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Studies, Romania

*CORRESPONDENCE
Christo Bisschoff
✉ Christo.Bisschoff@nwu.ac.za

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A conceptual model to measure and manage the implementation of green initiatives at South African public universities

Lelo Tshivhase and Christo Bisschoff*

NWU Business School, North-West University, Potchefstroom, South Africa

Introduction: The growing need for environmental awareness accentuated the importance of green and sustainable business practices. This is also true for universities that modernly expanded their green training and research to engage in green operational practices.

Methods: This article summarises the main principles and factors of implementing green initiatives. Firstly, a generic theoretical approach conceptualizes implementing green initiatives at universities. The investigation analyses existing and current green initiatives at the universities, considers the benefits and barriers of implementing green initiatives, and develops a theoretical model for implementing green initiatives at South African public universities. An adapted conceptual model consisting of twenty significant literature antecedents ($p \leq 0.05$) and 13 latent variables (factors) could be hypothesized. This model was tested empirically with reliable data ($\alpha = 0.749$) from a five-point Likert scale questionnaire administered to 144 responding green managers at eight selected South African public universities.

Results: Although the regression model explains satisfactory variance ($R^2 = 0.862$; R^2 adjusted $= 0.841$), only five of the 20 antecedents in the theoretical model are significant. They are *Cost of green products* ($r = 0.527$; $p \leq 0.05$), *Lack of awareness and training* ($r = 0.435$; $p \leq 0.05$), *Managerial attitude and commitment* ($r = 0.369$; $p \leq 0.05$), *Digitisation* ($r = 0.552$; $p \leq 0.05$), and *Management Committee* ($r = 0.451$; $p \leq 0.05$). Further analysis revealed that the data possess embedded intelligence. Resultantly, 13 factors were identified, explaining a cumulative variance of 61.8%. However, only six factors are reliable and, therefore, usable ($\alpha \geq 0.57$). They are *F1*: *Convenience and efficient workflow*, *F2*: *Personnel cooperation*, *F3*: *Efficient use of resources*, *F5*: *Learning and improvement*, *F6*: *Delegation of authority*, and *F7*: *Improved management attitude*. Cumulatively, the six usable factors explain a cumulative variance of 45.5%.

Discussion: The model aspires to demonstrate and measure the implementation of green initiatives at public universities. Although the theoretical model is detailed, the empirical study showed that not all of the antecedents are usable for measuring and managing the implementation of green initiatives at South African public higher institutions. This study validated five of the antecedents and six factors for immediate use. The model's unvalidated antecedents and unreliable factors require empirical revalidation before operationalizing it fully. Researchers and scholars exploring this avenue of green initiatives implementation models can also benefit from this article.

KEYWORDS

South Africa, universities, green, initiatives, model, framework, higher education

1. Contextual background

Universities are at the forefront of development, leading and assisting industry with research and innovation. South African universities are considered significant drivers of environmental awareness, cooperation with local industry and education (Pocol et al., 2022). This is specifically relevant in South Africa, where public universities' funding model provides research subsidies, grants and private sector contracts for research. Research is a significant income stream for South African public universities. Hence, these institutions are strongly research-driven (this funding model does not subsidize private universities' research; private educators tend to focus their energies on teaching and learning).

Research toward green initiatives and environmental protection significantly gained momentum in South Africa. Likewise, public universities engaged and participated in research ranging from academic master's and doctoral level to industry contracts, many focusing on environmental awareness, sustainable agricultural practices, water saving, waste management and green energy. Specifically, water-saving and alternative energy research gained popularity (Hashmi and Alam, 2019). South Africa is a water-scarce country facing a 17% water supply shortfall within a decade, yet municipalities waste up to 45% water (Carnie, 2022). Likewise, the continuous shortage of electricity results in severe electricity loadshedding while the coal-generated electricity grid cannot comply with demand (even facing the danger of total grid collapse). This is a severe threat to economic growth (projected at 0.4% for 2023) and the environment (electricity shortages, for example, cause inefficiencies and water treatment plants, and the untreated raw sewerage contaminates the main water supply rivers).

These and other environmental problems influence universities' operations (Yun and Liu, 2019). Most universities invest in power generation plants to provide high-cost electricity, while some use water-saving initiatives to provide the campuses with safe and clean drinking water. This direct impact on universities and their operating costs changed universities' role in green initiatives. They no longer act as agents of change by providing environmental affairs knowledge, awareness, education and research inputs. Still, they are also directly influenced to initiate and implement green initiatives to remain sustainable (Hasan et al., 2019). In practice, they must develop and utilize existing water supplies on campus, install photovoltaic panels on the existing building's roof to harvest the sun's energy and recycle campus waste, including a few green initiative options (Anwar et al., 2020). Moreover, with growing environmental awareness, universities need to improve their business sustainability within the territory of environmental regulations. Engaging in green initiatives also provides new opportunities for a public university to achieve a competitive advantage through applied and practical green research projects on campus and by combining academic disciplines in practice (for example, using engineering designs and accounting principles when initiating green initiatives). This academic and research integration is crucial in sustainable green business operations and research in higher education (Zameer et al., 2022). The need for environmental awareness and sustainability practices aiming at implementing green initiatives has become widespread across all universities (Habib et al., 2021). Initiating green initiatives is also crucial from an operational point of view because the South African Higher Education funding model for private universities does not provide for the additional costs of self-generated electricity on campuses or any other green initiative. These costs became an additional operational budget item (Armenia et al., 2019).

Consequently, South African public universities must formalize their green initiative strategies because if they do, they (1) can save on their operational budget, (2) gain a competitive advantage in interdisciplinary environmental research, and (3) approach the Minister of Education for financial support on green initiatives and the self-generated energy costs. However, to do so, public universities should be able to provide a formal balance sheet of green initiatives and how well they are progressing. This means that universities need to measure and report on the green initiatives so that progress can be monitored (and potentially be funded by the state or industry). Therefore, to assist the universities in conceptualizing green initiatives in their business operations and effectively integrating green practices, this article aims to develop a model that university management can use to measure and manage the implementation of their respective green initiatives.

2. Problem statement

Implementing green initiative domains at universities is steered by many social and technological forces, going through fundamental and extensive conversions (De Mello Santos et al., 2022). Universities function in a complex territory and should be able to respond, be innovative, flexible, and speedily react to unpredictable and, at times, continuous changes (Miceli et al., 2021) efficiently and effectively.

Universities provide education and training, aiming to do so while they remain green, competitive, and sustainable in the long run (Wang et al., 2022). Going green requires implementation assessment to monitor progress. Ramely et al. (2022) assert that green initiatives implementation needs to be assessed to establish whether the deployed resources and improvements have positively impacted the business operations. Practically, the term to assess means to set realistic goals and then to design a technique to execute a precise measurement. Realistically, the assessment of green initiatives implementation is complex and involves numerous factors to consider (Gholami et al., 2020). Furthermore, assessment models vary based on the industry, kind of business and the business domain. Many models to assess green implementation variables exist. However, most of them were developed for other private businesses and organizations and not for state-funded universities. Implementing green initiatives at universities differs from other institutions aiming to realize profits (Sanchez-Planelles et al., 2020).

It is also noteworthy that universities are in a strict regulatory domain within the Department of Higher Education and Training. The bureaucratic line-structure results in slow decision-making, and universities struggle to act quickly to green market needs. As a result, Rodríguez-Abitia et al. (2020) maintain that although universities as organizations have common features with other institutions, they possess distinct features in their business and operating periphery and cannot be treated as "normal" business enterprises. Implementing measuring models from the private industry cannot be applied 'as is' to assess the green initiatives and their implementation at public universities. They require an adapted implementation measurement model for green initiatives (Maciá Pérez et al., 2021) and business performance (Asvat et al., 2018). This article aims to develop a model to measure the implementation of green initiatives and their progress at public universities in South Africa.

3. Research objectives

The primary objective of this article is to develop a model to measure and manage the implementation of green initiatives at public universities in South Africa.

The following secondary objectives serve the primary objective:

- Construct a hypothesized model to measure and manage the implementation of green initiatives at South African public universities.
- Empirically evaluate the model for implementation at South African public universities.

4. A theoretical model to measure green initiatives at South African public universities

The researchers Bisschoff and Tshivhase (2023) and Tshivhase and Bisschoff (2023a,b) stepwise developed a theoretical model to measure the green initiatives at public universities in South Africa. This model consists of five antecedents, namely *Existing green initiatives* (Bisschoff and Tshivhase (2023), *Factors impacting green initiatives* (Tshivhase and Bisschoff, 2023a), *Implementation of green initiatives, Barriers*, and *Benefits* (Tshivhase and Bisschoff, 2023b). These five antecedents are hypothesized to influence the green initiatives of public universities based on the findings of these studies. Figure 1 shows the model.

It is hypothesized from the model that:

H_0: There are no significant positive relationships ($p \leq 0.05$; $p \leq 0.10$) between *Green initiatives at South African universities* and the antecedents *Existing green initiatives, Factors impacting on green initiatives, Implementation of green initiatives, Barriers*, and *Benefits*.

H_1: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between *Green initiatives at South African universities* and the antecedent *Existing green initiatives*.

H_2: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between *Green initiatives at South African universities* and the antecedent *Factors impacting on green initiatives*.

H_3: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between *Green initiatives at South African universities* and the antecedent *Implementation of green initiatives*.

H_4: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between *Green initiatives at South African universities* and the antecedent *Benefits of green implementation*.

H_5: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between *Green initiatives at South African universities* and the antecedent *Barriers of green initiatives*.

4.1. Existing green initiatives

In their research, Tshivhase and Bisschoff (2023a) investigated the existing green initiatives at eight leading South African public universtities. The study specifically investigated potential green initiatives that can be implemented at universities, (1) which green initiatives are being implemented, and (2) managements' perceptions on the success of implementation at their universities. The theoretical constructs were validated by exploratory factor analysis and measured with inferential statistics. Mazon et al. (2020) philosophy that the green initiatives implemented by public universities help sustain the economy's sustainable development and assist in sustaining the growth of the universities' operations. In the first step of the stepwise model development, Tshivhase and Bisschoff (2023a) identified and empirically validated five dominant existing green initiatives at South African universities which are being (or has already been) implemented. They are *renewable energy and consumption, water-saving technology and consumption, waste management, sustainable buildings,* and *personnel training and awareness*. These initiatives are discussed below.

4.1.1. Renewable energy generation and consumption

Renewable energy is energy derived from natural sources that are replenished at a higher rate than consumed. Sunlight and wind, for example, are such sources that are constantly being replenished (Güney, 2019). Examples of existing renewable energy generation and consumption initiatives at South African universities include using (1) solar photovoltaic panels to generate power at some of the universities' buildings, (2) harvesting wind energy, (3) combining nano bioscience, nanochemistry and nanophysics to develop alternative energy, (4) use new medical diagnostic and therapeutic agents, (5) install biological and chemical sensors, (6) use smart electronic materials, and (7) nanoscale robots (North-West University, 2023; The University of Pretoria, 2023; University of KwaZulu-Natal, 2023).

Alizadeh et al. (2020) and Rehman et al. (2022) add that universities reap the environmental and economic benefits of renewable energy and consumption by reducing greenhouse gas emissions because they use less energy from fossil fuels, reduce air pollution, limit their dependence on the unreliable electricity grid, and stimulate the local economy through developing new environmental product in their research, installing energy-efficient technology, and proper maintenance.

4.1.2. Water-saving technology and consumption

Water-saving technologies refer to all methods of conserving water by increasing water use efficiency, enhancing the capacity

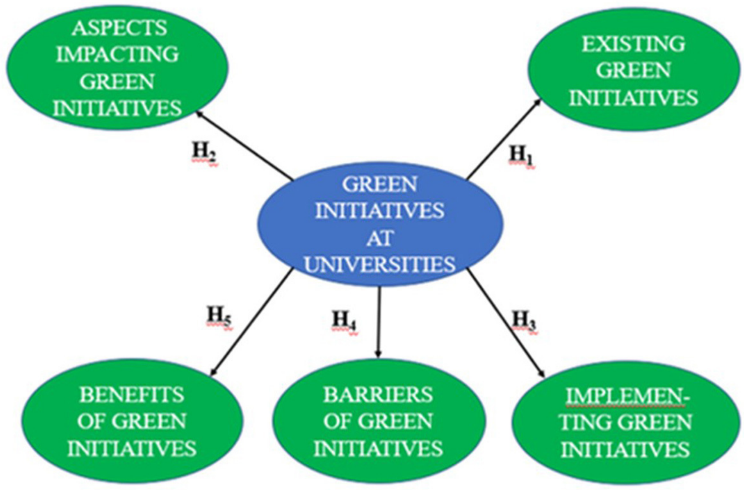

FIGURE 1
A conceptual model to measure green initiatives at public universities.

to retain runoff water, and eliminating water pollution (Guo, 2019). Capturing rainwater (Nelson Mandela University, 2023) or using existing fountains (North-West University, 2023) and boreholes (University of the Western Cape, 2023) are low-hanging fruit. Other universities in South Africa actively engage in research-based water-savings by implementing biomimicry, which mimics the biological processes of fauna and flora (Jamei and Vrcelj, 2021). For example, researching how mangrove plants and euryhaline fish extract salt from seawater using minimal energy or using biomimetic membranes enhanced with aquaporin that filter salts by shuttling water in and out of cells (Pistocchi et al., 2020). Other existing water-saving technology and consumption initiatives at South African universities include harvesting rainwater (University of the Witwatersrand, 2023), using registered boreholes onsite (University of the Western Cape, 2021; North-West University, 2023), applying sophisticated technologies to monitor the buildings' consumption of electricity and water in real-time to help minimize any water losses (such as leaks and faulty equipment) (The University of Pretoria, 2023), developing waterless gardens (The University of the Free State, 2022) and implementing water purification plants for portable water (Rohani et al., 2021).

4.1.3. Waste management

According to Chisholm et al. (2021), a waste management system is the strategy used by organizations to dispose of, reduce, reuse, and prevent waste. Most universities have multiple waste management strategies (Das et al., 2019). Existing waste management initiatives at South African universities focus on recycling. E-waste recycling is a specific focus area, and most campuses use designated containers to dispose of computers, cell phones, batteries, and other e-waste (Zorpas, 2020). Furthermore, facilities for recycling glass, paper and other waste are common on campuses, while the The University of Pretoria (2023) uses its garden waste for compost in the gardens and sports facilities. This university also applies microbes to accelerate the decomposition of kitchen waste infused in the compost.

4.1.4. Sustainable buildings

A sustainable building is defined as a building with high efficiency in using energy, water and materials and reduced impacts on the health and the environment through better sitting, design, construction, operation, maintenance, and removal throughout its life cycle (Munaro and Tavares, 2021). Examples of sustainable building initiatives at South African universities include air-conditioning policies that comply with international thermal standards regarding the comfort of staff and students and rigorously planning and implementing energy efficiency, materials, water usage, indoor air quality, transport, ecology, and lighting to ensure that stringent standards were achieved. Nelson Mandela University (2023) is the first South African university to build a self-sustaining, environmentally friendly business school. New buildings at the North-West University (2023) have specific environmental criteria to adhere to. This is also true for most other public universities where new building designs commonly include modern materials, components, assemblies, systems, and building shapes that support green initiatives, lower maintenance costs, and save energy (University of South Africa, 2021).

However, most South African universities have older buildings whose designs do not facilitate green initiatives. Ultimately, these financial models play a decisive role in the buildings' social, environmental, and economic design, and public universities cannot afford to decommission the older buildings (Ikudayisi et al., 2022).

4.1.5. Personnel training and awareness

Saiful et al. (2020) explain that environmental awareness, training, and education is a process whereby individuals explore environmental issues, engage in problem-solving and act to improve the environment. It, furthermore, encompasses developing a deeper understanding of environmental issues and attaining the skills to make informed and responsible decisions (Marpa, 2020) to develop the knowledge, attitude, and skills necessary to protect natural resources (Yadav et al., 2022). Becoming environmentally aware is the first step to encouraging students to conduct environmental research and foster a new generation of informed consumers, workers, and policy- or decision-makers (Aznam and Irwanto, 2021). Student education and awareness levels can be improved by incorporating green initiatives education into the tertiary curriculum (Zguir et al., 2022). Some South African universities (North-West University, University of Cape Town, 2023; University of Johannesburg, 2023 and others) already engaged students in green initiatives by embarking on clean-up projects of local streams in the surrounding communities, promoting cross-disciplinary transfer of environmental knowledge, engaging students in events such as sustainable gardening, improving gardening skills and beautifying the campus, eradicating alien vegetation and maintaining fire breaks, and including a compulsory environment sustainability module for all undergraduates (Suárez-Perales et al., 2021).

From the literature, it is hypothesized that:

$H_{1.1}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Existing green initiatives* and *Renewable energy generation and consumption*.

$H_{1.2}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Existing green initiatives* and *Water saving technology and consumption*.

$H_{1.3}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Existing green initiatives* and *Waste Management*.

$H_{1.4}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Existing green initiatives* and *Sustainable buildings*.

$H_{1.5}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Existing green initiatives* and *Personnel training and awareness*.

4.2. Factors impacting green initiatives

In the second step of developing the conceptual model, Tshivhase and Bisschoff (2023a) investigated the factors that impact implementing green initiatives at South African public universities. Guided by Shahzad et al. (2021), these authors identified and empirically validated the factors that impact on universities when they implement green practices. Albeit many studies (Watson et al., 2008; Leonidou et al., 2017; Li et al., 2017; Bhatta et al., 2020) investigated the relationship between business operations and green initiatives, limited studies focused on universities *per se*, financial realities often trump good intentions when considering green initiatives (Wu and Issa, 2015). However, Tshivhase and Bisschoff (2023a) expanded this line of thought and identified ten potential theoretical antecedents from existing green measurement models. Five were relevant to public universities. These antecedents were subjected to exploratory factors analysis and measured by inferential statistics. The five antecedents are the *cost of green products, management attitude and commitment, digital transformation, a committee for sustainable accountability* and *awareness, training and education*. Only three antecedents were confirmed.

4.2.1. Cost of green products

Pahlevi and Suhartanto (2020) assert that there is a notion that perceives efforts to green the surroundings as an expensive endeavor. It may also be difficult and costly to access eco-friendly products. Eco-friendly products are more expensive than traditional products (Li et al., 2017) but save money in the long run (Bhatta et al., 2020). The demand for these products is also not as high as for traditional products, as environmentally friendly items are more expensive than non-green products (Sana, 2020). It might be costly to go green as this would mean replacing traditional equipment with green products. For instance, breaking down a brick-and-mortar building and replacing it with a green and sustainable building requires high capital costs; this is impractical in a public university environment. However, going green makes business sense (Bhatta et al., 2020), while focusing on environmental awareness can help management reduce capital costs and positively influence the university's operating budget (Zameer et al., 2022).

4.2.2. Management attitude and commitment

González et al. (2022) maintain that top management commitment is critical to implementing and adopting green practices. Support from senior personnel is perceived as one of the primary internal drivers of business practices that are environmentally responsible (Li et al., 2017). The lack of green management personnel who can guide and supervise the process of green practices in any organization is also a contributing factor. According to Hossain et al. (2020), the inconvenience of finding available green expertise also stops most organizations from practicing green, as they cannot simply start implementing green practices without the guidance of professionals or consultants (Ikudayisi et al., 2022). Top management's commitment is critical in realizing an organization's mission in practice; this is also true for the dive toward a more environment-friendly university. Hence the successful accomplishment of all organizational goals (including green initiatives) depends on top management's commitment (Sulich et al., 2021).

4.2.3. Digital transformation

Ciasullo and Lim (2022) describe digitalizing as a process adopted by a business to embrace digital technologies to change their operations model or to neglect traditional business processes. It aims at getting value from using advanced and new technologies by using the dynamics of digital networks and the extensive digital information flow (Folaron, 2017). Management's active decision-making can improve communication and transparency, enhance collaboration, increase productivity, and increase efficiency. Management can also ensure that digitalization manifests efficient and effective organizational business operations (Williams, 2021).

Digital transformation also improves productivity, enhances safety and reduces risks while using less energy. Kim et al. (2022) report that some Japanese smart buildings are now achieving a 20% increase in productivity, while German smart factories reduced the import/export gap by 50%. Likewise, universities can improve productivity while enjoying energy savings from a digitally transformed infrastructure.

From the literature above, it is hypothesized that:

$H_{2.1}$: There is a significant positive relationship ($p \leq 0.05; p \leq 0.10$) between the antecedent *Factors impacting green initiatives* and *Cost of green products*.

$H_{2.2}$: There is a significant positive relationship ($p \leq 0.05; p \leq 0.10$) between the antecedent *Factors impacting green initiatives* and *Management attitude and commitment*.

$H_{2.3}$: There is a significant positive relationship ($p \leq 0.05; p \leq 0.10$) between the antecedent *Factors impacting green initiatives* and *Digital Transformation*.

4.3. Implementation of green initiatives

In their third step during the stepwise model development, Tshivhase and Bisschoff (2023b) investigated the *implementation, barriers* and *benefits* of green initiatives at universities. Each antecedent was identified from the lieterature review, where exploratory factor analysis empirically validated them. Three factors were extracted for each antecedent.

Aldulaimi et al. (2022) assert that implementing green initiatives refers to the decision taken by organizations to preserve the health of the environment by reducing waste, pollution, and others. This process is also linked with practicing, learning, and contributing in ways that contribute to conserving the natural resources and habitats of the earth (Takahashi et al., 2021). The three factors for implementation of green initiatives are *advanced technology and training, digitization* and *reallocation of resources*. These factors are theorized below.

4.3.1. Advanced technologies and training

Advanced or environmental technology refers to using science and technology to preserve, conserve and protect natural resources and combat the negative impact of human activities on the environment (Vrontis et al., 2022). These technologies include, among others, wastewater treatment and water purification, waste management and recycling, waste-to-energy, electric transport, programmable thermostats, self-sufficient buildings, low carbon construction, carbon capture and storage, LED lighting, vertical farming, composting, wave energy, batteries, green materials and carbon tracking software (Wang et al., 2020).

4.3.2. Digitalization

Digitalization is using digital technologies to adapt the business operations model to a model that will provide new revenue and value-producing opportunities by moving to digital business operations (Kalimullina et al., 2021). The main areas of digital transformation include business model transformation, process transformation, domain transformation and organization transformation (Chawla and Goyal, 2022).

4.3.3. Reallocation of resources

This is a crucial source of improving efficiency by reallocating resources from less productive to more productive business areas, like deciding where business resources should be used to save and boost productivity (Gupta et al., 2023). Reallocating resources effectively and accurately can be achieved by mapping the timeline, identifying necessary resources, finding the resources, assigning the resources, and tracking the reallocation progress (Noorizadeh et al., 2021).

From the literature above, it is hypothesized that:

$H_{.3.1}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Implementation of green initiatives* and *Advanced technologies and training*.

$H_{.3.2}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Implementation of green initiatives* and *Digitalisation*.

$H_{.3.3}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Implementation of green initiatives* and *Re-allocation of resources*.

4.4. Benefits of green initiatives

The basis of implementing green initiatives is the framework of economic, risk management, productivity, financial, project funding, public relations and marketing benefits (Shad et al., 2019). Although inconclusive, previous research generally shows that implementing green initiatives results in reduced operating costs and non-financial benefits through a better work environment (Tsagas and Villiers, 2020). Some benefits are accrued immediately, while some are realized in the future economic and financial performance. Furthermore, retrofitting requires capital investment and related costs during implementation (Ahmed et al., 2023). The three factors identified and validated by Tshivhase and Bisschoff (2023b) regarding the benefits for universities to implement green initiatives are *cost-saving strategies*, *convenience and business continuity* and *reduced energy costs*. These factors are theorized below.

4.4.1. Cost-saving strategies

Bhatta et al. (2020), in support of Shad et al. (2019), maintain that the most regularly listed benefits of going green are the savings in operating costs. Universities can, therefore, capitalize on reduced operating costs in the medium and long term (Averfalk and Werner, 2020). Although the initial capital investment might be challenging, university managers should consider the investment trade-off decisions against the long-run advantages over the project's lifetime (Watson et al., 2008; Li et al., 2017). Furthermore, the environmental costs should be incorporated into this decision-making and managers should consider total sustainability and refrain from prioritizing economic objectives over environmental objectives (Hirunyawipada and Pan, 2020).

4.4.2. Convenience and business continuity

According to Evandro (2021), these are especially suitable to the service domain. Implementing green initiatives realizes productivity gains due to convenience and continuity (Kim et al., 2022). Focusing on processes of improving the service to customers (Leonidou et al., 2017), like digitized filing, enhances the performance of the employees (Mujan et al., 2019). Managers and decision-makers should emphasize the intangible benefits of going green (Li et al., 2017) as they have comparatively received little attention, despite their significant role in the success of business operations (Rehman et al., 2021).

4.4.3. Reduced energy costs

Lange et al. (2020) assert that reduced energy costs are the efficient use of less energy to perform the same task or produce the same result. Energy-efficient buildings use less energy to heat, cool, and run appliances and electronics (Nelson Mandela University, 2022), while energy-efficient manufacturing facilities use less energy to deliver goods (Kim et al., 2022). Reduced energy costs are one of the most cost-effective ways of combating climate change, reducing energy costs and improving the competitiveness of any business. Energy efficiency is also vital in achieving zero carbon dioxide emissions through decarbonization (Misztal et al., 2021).

From the literature above, it is hypothesized that:

- $H_{4.1}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Benefits of green initiatives* and *Cost-saving strategies*.
- $H_{4.2}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Benefits of green initiatives* and *Convenience and business continuity*.
- $H_{4.3}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Benefits of green initiatives* and *Reduced energy costs*.

4.5. Barriers of green initiatives

An overview of the current literature on the barriers and the implementation of green initiatives at university campuses reveals two recurring themes, financial and organizational (Li et al., 2020). The literature has mixed views regarding whether going green has higher initial capital costs than traditional processes. In contrast, others maintain that going green does not necessarily result in higher initial capital costs (Álvarez Jaramillo et al., 2019). Going green has equal capital costs and lower operating costs than conventional practices under the right circumstances (Wills, 2020). The barriers hindering the implementation of green initiatives at universities also yielded three factors from the exploratory factor analysis. These factors are a *lack of awareness and training, management attitude* and *reluctance to adapt*.

4.5.1. Lack of awareness and training

A basic problem for many countries is the general lack of environmental awareness that hinders the implementation of green initiatives (Gholami et al., 2020). This lack of awareness can partially be attributed to the absence of environmental studies in school education. In South Africa, it is not part of the school curriculum in either primary or secondary school (Bonnett, 2021). Adding insult to injury, the University of the Witwatersrand (2023) is the only South African university that currently includes environmental studies as a compulsory module for first-year students. At other universities, environmental studies are only accessible to natural science students (North-West University, 2023). This means that most university-educated decision-makers and managers lack formal environmental training and may not incorporate environmental issues as part of their decision criteria. They may also be unaware of the detrimental consequences of their managerial decisions on the environment (Darmawan and Dagamac, 2021).

4.5.2. Managerial attitude

In any business context, the attitudes, personal expectations, beliefs and responsibilities of the management influence the organizations' green strategic goals (Ogiemwonyi et al., 2020). The sense of personal responsibility and management attitudes influence employees' environmental preservation (Afsar et al., 2020). However, these managers also have their own beliefs, environmental awareness and ethical standards; all these influences play a role in how a manager makes environmentally sensitive decisions (Ansari et al., 2021). Therefore, awareness and training (Factor 1 above) are significant in managerial education and attitudes. Attitudes drive behavior (Kotler and Armstrong, 2022), and by educating managers, attitudes could significantly improve, resulting in better environmental decisions.

4.5.3. Reluctance to adapt

Reluctance to adapt is the resistance to adapting to change when it is inevitable and proposed (Galanti et al., 2023). Individuals can be either subtle or secretive about their unwillingness to adapt to organizational changes (Cox and Cox, 2020). They may even express their reluctance publicly through general actions or language. Overcoming resistance to change involves an actively managed three-step "Unfreeze, Change, Refreeze" model developed by the German/American psychologist Kurt Lewin in 1930 (Expert Program Management, 2021). In the first stage, "unfreezing" aims to create awareness about the upcoming change. In the second stage, change is implemented, while the final stage is to refreeze the new modifications to achieve stability and prevent a fallback to the original way of performing tasks, for example (Awati, 2023). The model is an active plan to manage a smooth transition from the old to the new. The decision to adapt is easy to implement when the causes of resistance is known and mitigated (González et al., 2022).

From the literature above, it is hypothesized that:

- $H_{5.1}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Barriers of green initiatives* and *Lack of awareness and training*.
- $H_{5.2}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Barriers of green initiatives* and *Managerial attitude*.

$H_{5.3}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Barriers of green initiatives* and *Reluctance to adapt*.

5. Methodology

This study applied a literature review of measuring and managing green initiatives and their implementation. The identified theoretical constructs and each of the five antecedents (existing green initiatives, impacting factors, implementation, barriers and benefits) were stepwise empirically validated using confirmatory or exploratory factor analysis.

The mixed method research design used qualitative interviews and a quantitative self-administered questionnaire to collect primary data. The questionnaire consisted of two sections: Section A for the demographics and Section B for the antecedents, constructs and their respective measuring criteria. Section A consists of three questions to gather the demographic profile of the respondents. Section B consists of five subsections, with subsection II dealing with the green initiatives and the factors impacting their implementation, each factor with its distinctive measuring criteria. The criteria were written in a statement format. The respondents were requested to specify their level of agreement or disagreement on a five-point Likert scale (ranging from 1 = Strongly Disagree to 5 = Strongly Agree). In total, Section B comprised 74 measuring criteria.

The population comprised the eight universities' senior personnel: Executive Directors, Assistant Directors, Senior Managers, Senior Lecturers and Faculty Deans. No sample was drawn, and the total population was targeted. Eight interviews were conducted with managers at these universities tasked with green initiatives. These interviews were done to discuss and confirm the antecedents, constructs and their respective measuring criteria. This information helped to structure, adjust and finalize the questionnaire developed from the theory.

The adapted questionnaire was pilot-tested and then placed on the electronic platform Googleforms. The researcher forwarded the Google form link to the selected eight universities' Human Resources departments to assist with distributing the questionnaire. Upon request to complete the questionnaires, it was clearly communicated to the universities' senior personnel that participation is anonymous and voluntary and that their universities' Research Ethics Committee approved the survey. The link was distributed to 150 senior personnel, and 144 responses were received, signifying an effective response rate of 96%. The data were analyzed with the IBM Social Package for Social Services and IBM's Amos (Version 28) (Rohani et al., 2021; IBM SPSS, 2022).

6. Results

Data analysis consists of three steps. The first step is to test the data for normality. Normality is determined by examining the data's skewness and kurtosis (Pallant, 2016) to ensure that the data can be used. The data's reliability and sample adequacy are evaluated in the second step, while the final step presents the empirical findings.

TABLE 1 Sample adequacy and sphericity.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.821
Bartlett's test of sphericity	Approx. Chi-Square	12829.18
	df	2628
	Sig.	0.000

These results include inferential statistics, analysis of variance, correlations and multiple regression to test the hypotheses.

6.1. The data's suitability

The analysis shows that the data are suitable to use. The data distribution as per the skewness measure (0.202) and peakedness of the data, as measured by the kurtosis (0.401), are within acceptable normality deviation levels (<0.50) (Field, 2017; Tshivhase and Bisschoff, 2023a). The data is slightly positively skewed, meaning most of the data are left of the normal distribution. At the same time, the data is also more highly peaked than the perfect normal distribution. However, these deviations are within acceptable limits (Field, 2017).

The data's reliability and internal stability are determined by Cronbach's coefficient alpha (α) (Pallant, 2016; Field, 2017). This desired reliability level is generally accepted to be 0.70. Alpha coefficients of 0.70 and higher are deemed satisfactory (Cortina, 1993). The data has a satisfactory reliability coefficient of 0.749, and the data is, therefore, regarded as reliable and fit for use (Sürücü and Maslakçi, 2020).

The final tests to determine if the data is suitable for use are to test sample adequacy and sphericity. Kaiser, Meyer, and Olkin (KMO) should have a value of 0.70 and higher (Field, 2017), while Bartlett's Test of Sphericity needs to be significant ($p \leq 0.05$) at the 95% confidence interval (Rohani et al., 2021). Table 1 shows the satisfactory KMO (0.821) and sphericity ($p \leq 0.00$) measures.

The results in Table 1 finally approve the suitability of the data. The suitability tests consider the data normal, reliable, adequate, and significant. This means the data can confidently be analyzed (Karosekali and Santoso, 2019).

6.2. Employment profile of respondents

The data collected contains three employment variables: the years of managerial experience, years at the university and the managerial level of respondents. These results are shown in Tables 2–4.

Table 2 clearly shows that most of the respondents (72.2%) have more than 10 years of management experience, indicating that the respondents are well-equipped to address green management at the university. Table 3 shows the university-specific experience.

Table 3 supports the findings of managerial experience and shows that the respondents' experiences are related to the university environment. Only 25% have <10 years of university experience.

TABLE 2 Years of management experience.

		Frequency	Percent	Valid percent	Cumulative percent
Valid	0–5 years	16	10.1	11.1	11.1
	6–10 years	24	15.1	16.7	27.8
	11–15 years	28	17.6	19.4	47.2
	16–20 years	40	25.2	27.8	75.0
	20+ years	36	22.6	25.0	100.0
	Total	144	90.6	100.0	

TABLE 3 Number of years at the university.

		Frequency	Percent	Valid percent	Cumulative percent
Valid	0–5 years	13	8.2	9.0	9.0
	6–10 years	24	15.1	16.7	25.7
	11–15 years	29	18.2	20.1	45.8
	16–20 years	41	25.8	28.5	74.3
	20+ years	37	23.3	25.7	100.0
	Total	144	90.6	100.0	

TABLE 4 Managerial level.

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Executive director	9	5.7	6.3	6.3
	Assistant director	18	11.3	12.5	18.8
	Senior management	36	22.6	25.0	43.8
	Senior lecturer	46	28.9	31.9	75.7
	Faculty dean	35	22.0	24.3	100.0
	Total	144	90.6	100.0	

The final variable examines the level of experience of the respondents. Table 4 shows that 43.8% of the respondents are on a senior management level or higher, while another 24% are on Deans' level. Resultantly, 67.8% of the respondents have management experience at high levels.

Finally, it was prudent to determine if there were significant difference between the groups and their answers to the individual questions of the questionnaire. The ANOVA and Cohen's effect size determined if there were significant differences. The results indicate that few significant differences on individual questions exist, and where they do, these differences are small (Cohen's d $\leq$ 0.30). As such, the total dataset could be analyzed because no sub-sets of data exist.

6.3. Measuring green initiatives at universities

Bisschoff and Tshivhase (2023) and Tshivhase and Bisschoff (2023a,b) empirically validated the antecedents and their respective constructs using confirmatory and exploratory factor analysis. These researchers performed independent studies, confirming the constructs about existing green initiatives. They then moved on to confirm the constructs about impacting factors. Validation of the other antecedents (implementation, barriers and benefits) followed similarly. This study uses these results and combines the independently validated constructs into one model. The analysis first used structural equation modeling to build a model where all the antecedents are dependent (not independent as per the individual studies). However, the model fit was poor and unsatisfactory (Arbuckle, 2021). As such, other avenues of analyses were explored to determine dependency and relations. Multiple regression successfully identified significant relations, while exploratory factor analysis extracted sensible new factors.

The independent analysis identified 13 constructs of the five antecedents. Table 5 shows the descriptive statistics of the constructs that describe the green initiatives at public universities.

6.4. Identifying significant relationships

As hypothesized from Figure 2, the significance of the factors of green initiatives at universities (as identified by Bisschoff and Tshivhase, 2023; Tshivhase and Bisschoff, 2023a,b) must be determined. Multiple regression was used to do so. These results appear in Tables 6, 7.

TABLE 5 Descriptive statistics measuring green initiatives.

	N	Mean	Std. Dev.
Renewable energy generation and consumption:	144	1.09	0.279
Water-saving technology and consumption	144	1.05	0.267
Waste management	144	1.04	0.201
Sustainable buildings	144	1.04	0.201
Personnel training and awareness creation	144	1.05	0.216
Cost of green products	144	4.96	0.243
Awareness, training and education	144	4.95	0.201
Top management attitude and commitment	144	4.96	0.214
Digital transformation	144	4.96	0.198
Committee for sustainability accountability	144	4.95	0.216
Implementation	144	4.95	0.216
Benefits	144	4.17	0.165
Barriers	144	4.97	0.184

The regression function explains a satisfactory variance with $R^2 = 0.862$ (adjusted $R^2 = 0.841$). Table 6 shows the significance of the individual predictor variables.

Five of the variables, *Cost of green products* ($r = 0.527; p \leq 0.05$), *Lack of awareness and training* ($r = 0.435; p \leq 0.05$), *Managerial attitude and commitment* ($r = 0.369; p \leq 0.05$), *Digitization* ($r = 0.552; p \leq 0.05$), and *Management Committee* ($r = 0.451; p \leq 0.05$) all shave a significant positive relationship at the 95% confidence interval with *Green initiatives at universities*. The other variables do not have a significant relationship with green initiatives at universities.

7. Acceptance of hypotheses

The following hypotheses are accepted:

$H_{2.1}$: There is a significant positive relationship ($p \leq 0.05; p \leq 0.10$) between the antecedent *Factors impacting green initiatives* and *Cost of green products*.

$H_{2.2}$: There is a significant positive relationship ($p \leq 0.05; p \leq 0.10$) between the antecedent *Factors impacting green initiatives* and *Management attitude and commitment*.

$H_{2.3}$: There is a significant positive relationship ($p \leq 0.05; p \leq 0.10$) between the antecedent *Factors impacting green initiatives* and *Digital Transformation*.

$H_{.3.2}$: There is a significant positive relationship ($p \leq 0.05; p \leq 0.10$) between the antecedent *Implementation of green initiatives* and *Management Committee*.

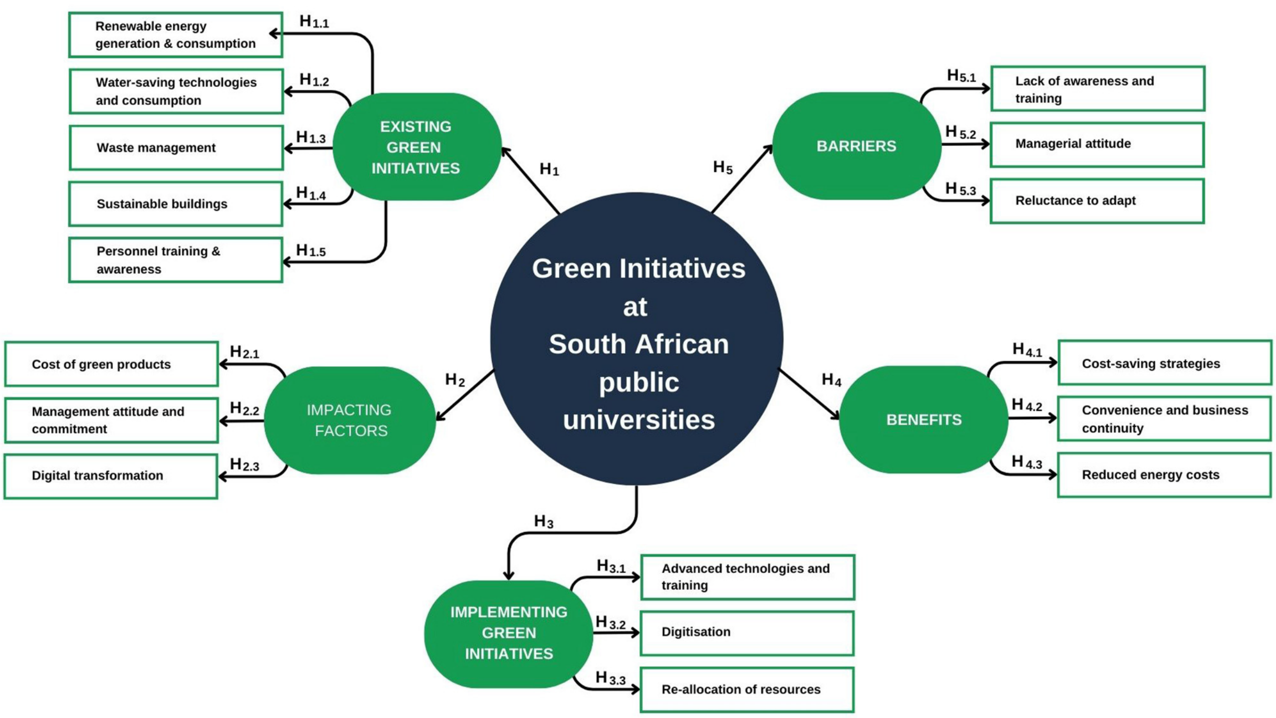

FIGURE 2
Theoretical model of green initiatives at public universities.

TABLE 6 Multiple regression model summary.

Model	R	R^2	Adjusted R^2	Std. estimate error	Change statistics				
					R^2 change	F change	df1	df2	Sig. F change
1	0.928[a]	0.862	**0.841**	0.02291	0.862	40.691	19	124	<0.001

[a]Predictors: (Constant), PersonTrain, Cost, Management, Convenience, Committee, Aware, SustBuild, Digi, ReduceCost, RenEnergy, CostSave, ManagerialAttitude, ReallocateResources, Digitization, AdvTechTrain, WasteMan, ReluctAdapt, LackofAwareness, WaterSave.

TABLE 7 Significance of individual predictor variables.

Model		Unstandardized coefficients		Standardized coefficients		
		B	Std. Error	Beta	*t*	Sig.
1	(Constant)	0.175	0.215		0.815	0.416
	ReallocateResources	−0.001	0.007	−0.010	−0.215	0.830
	Digitization	−0.005	0.007	−0.035	−0.705	0.482
	AdvTechTrain	−0.017	0.013	−0.069	−1.310	0.193
	Cost of green products	0.198	0.015	0.527	13.619	<0.001
	Awareness and training	0.182	0.018	0.435	9.824	<0.001
	Management attitude	0.142	0.022	0.369	6.339	<0.001
	Digital transformation	0.272	0.025	0.552	11.072	<0.001
	Management committee	0.203	0.024	0.451	8.372	<0.001
	Lackofawareness	−0.002	0.006	−0.027	−0.416	0.678
	Managerial Attitude	−0.004	0.014	−0.014	−0.303	0.763
	ReluctAdapt	−0.009	0.010	−0.056	−0.891	0.375
	CostSave	0.003	0.005	0.035	0.716	0.475
	Convenience	0.006	0.006	0.051	0.982	0.328
	ReduceCost	0.01	0.006	0.000	−0.003	0.998
	RenEnergy	−0.002	0.006	−0.018	−0.404	0.687
	WaterSave	−0.005	0.011	−0.041	−0.423	0.673
	WasteMan	−0.001	0.010	−0.012	−0.138	0.890
	SustBuild	−0.001	0.002	−0.022	−0.475	0.636
	PersonTrain	−0.003	0.008	−0.031	−0.383	0.703

$H_{.5.1}$: There is a significant positive relationship ($p \leq 0.05$; $p \leq 0.10$) between the antecedent *Barriers of green initiatives* and *Lack of awareness and training*.

All the other hypotheses are rejected. As a result, the hypothesized model cannot be confirmed (Kumar, 2015), and exploratory research is applied to identify latent variables (factors) in the data (Pallant, 2016; Field, 2017). As a result, the data were analyzed further to identify latent variables (factors).

The exploratory factor analysis identified 13 factors in the data using the Varimax rotation. All these factors have an Eigenvalue higher or equal to one, cumulatively explaining 62% of the variance. Table 8 shows the rotated factor matrix and variance explained by each factor. Only one statement was reverse-scored because of its negative factor loading. The statement deals with existing water-saving infrastructure loaded onto Factor 7. Table 8 shows the labels, Cronbach alpha's reliability coefficient and the variance explained by each of the 13 factors.

Table 8 shows that six of the 13 factors are reliable ($\alpha \geq 0.57$) (Cortina, 1993; Field, 2017). These factors were retained, and they are F1: *Convenience and efficient workflow, F2: Personnel cooperation, F3: Efficient use of resources, F5: Learning and improvement, F6: Delegation of authority,* and *F7: Improved management attitude.* Cumulatively, these factors explain a variance of 45.5%.

8. The conceptual model to measure green initiatives at public universities

The integrated conceptual model comprises the significant literature antecedents and the reliable factors. Figure 3 shows the conceptual model.

TABLE 8 Factor labels, reliability, and variance explained.

Factor number	Factor label	Reliability (alpha)	Variance %
1	Convenience and efficient workflow	0.876	11.5%
2	Personnel cooperation	0.695	9.6%
3	Efficient use of resources	0.821	5.8%
4	Innovation and adaptation	−0.717*	***
5	Learning and improvement	0.662	4.7%
6	Delegation of authority	0.698	3.6%
7	Improved management attitude	0.842	3.3%
8	Commitment by leadership	−737*	***
9	Improved operational systems	−0.830*	***
10	Interdisciplinary learning	−0.141*	***
11	Empirical investigation	−1.532*	***
12	Organizational values and ethics	0.107	***
13	Financial resources allocation	−0.321*	***

*Unreliable alpha coefficient.
***No variance reported due to unreliability.

The conceptual model illustrates that two sets of variables exist to measure green initiatives at public universities. The variables found in the literature (antecedents) explain an adjusted cumulative variance of 84.1%. The antecedents *Lack of awareness, Management committee* and *Managerial attitude* have significantly low positive correlations ($0.30 \leq r \leq 0.50$; $p \leq 0.05$), while the other two antecedents (*Cost of green products* and *Digitization*) have significant moderate positive correlations ($0.50 \leq r \leq 0.70$; $p \leq 0.05$) with the dependant variable *Green initiatives at South African public universities* (Mulaka, 2012). The latent variables (or factors) explain a cumulative variance of 45.5%. Four of the factors have "usable" reliability coefficients ($\alpha \geq 0.57$) (Cortina, 1993; Field 2017), while two factors (*Convenience and efficient workflow*, and *Improved management attitude*) have a very satisfactory reliability coefficient ($\alpha \geq 0.80$).

9. Areas for further research

Future research should be focused on the areas listed below:

- A comprehensive evaluation of each factor in the conceptual model to further assess and validate them. The factors still need final validation and tested for model fit using confirmatory factor analysis.
- A comparative study between South African public universities can identify good practices and share these practices between the universities. This study will highlight good green practices and identify ones that are not working well in the public university environment. As such, universities can share their experiences and collaboratively address green initiatives. This will also enable them to collaboratively address issues with the Department

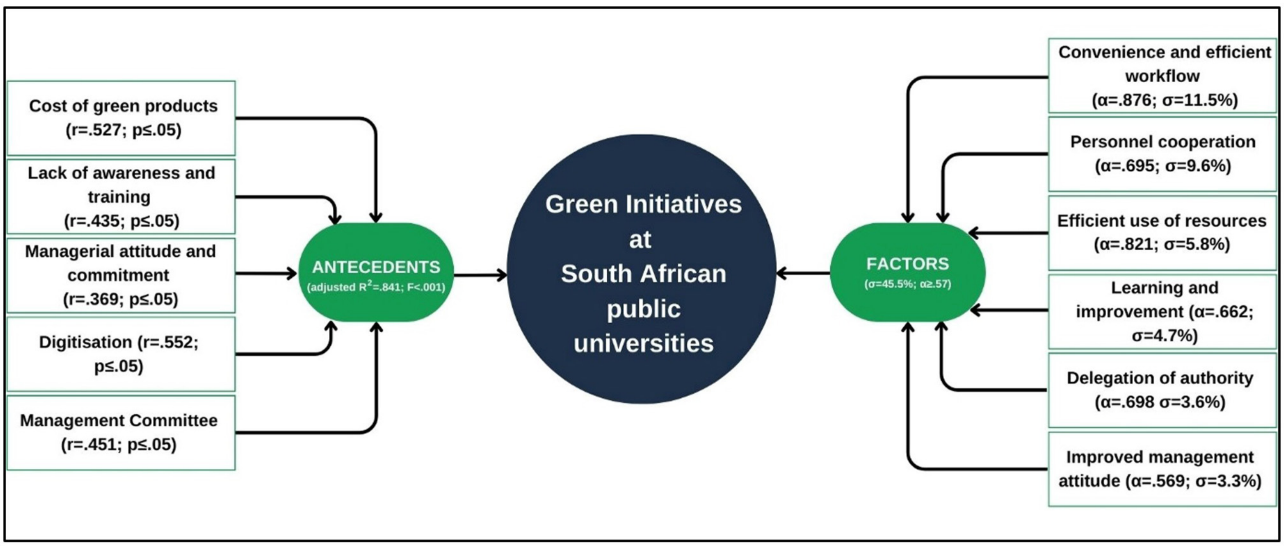

FIGURE 3
Conceptual model to implement and measure green initiatives at South African public universities.

of Higher Education, for example, the higher costs of green products.

10. Limitations

The limitations of this study are:

- This study does not cover all higher education institutions or all universities. This means that the data may not be relevant to all public universities. Likewise, private higher education has different constraints than public universities; hence this conceptual model would only partially apply to them. As such, the model cannot be fully operationalised to other higher education institutions without validation.
- The geographic location limits the results to South Africa and the business model and constraints imposed by the South African Department of Higher Education. These constraints should be considered if the study were to be operationalised in other African countries; their higher education authorities might have similar or different business models for their public universities.

11. Summary

This study's focal point was developing a model to measure and manage the implementation of green initiatives. The departure point in developing the model was to identify the suitable antecedents related to the implementation of green initiatives at universities in South Africa, followed by identifying the measuring criteria for each antecedent, thus, developing a hypothesized theoretical model (shown in Figure 1). The antecedents, and their respective measuring criteria, were identified from the existing models and other literature sources.

The empirical analysis showed that five of the 17 hypotheses could be accepted. These antecedents were retained. As is customary with exploratory research, the data were subjected to exploratory factor analysis to identify latent variables for potential inclusion in the conceptual model. The results show that 13 factors exist. However, after scrutinizing the reliability of these factors, six factors are retained because they have acceptable reliability coefficients.

The postulated theoretical model is only partially successful, retaining five antecedents and six factors (see Figure 2). Therefore, this article does not constitute a validated model but rather a conceptual model of framework that needs further validation before it can be operationalized. However, the study succeeded in simplifying and validating some antecedents and factors that can be used.

The conceptual model successfully identified some key aspects public universities face in implementing green initiatives on campus. As such, the model (partially or in full) can assist managers and leaders in implementing green initiatives at universities. Specifically, managers and leaders at South African public universities could find the results helpful amid the country's challenges in public higher education.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the study involving human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants in accordance with the national legislation and the institutional requirements.

Author contributions

LT did the literature study, developed the theoretical model to measure green initiatives at public universities, developed the measuring instrument, collected the data, and populated the structure. CB designed the empirical study, model evaluation, also conducted the statistical analysis, did the structural layout of the article, and did the final editing and signed off on the article. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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