sustainability means for their specific facilities, developing measurable, specific objectives and goals, gathering baseline data on the condition of their objectives, indicating action steps to execute change, implementing the action steps, conveying the plan to all stakeholders, observing the efficiency based on measurable objectives and taking data-based changes when necessary.

10. SUMMARY

This paper focused on analysing the existing green initiatives at SAU and the green initiatives suitable for implementation in South Africa. There are substantial concerns about the impact on the environmental awareness of SAU's graduates and the management practices challenges faced due to implementing green initiatives at these

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institutions. The difficulties in putting more green ideas into action are exacerbated by these worries as well as the growing demand for environmental knowledge and the services of green consulting and environmental training organisations.

The existing green initiatives at SAU include energy and water conservation through the erection of solar panels, boreholes and rainwater harvesting. Waste reduction and management through recycling, e-waste recycling, disposal and recycling of paper, glass and other waste are also available at SAU. Production of compost and bark chips where green waste is taken and converted into usable compost is one of the open initiatives. Awareness is created by assisting the surrounding communities by launching clean-up projects of the local streams that contaminants have polluted and educating students about improving gardening skills, sustainable gardening and beautifying the campus to advance sustainability. Preservation of natural resources by planting more indigenous trees which are more adaptive to local environmental conditions is among the existing initiatives. Feral cats are provided with decent care and a safe environment. Certain SAU campuses have naturally reduced the number of rodents.

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INSTITUTIONAL REVIEW BOARD STATEMENT

The Ethical Committee of the North-West University, South Africa has granted approval for this study on 27 June 2022 (Ref. No. NWU-00588-22-A4).

TRANSPARENCY

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

Both authors contributed equally to the conception and design of the study. Both authors have read and agreed to the published version of the manuscript.

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