Towards Promoting Green ICT in Institutions of Higher Learning

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ABSTRACT

The integration of green ICT practices into institutions of higher learning (IHLs) in Zimbabwe is crucial for achieving Sustainable Development Goals (SDGs) and promoting environmental responsibility. Higher education institutions in Zimbabwe have embraced this valuable technology so as to improve the country's chances of achieving both organisational and environmental sustainability in order to accomplish its Vision 2030 development roadmap. This study aims to explore the current state of green ICT adoption in Zimbabwean institutions of higher learning, establish the perceptions and attitudes towards green ICT in these institutions, uncover the elements that promote or impede the adoption and implementation of green ICT practices in Zimbabwean higher education institutions, and determine the challenges of implementing green ICT in institutions of higher learning, as well as prescriptions that can promote green ICT practices in these institutions. A comprehensive review of literature in developed and developing nations on green ICT from 2015 to 2023 was conducted, coupled by in-depth interviews with higher learning institutions' key stakeholders for triangulation purposes. The findings from the study highlight the need for a multi-pronged approach that encompasses institutional leadership, policy frameworks, financial incentives, technical expertise and awareness raising initiatives. The challenges of implementing green ICT include low awareness, constrained collaboration and scarcity of financial resources. These result in carbon footprints in institutions of higher learning. Strategies to counter these challenges include awareness raising, embedding energy saving programmes in ICT policy, virtualisation, the use of a thin client, and curriculum enrichment. By addressing these critical factors, Zimbabwean IHLs can effectively transition towards a greener and more sustainable future.

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INTRODUCTION

Information technology (IT) has become pervasive in all aspects of our lives, from our homes and offices to our schools and communities. IT innovations and developments are constantly changing the way we live, work and communicate. Despite the transformative power of IT, its widespread adoption has unfortunately resulted in a surge in energy consumption, electronic waste and environmental hazards, potentially compromising human well-being (Bekaroo *et al.,* 2018; Amankwaa *et al.,* 2017). To mitigate the environmental impact of information technology's burgeoning growth, initiatives such as green computing and energy minimisation, which focus on reducing carbon emissions and improving resource efficiency, should be taken into account and implemented (Debnath *et al.,* 2016). It is essential to harness the power of IT in a sustainable way not only to reap its benefits, but also to preserve our environment. Our actions and inactions today will shape the future of life for generations to come (Ogwuegbu, 2018). Achieving a more sustainable computing paradigm involves increasing the energy efficiency of data centres and computing devices, utilising renewable energy sources, reducing the presence of hazardous materials in computing devices, extending device lifecycles, and enhancing device recyclability (Mukesh *et al.,* 2017).

The culture of IT disposal differs from one country to another. Undeniably, the global environmental impact of information technology is determined by its pervasive use across nations, where it is integral to both mundane and intricate tasks. This holds true for Zimbabwe with her distinctive IT practices where the disposal of ICTs (Information and Communication Technologies) in Zimbabwean institutions of higher learning (IHLs) is a complex issue, with a variety of factors at play. Some of the most common methods of disposal include donation or sale, landfill, incineration and recycling. These methods pose both environmental and health effects since ICT gadgets contain a variety of hazardous materials. When e-waste is carelessly dumped in landfills, toxic materials can permeate the soil and groundwater, leading to environmental contamination and potential health hazards which include cancer, neurological disorders and reproductive

problems (Moyen Massa & Archodoulaki, 2023). Incineration of ICT gadgets releases pollutants into the air, including dioxins and furans, which are known carcinogens. Incineration also contributes to climate change by releasing greenhouse gases into the atmosphere. It can also cause respiratory problems, cardiovascular problems and cancer. This research seeks to investigate green ICT practices in Zimbabwean institutions of higher learning with the objective of identifying strategies to promote green ICT adoption in Zimbabwe. Its main objective is to significantly reduce the environmental impact of ICTs in institutions of higher learning through the implementation of sustainable practices and the promotion of a culture of environmental responsibility among faculty, staff and students. For an in-depth scrutiny of the issue under investigation, the following research objectives guided the discussion:

RESEARCH OBJECTIVES

1. To explore the current status of green ICT adoption in Zimbabwean institutions of higher learning.
2. To establish perceptions and attitudes towards green ICT in institutions of higher learning.
3. To uncover elements that promote or impede the adoption of green ICT practices in Zimbabwean higher education institutions.
4. To examine challenges of implementing green ICT in institutions of higher learning.
5. To establish strategies that can promote green ICT practice in Zimbabwean higher education institutions.

LITERATURE REVIEW

THE CONCEPT OF GREEN IT

Green computing, as a sustainable IT practice, encompasses the use of computers and related technologies in a way that promotes environmental stewardship and long-term resource conservation (Bansal *et al.,* 2019). Sahay and Bharti (2021) also define green computing as the scientific study of how to design, manufacture, use, dispose of, and recycle computers, hand-held devices and other computer-related products in a way that is not only efficient and effective, but also minimises environmental impact.

Green computing principles are anchored on four crucial pillars: energy conservation, environmentally conscious system design, effective resource management, and sustainable e-waste disposal (Jha *et al.,* 2022; Adimoolam *et al.,* 2021).

Energy conservation involves using IT resources in a way that minimises energy consumption (Patil *et al.,* 2019). Examples include using energy-efficient hardware and software, virtualisation, cloud computing and designing data centres for usage within institutions. The design of a computer system and resources (materials) involves using environmentally friendly materials in the design, manufacturing and disposal of IT products (Patil *et al.,* 2019). Some examples of green IT materials include recycled materials, biodegradable materials, fair trade materials and materials that are free of hazardous substances (Jha *et al.,* 2022).

Computer resource management (CRM) is a critical component of green ICT. By efficiently managing computer resources, organisations can reduce their energy consumption, carbon emissions and e-waste (Moyen Massa & Archodoulaki, 2023). Several strategies such as load balancing, that is, distributing workloads across multiple servers or other computing resources to improve performance and efficiency, can be adopted. Virtualisation offers another viable solution, enabling the creation of multiple virtual machines on a single physical server, thereby enhancing hardware resource utilisation. Computers and other ICT gadgets produce a lot of heat, hence there is need to use efficient cooling systems to prevent overheating and reduce energy consumption. There is need to track and manage IT assets throughout their lifecycle to ensure that they are used efficiently and disposed of responsibly (Adimoolamet *et al.,* 2021).

Sustainable e-waste disposal involves reducing the amount of electronic waste (e-waste) produced, and ensuring that e-waste is disposed of in a responsible manner. Some examples of green IT e-waste management practices include repairing and reusing IT equipment whenever possible, donating or recycling unwanted IT equipment, and using certified e-waste recyclers. Implementation of green IT practices would enable organisations to reduce the environmental impact of ICT, save money on energy and

other costs, and improve their public image (Jha *et al.,* 2022; Adimoolam *et al.,* 2021).

FACTORS AFFECTING THE ADOPTION OF GREEN ICT

a) **Financial Considerations**: The adoption of green ICT practices in universities is becoming increasingly important as these institutions strive to reduce their environmental impact and promote sustainability. However, the adoption of green ICT in institutions of higher learning is influenced by a number of factors. Financial considerations should be made when implementing green ICT. The initial costs of implementing green ICT infrastructure and equipment can be significant, which can deter IHLs from adopting these practices (Kamal, 2023).

b) **Awareness and Understanding**: Junior *et al.* (2020) point out that awareness and understanding of green ICT concepts is of utmost importance. Lack of awareness and understanding of the environmental benefits and cost-saving potential of green ICT can hinder its adoption. Nurturing awareness among faculty, staff and students about the ICT's ecological impact and the benefits of embracing green ICT solutions is crucial for encouraging behavioural change. Regular training programmes can equip individuals with the knowledge and skills to adopt sustainable ICT habits.

c) **Policies and Incentives**: Government policies and incentives can play a crucial role in promoting green ICT adoption in IHLs (Akbari *et al.,* 2017). Clear and comprehensive policies on green ICT procurement, usage and disposal are essential to guide decision-making and ensure consistent implementation across the institution. Stakeholders can as well be provided with incentives to enforce these policies and guidelines.

d) **Strong Leadership and Knowledge Sharing**: Strong leadership and commitment from senior management are essential for driving green ICT initiatives within IHLs (Akbari *et al.,* 2017). When leaders prioritise sustainability and provide the necessary resources, it creates a culture of environmental responsibility within the institution. Sharing of knowledge, experiences and best practices with other institutions and organisations can accelerate the adoption of green ICT practices and

provide valuable insights for overcoming challenges of green ICT. The implementation of green ICT requires technical expertise in areas such as energy efficiency, waste management and sustainable procurement (Kamal, 2023).

e) **Organisational Culture**: The organisational culture and the behaviour of individuals within IHLs can influence the adoption of green ICT practices (Junior *et al.,* 2020). Cultural norms within the Zimbabwean higher education context may influence the acceptance and adoption of green ICT practices. Institutions should tailor their strategies to align with local cultural values and traditions and develop a holistic approach in addressing greening strategies in institutions of higher learning.

GREEN COMPUTING AND ITS PRACTICES

Green computing initiatives are a combination of strategies and actions designed to minimise the environmental footprint of IT infrastructure and operations (Singh *et al.,* 2015; Agarwal *et al.,* 2015). These initiatives can focus on a variety of areas, including:

a) **Virtualisation**: Virtualisation is a technology that allows users and devices to access servers and other resources from anywhere in the world where there is an internet connection (Anand *et al.,* 2021). Cloud computing, which offers on-demand access to computing resources via the internet, has emerged as a close ally to green computing initiatives (Geeta, 2019). Virtualisation stands as a cornerstone of green computing efforts, offering a multitude of avenues for reducing energy consumption, waste generation and greenhouse gas emissions. By consolidating multiple workloads onto a single physical server, virtualisation significantly reduces the number of servers requiring power and cooling, thus leading to substantial energy savings. Additionally, virtualisation prolongs the lifespan of hardware by alleviating the workload on individual servers, thereby minimising e-waste generation (Anand *et al.,* 2021). Furthermore, virtualisation enhances power management efficiency by enabling virtual machines to automatically power down or enter sleep mode when not in use, further curtailing energy consumption.

b) **Power Management**: Power management is essential as it can extend battery life and reduce cooling requirements and noise (Saleem *et al.,* 2020). Kothari (2019) postulates that the hibernate or sleep mode is a widely supported and effective power management feature that has an embedded function that automatically powers down RAM and CPU when idle, thus effectively diminishing background activity. Power management can help to reduce energy consumption and carbon emissions. By putting devices into sleep mode, and by turning them off completely when they are not in use, organisations can save a significant amount of energy. Power management prevents gadgets from overheating and wearing out prematurely, and can extend the lifespan of the hardware. Additionally, it can help reduce the environmental impact of e-waste. When devices are properly powered down and disposed of, they are less likely to end up in landfills, where they can release hazardous chemicals into the environment (Saxena *et al.,* 2021).

c) **Power Supply**: Power supplies constitute an essential component of green IT practices, as they can significantly contribute to lowering energy consumption and carbon emissions. 80 Plus certified power supplies are particularly efficient (Agarwal *et al.,* 2015), converting at least 80% of the power they consume into useful output (Karuppusamy & Parimala, 2017). This can help to reduce the amount of energy wasted as heat, and can also extend the lifespan of power supplies and other components. In addition to using 80 Plus certified power supplies, right-sized power supplies for the system's needs, properly ventilated power supplies and the usage of power supplies that support power management features such as sleep mode and hibernation (Prasad *et al.,* 2022), are important
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d) **Displays**: Displays emit heat directly into devices, and this increases energy consumption. Making use of LED displays which are energy-efficient and produce less heat is a good way to reduce environmental impact (Karuppusamy & Parimala, 2017). It is important to use displays that are the right size for the task at hand. Also important is reducing the brightness of displays, turning off displays when they are not in use, using energy-saving display setting and purchasing displays with Energy Star certification (Pise, 2016).

GREEN ICT IN INSTITUTIONS OF HIGHER LEARNING: GLOBAL OVERVIEW

Green ICT and sustainability are a top global priority, calling for transformative changes in how we use ICT to protect the environment and make ICT itself more sustainable. Higher learning institutions are warning and teaching societies about environmental issues, and also preparing them to use ICT in an environmentally friendly way (Samoei *et al.,* 2021). Green ICT in European higher education institutions is a multi-faceted approach that combines technology, responsible user behaviour, and a commitment to sustainability (Gorski *et al.,* 2023). This holistic approach fosters a more environmentally friendly future for universities and the communities they serve. Their approach goes beyond simply deploying energy-efficient technology. They, instead, have adopted a comprehensive framework that combines three key elements: energy-efficient infrastructure, responsible user behaviour and strong policy framework that sets targets and regulations for sustainable ICT practices (Gorski *et al.,* 2023). The United Kingdom has emerged as a trailblazer in promoting green ICT. This is spearheaded by government-led policies and a strong emphasis on incorporating green ICT practices within UK universities (Islam *et al.,* 2020). UK higher education institutions have shown a significant increase in their focus on green ICT practices, reflecting a growing awareness of the environmental impact of ICT. It is also noted that the UK higher education institutions have been committed to developing green ICT practices for printing, such as reducing consumable usage and waste, and with respect to individual computer usage. In a collective effort to adopt green ICT practices, Dutch higher education institutions have established a community of over 300 members that provides encouragement and assistance to universities in addressing environmental issues related to ICT (Hankel *et al.,* 2019). They are also adopting a comprehensive set of green ICT practices encompassing mobile workspaces, flexible office and classroom configurations, distance learning and teaching approaches, and measures to minimise student commuting. Studies by Asabere *et al.* (2016) and Muranganwa (2023) suggest that the uptake and readiness for green ICT initiatives in Sub-Saharan higher education institutions is still lagging behind. A 2016 global ranking of universities examined carbon footprints and found that only five of the 400 African universities ranked are implementing environmentally sustainable policies to combat climate change (Samoei, 2016).

A BRIEF OVERVIEW OF IT IN ZIMBABWEAN HIGHER EDUCATION LEARNING INSTITUTIONS

Zimbabwean higher education learning institutions are increasingly adopting green ICT practices in an effort to reduce IT environmental impact and reduce costs. Maphosa (2022) points out that the 21st Century has seen a surge in the adoption of Information and Communication Technology (ICT) by universities, driven by a desire to automate processes and support technology-based learning. This has led to a growing demand for data centre infrastructure to run applications and store data. Virtualisation is one the concepts that universities have adopted. This involves consolidating multiple servers into a single physical server, which can reduce energy consumption. Giyane *et al.* (2015) postulate that institutions of higher learning have also adopted cloud computing, which involves storing data and applications on remote servers. This can reduce the need for on-campus IT infrastructure and save energy. Dzobo *et al.* (2020) point out that the usage of energy-efficient devices in Zimbabwe is still very new and very low. They further explain that this was aggravated by the lack of practical studies at institutions of higher learning to provide continuous professional development courses in this fields. Energy-efficient devices involve purchasing energy-efficient computers, monitors and other ICT devices. A study of a survey of 17 higher education institutions in Zimbabwe carried out by Maphosa *et al.* (2020) reveals that most participants were unaware of the national e-waste policy. Despite being aware of the harmful effects of e-waste, over half of the institutions did not have formal e-waste policies in place. All institutions reported storing obsolete equipment for a period before disposing of it through auctions to staff and the public, with some e-waste ending up in landfills. More than half of the institutions disposed of e-waste as regular garbage, while only a tenth recycled it, and one institution used e-waste collectors. The institutions' preference for replacing obsolete electrical equipment, with over 80% choosing replacement over repair, contributed to the e-waste problem.

Dey (2022) highlights that the outbreak of Covid-19 incidentally compelled all institutions of higher learning in Zimbabwe to embrace digitalisation in most of the institutional services. The institutions have adopted e-learning, institutional email, online library systems and information systems. These initiatives have primarily addressed the facilitative aspects of green ICT,

with less emphasis on its direct and measurable environmental benefits. The current implementation of sustainable green ICT in institutions of higher learning underscores the need for a more comprehensive and integrated approach that encompasses all aspects of ICT infrastructure and usage (Iyer-Raniga *et al.,* 2021; Caeiro *et al.,* 2020; Junior *et al.,* 2020). Considering the prevailing context, it is imperative to assess the impact of green ICT on sustainable environments and understand the perspectives of key stakeholders on the adoption of green ICT and sustainable practices in higher education institutions. This evaluation would provide valuable guidance for decision-makers in such institutions to develop a comprehensive framework for implementing green ICT policies. Green ICT should be a top priority for both hardware and software producers and users alike (Radu, 2016; Vermesan *et al.,* 2022). Companies can stimulate demand for less harmful products by playing a key role in the after-sales stages. This entails fostering resource optimisation, minimising material usage, curbing e-waste production, amplifying recycling initiatives and mitigating carbon dioxide (CO2) emissions. Furthermore, it is noted that in Zimbabwe, electricity from the national grid is inadequate and erratic (Mhaka *et al.,* 2020; Government of Zimbabwe, 2015). As a result, institutions of higher learning are seeking alternative power solutions to meet their energy demands. The most common alternative power source is diesel-powered generating sets. While the use of clean solar power systems (Shafiullah *et al.,* 2021; Al-Ghussain *et al.,* 2020) holds potential, its practicality is, however, limited by the significant financial burden of installation and upkeep.

LOCAL, LEGAL AND POLICY PROVISIONS AND PRACTICES ON GREEN ICT IN ZIMBABWE

The United Nations Sustainable Development Goals (SDGs) (UN, 2015) appreciate the crucial role of green implementation in promoting shared prosperity and environmental sustainability. Zimbabwe has integrated the SDGs into its national development plans and has taken concrete steps to embrace environmental sustainability. Several Acts with legal provisions regarding green ICT have been put in place. Zimbabwe has developed a National Green ICT Strategy (NGICS) to guide the implementation of green ICT initiatives. The NGICS outlines a comprehensive framework for promoting sustainable ICT practices, including energy efficiency, e-waste management and the use of ICTs for environmental monitoring and

management. The Environmental Management Act (2000) also provides a comprehensive framework for managing the environment, including the prevention of pollution and the conservation of natural resources. The Environmental Management Agency (EMA) also includes specific provisions for the regulation of electronic waste (e-waste). Key provisions of EMA which are relevant to green ICT include the prohibition of the influx of discarded electronic waste into Zimbabwe, the obligation to dispose of e-waste responsibly, and the establishment of an environmental management fund to finance the activities of EMA. The Postal and Telecommunications Act (1998) includes a number of provisions that are relevant to green ICT, such as:

1. the requirement for telecommunications operators to develop and implement environmental management systems.
2. the promotion of the use of energy-efficient telecommunications equipment and the encouragement of the development and deployment of ICT applications that promote sustainable practices.

Government has also put in place policies which fully support green ICT. The National ICT Policy (2015) outlines the government's vision for the development of the ICT sector in Zimbabwe. The policy is geared towards promoting the adoption of green ICT practices to reduce the environmental footprint of the ICT sector. It also emphasises the promotion of energy-efficient ICT equipment, the development of e-waste management strategies, and the use of ICT applications for environmental monitoring and management. The Green Public Procurement Policy requires government agencies to procure environmentally friendly products and services, including ICT equipment. The policy sets out a number of criteria that government agencies need to consider when making procurement decisions. These comprise the product's energy efficiency, the employment of recycled materials and the product's suitability for recycling.

Some government departments in Zimbabwe have come up with several practices which support green ICT. EMA, for example, has devised a comprehensive national e-waste management strategy in response to the burgeoning e-waste crisis in Zimbabwe. The key components of the

strategy, which outlines a number of measures to be taken to manage e-waste effectively, include:

1. creating e-waste collection centres and establishing e-waste recycling facilities.
2. enhancing public understanding of e-waste hazards (National E-Waste Management Strategy, 2015).

Telecommunication operators have come up with some green initiatives that include the use of energy-efficient equipment such as base stations that use renewable energy sources, the implementation of telecommuting programmes which can reduce the amount of energy used for transportation, and the development of mobile applications that promote sustainable practices such as applications that encourage the use of public transportation or provide information about recycling programmes (POTRAZ, 2022). It is in this context that all IHLs should implement these practices and adhere to the policy guidelines and provisions. This will enable greening strategies to be universal across institutions of higher learning, as well as countries. If greening strategies are implemented, institutions without adequate computers, or those without any at all, should not reject donated old computers with short lifespans remaining, especially if the institutions are equipped with adequate knowledge on how to recycle them rather than dispose of them through burning or landfill.

EFFECTS OF ADOPTING GREEN ICT

Research carried out by Marques (2019) points out that the ICT impact analysis framework has documented the diverse environmental effects of ICT. These can be divided into three tiers: immediate or primary effects, secondary or consequential effects, and tertiary or transformative effects (Radu, 2016; Samoei, 2016; Bieser *et al.,* 2018; Prasad *et al.,* 2022; Latif *et al.,* 2023).

a) **Immediate or Direct Effects**: These effects are attributable to the physical presence of ICT equipment throughout its lifespan, encompassing its production, utilisation, recycling and disposal phases. These are the immediate environmental benefits of using ICT, such as reduced energy consumption, reduced emissions and reduced waste (Radu, 2016; Samoei, 2016; Bieser *et al.,* 2018; Prasad

et al., 2022; Latif *et al.,* 2023). For instance, using a laptop computer instead of a desktop computer can save energy and reduce greenhouse gas emissions.

b) **Consequential or Enabling Effects**: These are the indirect environmental benefits of ICT, such as enabling new ways of working and communicating that can reduce travel and other environmentally harmful activities (Radu, 2016; Samoei, 2016; Bieser *et al.,* 2018; Prasad *et al.,* 2022; Latif *et al.,* 2023). For example, video conferencing can reduce the need for business travel.

c) **Transformative or Systematic Effects**: These are the negative environmental impacts that can occur when ICT is used to increase economic activity or productivity (Radu, 2016; Samoei, 2016; Bieser *et al.,* 2018; Prasad *et al*., 2022; Latif *et al.,* 2023). For example, if ICT is used to increase the production and consumption of goods, this can lead to increased greenhouse gas emissions and other environmental problems.

PERCEPTION AND ATTITUDES OF STAKEHOLDERS ON GREEN ICT IN INSTITUTIONS OF HIGHER LEARNING

In the context of institutions of higher learning (IHLs), stakeholders such as administrators, faculty, staff, students and external stakeholders encompass a broad range of individuals and groups with varying interests and perspectives on green ICT. IHLs administrators play a crucial role in overseeing the implementation and adoption of green ICT practices within institutions. Their perceptions and attitudes towards green ICT can significantly influence the success of green ICT initiatives. Faculty and staff are the backbone of IHLs, therefore their engagement with green ICT practices is essential for achieving sustainability goals. Their perceptions and attitudes can be influenced by factors such as awareness, training and perceived impact on their work (Kyle *et al.,* 2022). Students are the primary beneficiaries of IHLs, and their engagement with green ICT practices can promote a culture of sustainability beyond the institution. A study carried out by Dagiliūtė *et al.* (2018) also indicates that with their large numbers and enthusiasm, students are a crucial stakeholder group at universities and could make a significant impact on sustainability efforts. Their perceptions and attitudes can be shaped by factors such as

environmental awareness, personal values and perceived benefits. This also concurs with Maphosa (2021) who points out that institutions should establish e-waste clubs to foster a culture of awareness, knowledge and positive attitudes towards e-waste management. This will enable the curbing of major obstacles to effective e-waste management such as lack of awareness and absence of policies and collection points, and also enhance recycling facilities. External stakeholders such as government agencies, industry partners and community members can play a supportive role in promoting green ICT adoption within IHLs. Their perceptions and attitudes can influence policy decisions, funding opportunities and collaborations. Findings from a study by Maphosa (2021) urge policymakers to formulate comprehensive e-waste policies and foster a robust e-waste value chain to ensure the long-term sustainability of e-waste management.

Research has shown that perceptions and attitudes towards green ICT vary among stakeholders in IHLs. Those with positive perceptions and attitudes perceive it to have some environmental benefits such as reduced energy consumption, reduced greenhouse gas emissions and reduced e-waste generation. Green ICT practices can lead to cost savings in terms of energy bills, maintenance expenses and disposal costs. An institution that embraces green ICT enhances its image and reputation as a leader in sustainability. There are some educational opportunities associated with green ICT. A study conducted by Wang *et al.* (2020) advocates for a shift in higher education away from centralised decision-making and towards a more decentralised approach that empowers students, staff and faculty to contribute to sustainable planning and decision-making. Additionally, public universities should integrate more sustainability-related content into their curricula and academic projects. Research conducted by Boca *et al.* (2019) corroborates that there is a positive correlation between perceptions, attitudes and behaviours of stakeholders.

CHALLENGES OF IMPLEMENTING GREEN ICT

As highlighted by various studies, the adoption of green ICT presents certain challenges and concerns. Implementing green ICT initiatives may necessitate significant initial investments in new technologies and infrastructure, especially in the case of IHLs which have limited infrastructure for recycling ICT equipment (Alhanouf & Abdul, 2020).

Moreover, stakeholders may lack the necessary knowledge and expertise in green ICT technologies and practices (Alhanouf & Abdul, 2020). Research has shown that staff and students may be unaware of the environmental impacts of ICT and the importance of green ICT practices. In addition, the need to modify existing practices and habits may encounter resistance and reluctance to embrace green ICT. The Government of Zimbabwean has not yet developed comprehensive policies to promote green ICT practices (Maphosa, 2022). Macherera *et al.* (2023) point out that the importation of e-waste is not regulated at ports of entry. Disposal of obsolete ICT equipment can be done through auctioning, tendering, donation, destruction or burying (Government of Zimbabwe, 2017; Government of Zimbabwe, 2019). Furthermore, virtualisation and cloud computing can be implemented for efficient use of energy, although Kumar *et al.* (2018) point out that this has a huge impact on security. The major threat with these technologies is that it is not always obvious in which country the data is warehoused and whose security laws and regulations should be applied (Almutairy *et al.,* 2019).

STRATEGIES THAT PROMOTE GREEN ICT PRACTICE IN ZIMBABWEAN HIGHER EDUCATION INSTITUTIONS

IHLs can implement various strategies in order to promote positive perceptions towards green ICT. The findings of a research by Ribeiro *et al.* (2021) indicate that sustainable development of dissemination strategies implemented in higher education institutions contributes to approximately 18% of students' proactive engagement in sustainable practices, and 27.7% of their knowledge and understanding of sustainable development concepts. These research findings have shown that stakeholders should be provided with training workshops, seminars and campaigns to raise awareness of green ICT benefits and practices. Stakeholders in institutions of higher learning should be engaged in the planning and implementation of any initiatives to gain their buy-in and support (Shava *et al.,* 2021; Garwe & Thondhlana, 2022). Positive success stories and measurable outcomes of green ICT initiatives should be shared to demonstrate their effectiveness. Institutions should as well collaborate and partner with external stakeholders such as industry experts, government agencies and community organisations to foster knowledge sharing and support (Atlhopheng *et al.,* 2020).

RESEARCH METHODOLOGY

To successfully tackle the research questions and attain the specified objectives of the research, the researchers reviewed relevant literature and conducted in-depth interviews with key stakeholders in Zimbabwean IHLs, who include ICT administrators, faculty and students. This was done in order to achieve a nuanced and exhaustive understanding of the topic being explored. In order to gain a comprehensive understanding of the current state of knowledge, a rigorous review of literature published from 2015 to 2023 in both developed and developing nations was conducted. The research made use of a diverse selection of electronic databases including Google Scholar, Scopus, Science Direct, Elsevier, Springer Link, ACM Digital Library and IEEE Xplore Digital Library. This review followed steps guided by Kitchenham's (2004) procedures, namely, search strategy, study selection (inclusion/exclusion criteria), study eligibility and quality assessment. Previously published peer-reviewed articles were reviewed based on titles and abstracts. The search terms used were 'green ICT', 'sustainability' and 'higher education institutions'. The documents were purposively sampled based on the basis that they contain rich and authentic information of the issue under study (Collingridge & Gantt, 2019). This approach brought about the need for the researchers to organise, synthesise, account for and interpret the data. Collected qualitative data was also analysed according to emerging themes.

FINDINGS AND DISCUSSION

Information and Communication Technology (ICT) has become indispensable in institutions of higher learning in Zimbabwe. Although ICT offers numerous benefits for teaching, learning and research, it, however, also contributes to environmental impacts associated with energy consumption, e-waste generation and resource utilisation.

CURRENT STATUS OF GREEN ICT ADOPTION IN ZIMBABWEAN IHLS

In order to establish whether key stakeholders have knowledge about green ICT and what is being done in IHLs, one of the objectives of this study was to establish the current status of green ICT adoption in Zimbabwean IHLs. The study also sought to determine if participants understand green ICT and how best to create sustainable environments. The interview questions sought to find out if participants could outline best practices for green ICT. It emerged from the collected data from

universities and teachers' colleges that most of the participants were aware of some practices, though they seemed not to understand the reasons behind doing such. In regard to the status of adoption of green ICT, participants in one institution pointed out that they are not allowed to dispose of computer consumables such as toner cartridges in bins, but that they are expected to keep them safely. At the end of each month, the Information Technology Services (ITS) Department collects them. On further probing why they are required to keep the used cartridges, the users could not provide a reason for that. This is consistent with the research carried out by Maphosa (2022) which suggests that while the disposal of equipment poses environmental risks, his study's quantitative findings indicate that end-users have varying degrees of awareness about this issue. This, therefore, clearly depicts that there is an awareness gap on the disposal of ICT equipment. The users also revealed that in each office or computer lab, a notice is affixed which compels them to switch off all ICT gadgets when not in use. It was also mentioned that one block of computer labs, if fully powered by solar panels, could be a clean and uninterrupted source of energy for the institution.

The above findings indicate that although the adoption of green ICT in Zimbabwean IHLs is still in its infancy, there is growing interest and commitment to promoting sustainable practices in the ICT sector. Government has also provided several Acts and policies that provide guidelines, provisions and best practices of green ICT, and some IHLs have already implemented some initiatives to reduce the negative environmental impact. For instance, some institutions like the Manicaland State University of Applied Sciences have installed solar panels on several of their buildings to power their ICT infrastructure, the National University of Science and Technology, among others, has implemented a paperless admissions process, and Chinhoyi University of Technology has established a green ICT committee to oversee the implementation of green ICT practices across the institution.

A 2022 study by the Zimbabwe Information and Communications Technology (ICT) Regulatory Authority (POTRAZ) indicates that 60% of IHLs in Zimbabwe have implemented at least one green ICT initiative. A key initiative is the widespread adoption of energy-efficient equipment (35%), the installation of solar panels (25%), and the implementation of

e-waste management programmes (20%). IHLs generate a significant amount of e-waste from their ICT equipment, which is often disposed of improperly. Maphosa (2022) notes that in developing nations, outdated ICT equipment is carelessly disposed of in landfills alongside general waste. The quest for valuable metals often drives individuals to employ rudimentary techniques such as heating, burning and leaching, leading to a cascade of environmental and health hazards. While the disposal of ICT equipment through auctioning procedures may appear to be well-intentioned, it can have significant negative environmental consequences owing to the contribution of computers to e-waste. Anyone can acquire the used ICT products for personal use. Consequently, some users only utilise a portion of the purchased product, discarding the rest in environmentally harmful ways. This practice hinders monitoring the end-of-life disposal of the item.

Despite the advancements made, the integration of green ICT in Zimbabwean IHLs encounters several unresolved obstacles that impede its widespread adoption. Of note is that IHLs are failing to adhere to the provisions and guidelines in policy documents. The widespread adoption of green ICT in Zimbabwean IHLs is impeded by several factors, including the high upfront costs of green ICT equipment, a lack of awareness and appreciation of its benefits, inadequate government support, and a shortage of skilled professionals to drive green ICT initiatives. There is need for IHLs to work together to share best practices and develop innovative solutions. There is also need to engage with government and industry to set up campaign teams which will monitor and audit the extent to which each IHL has adopted the green ICT initiatives.

PERCEPTIONS AND ATTITUDES TOWARDS GREEN ICT IN INSTITUTIONS OF HIGHER LEARNING

The participants were also requested to give their perceptions and attitudes towards green ICT, and these were noted to be varying widely. From the online interviews conducted, some institutions are at the forefront of green ICT adoption, while others are still in the early stages of developing and implementing green ICT policies and practices. Participants pointed out that the adoption of green ICT yields positive benefits for environmental sustainability, which include reduced environmental impact, cost saving through the use of virtualisation and cloud computing of data

centres, improved health and well-being and enhanced reputation. This is in tandem with Geeta (2019) who vows that virtualisation is a key initiative to green computing which could reduce energy consumption, e-waste and greenhouse gas emissions. However, some participants have negative perceptions about green ICT. They pointed out that green ICT practices may not only require high initial investment in new equipment and technologies, but that they can also be complex to implement and manage. It was also noted that some IHLs lack the expertise to implement and manage green ICT practices, as well as adequate government support for green ICT adoption. This tallies with research carried out by Junior *et al.* (2020) who posit that green ICT is about managers taking actions and making informed decisions to create a more sustainable ICT environment. This also concurs with research studies by Shava *et al.* (2021) and Garwe *et al.* (2022) who emphasise that it is the duty of management to inculcate a spirit of green ICT through the provision of training workshops incentives, awareness campaigns and partnering with external stakeholders.

FACTORS INFLUENCING THE ADOPTION OF GREEN ICT PRACTICES IN ZIMBABWE'S HIGHER LEARNING INSTITUTIONS

From the literature reviewed and data collected from interviews, there is evidence of a constellation of factors that shape the adoption of green ICT in institutions of higher learning. These factors can be classified as institutional, financial, technical and social factors. Institutional factors involve senior leadership commitment to environmental sustainability through ICT. When leaders prioritise sustainability and provide the necessary resources, it creates a culture of environmental responsibility within the institution. Junior *et al.* (2020) similarly emphasise that green ICT entails proactive managerial actions and informed decision-making to establish a more sustainable ICT infrastructure. Policies and procedures also have a bearing on the adoption of green ICT. Clear and comprehensive policies on green ICT procurement, usage and disposal are essential to guide decision-making and ensure consistent implementation across the institution. Government has policies and guidelines in place with relevant information regarding green ICT (National ICT Policy, Green Procurement Policy, Environmental Management Agency [EMA]. There is need for higher learning institutions to enforce these policies and guidelines. Fostering awareness among faculty, staff and students about ICT's ecological impact and the benefits of embracing

green ICT solutions is crucial for encouraging behavioural change. Regular training programmes can equip individuals with the knowledge and skills to adopt sustainable ICT habits.

It was also noted that financial factors have an influence on green ICT. The upfront costs of green ICT hardware and software can be a barrier to its adoption. However, institutions should consider the long-term financial benefits, such as reduced energy consumption and maintenance costs. Government should make available access to grants, subsidies or other financial incentives as this can significantly encourage institutions to invest in green ICT initiatives. In order to make sound financial decisions regarding green ICT adoption, institutions should conduct detailed cost-benefit analyses that encompass both initial investments and potential cost reductions over time (Shuja *et al.,* 2017).

Technical factors also influence the adoption of green ICT. The existing ICT infrastructure may not be readily compatible with green technologies, as it may require upgrades or modifications. Institutions should therefore assess their infrastructure needs and plan accordingly. Implementing and maintaining green ICT solutions often requires specialised technical knowledge. Institutions may need to hire or train staff with expertise in green ICT technologies. Participants postulated that the availability of green ICT solutions in the Zimbabwean market may be limited. For this reason, it is important for institutions to research and identify vendors that can provide the necessary hardware, software and services.

Social factors such as public perceptions, collaboration, knowledge sharing and cultural norms also influence the adoption of green ICT. The growing public demand for sustainable practices can pressure institutions to adopt green ICT initiatives to enhance their reputation and attract students and faculty who value environmental responsibility. Participants also pointed out that there is need for institutions to share experiences and best practices with other institutions and organisations as this can accelerate the adoption of green ICT practices and provide valuable insights for overcoming challenges. This concurs with research that notes, with concern, the lack of a holistic approach in the implementation of sustainable green ICT in institutions of higher learning (Iyer-Raniga *et al*.,

2021; Caeiro *et al.,* 2020; Junior *et al.,* 2020). Lastly, cultural norms within the Zimbabwean higher education context may influence the acceptance and adoption of green ICT practices. It is therefore necessary that institutions should tailor their strategies to align with local cultural values and traditions and develop a holistic approach in addressing greening strategies in institutions of higher learning.

CHALLENGES OF IMPLEMENTING GREEN ICT IN INSTITUTIONS OF HIGHER LEARNING IN ZIMBABWE

Implementing green ICT in institutions of higher learning in Zimbabwe faces a number of challenges, including lack of awareness where many staff members and students are unaware of the environmental impacts of ICT and the importance of green ICT practices. Institutions of higher learning lack resources to invest in energy-efficient ICT hardware and software, renewable energy sources and other green ICT initiatives. It was also noted that these institutions have limited infrastructure for recycling ICT equipment. Participants also noted that there is a culture of paper-based administration in many Zimbabwean institutions, which can make it difficult to implement paperless processes.

It was also noted that government has not yet developed comprehensive policies to promote green ICT practices, a concern also expressed by Maphosa (2022). Additionally, Macherera *et al.* (2023) have observed that the importation of e-waste is not regulated at ports of entry. Participants emphasised the bureaucratic challenges faced by government offices in deeming items obsolete, necessitating a lengthy and intricate process before disposal. The disposal can be through auctioning, tendering, donation, destruction or burying (Government of Zimbabwe, 2017; Government of Zimbabwe, 2019).

Participants also noted that virtualisation and cloud computing have some security concerns, though their usage would result in efficient energy use. This concurs with Kumar *et al.* (2018) who mention that these two technologies have a huge impact on security. Almutairy *et al.* (2019) additionally explain that a major threat posed by these technologies is that users would not be aware in which country the data is warehoused and whose security laws and regulations have been applied.

STRATEGIES THAT PROMOTE GREEN ICT PRACTICE IN ZIMBABWEAN HIGHER EDUCATION INSTITUTIONS

In the age of digital transformation, ICTs have become an integral part of higher education institutions worldwide (Mohamed *et al.,* 2021; Sych *et al.,* 2021). While ICT plays a crucial role in enhancing teaching, learning and research, it also contributes to environmental impacts associated with energy consumption, e-waste generation and resource utilisation (Ahmed *et al.,* 2021). In Zimbabwe, where higher education institutions are increasingly adopting ICT, implementing green ICT practices is essential to minimise environmental impacts and promote sustainability.

Green ICT encompasses strategies that aim to reduce the environmental footprint of ICT infrastructure, operations and disposal. Implementing green ICT practices in Zimbabwean higher education institutions can bring about numerous benefits. Several strategies can be implemented which include:

a) **Investing in Energy-efficient ICT Hardware and Software**: This will help to reduce the institution's energy consumption, and can be achieved through implementing power management strategies and virtualisation of IT infrastructure. Institutions can significantly lower their energy consumption, leading to cost savings and reduced greenhouse gas emissions. This is consistent with research carried out by Agarwal *et al.* (2015) who note that deployment of online services like online learning, email practices and policies, and telecommuting can reduce carbon footprint.

b) **Properly Disposing of ICT Equipment at the End of Its Life**: This should be done in a way that minimises environmental impact, such as by recycling or donating equipment to charities. Implementing proper e-waste management practices such as take-back schemes and recycling programmes can divert e-waste from landfills and minimise its harmful effects on the environment.

c) **Usage of Renewable Energy Sources to Power ICT Infrastructure**: This can be done through the use of recycled materials. This will further reduce the institution's environmental impact of ICT resource consumption and help to achieve its sustainability goals.

d) **Reducing the Use of Paper and other Consumables**: This can be done by encouraging faculty, staff and students to use electronic documents and by implementing paperless processes. Staff and students should be encouraged to use ICT resources responsibly. This includes turning off computers and other devices when they are not in use, and avoiding unnecessary printing and emailing.

e) **Raising Environmental Awareness**: This involves raising awareness about environmental sustainability, the environmental impacts of ICT, and the importance of green ICT practices among faculty, students and staff, as well as encouraging responsible ICT usage. This can be done through education and training programmes for faculty, staff and students, as well as through public awareness campaigns. There is need to incorporate green ICT principles into the curricula and campus operations.

f) **Developing and Implementing Green ICT Policies and Procedures**: This will provide a clear framework for sustainable ICT practices in the institution. The policy should cover a range of issues such as energy efficiency, e-waste management, and procurement and disposal of ICT equipment and consumables.

Promoting green ICT practices in Zimbabwean higher education institutions requires a comprehensive and collaborative approach among various stakeholders. Policymakers can establish guidelines and incentives for green ICT adoption, while institutions can implement green procurement policies and invest in energy-efficient technologies. Faculty members can integrate green ICT principles into their teaching and research, while students can actively participate in campus sustainability initiatives. It is also necessary for institutions to establish green ICT committees or working groups to oversee the implementation of green ICT practices. Such committees will also be responsible for conducting regular audits of the institution's ICT footprint to identify areas for improvement. Institution can also partner with organisations such as government agencies and private companies to promote green ICT practices. By adopting green ICT practices, Zimbabwean higher education institutions can demonstrate their commitment to environmental sustainability and

contribute to a more sustainable future. By implementing these strategies, these institutions can play a pivotal role in promoting sustainable ICT practices and building a more sustainable future. It is also essential to recognise and reward individuals and departments for their contributions to green ICT adoption.

CONCLUSION

Green ICT implementation in institutions of higher learning in Zimbabwe is essential for achieving sustainable development goals. It can help to reduce energy consumption, greenhouse gas emissions, e-waste and the use of hazardous materials. It can also help to conserve natural resources and improve air and water quality. Its implementation has a number of positive effects, including a reduction in the following: energy consumption, greenhouse gas emissions, e-waste and the use of hazardous materials, and operating costs. One more positive is improved institutional reputation. However, institutions of higher learning in Zimbabwe face a number of challenges in implementing green ICT, including a lack of awareness and understanding of the green ICT concepts, resources to invest in green ICT initiatives, infrastructure to support green ICT practices, as well as the existence of cultural barriers that require change. As already mentioned, these can be overcome by adopting a multi-pronged approach.

The following strategies are considered essential in overcoming the challenges of implementing green ICT: raising awareness and understanding of green ICT among staff and students for purposes of promoting sustainable development and building a more sustainable future for students; seeking funding for green ICT initiatives from government agencies, private companies and other organisations; partnering with other organisations to implement green ICT practices; gradually transitioning to paperless processes; and advocating for the development of comprehensive government policies to promote green ICT. Additionally, designing or redesigning of courses or modules on green computing by all institutions of higher learning, as well as projects plugged into existing computing courses, are among the priority strategies.

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