A FRAMEWORK FOR ASSESSING THE IMPACT OF GREEN BUILDING IN THE SOUTH AFRICAN BUILT ENVIRONMENT

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Dissertation submitted in partial fulfilment of the requirements for the degree
Master of Management in Technology and Innovation
at
The Da Vinci Institute for Technology Management

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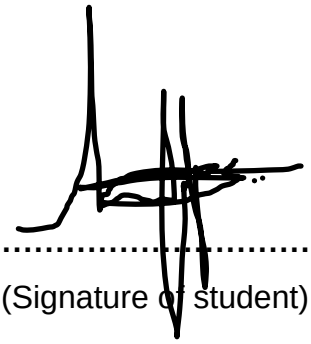
2024

Declaration of Authenticity

I declare that the research project*, Assessment of the Impact of Green Building on Job Creation, Entrepreneurship, Innovation, and Indigenous Knowledge in the South African Built Environment*, is my own work and that each source of information used has been acknowledged by means of a complete reference. This dissertation has not been submitted before for any other university research project, degree or examination.



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08 March 2024

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(City/town of student's residence)

Acknowledgements

The ongoing expansion of created universes permeates all life. Beyond the fabric of the known and unknown interstellar, it is expressed and spreads copiously throughout the ecosystem of nature and our own lives. It comprises our day-to-day lived experiences, in ideas we harvest from the divine supernatural of our Creator, to co-create and bring about innovations for the development of society, take better care of the planet, and facilitate a just and sustainable advancement of the global community of nations.

Through this dissertation, one is honoured to contribute to discovering and co-creating a body of knowledge to make good on our collective task of caring for the planet and its peoples through the Works of Holy Spirit.

In Yeshua HaMashiach, Christ, IMvana, I thank UMDALI YHWH our Creator for blessing me with this enlightened path, tasking Holy Spirit to lead our ancestors and angels to guide me in traversing the journey of life, including the process of writing this dissertation, engaging literature and the labour of others who worked on this area of study before me.

The journey towards achieving this milestone has been a paradox of challenges and fulfilment. It was manageable through the loving support of my whole family and clan. I particularly thank uMaDlamini uGogo Xulu and uMkhulu Xulu, my maternal Grandparents, who support, pray for and guide my life and academic journey in your unique form of leadership development. I equally thank uGogo Lerata, my paternal Grandmother, for your support, prayers, and guidance. I am eternally grateful for your support, ngiyabonga.

Understanding the need for relevant academic output towards socio-economic development of our country and the peoples of Africa, through global leadership, has been critical to traversing this journey. For such mrabulo, one benefited immensely from participating in democratic movements, and being a product of a village of oXulu, naboDlamini, le boLerata. Ngiyanibonga kakhulu!

I gratefully thank my wife, Boitumelo Dlamini, and our blessed, beautiful, intelligent children, Kamogelo and Remoabetswe for your incredible support. I give thanks and gratitude to my parents, uPhakanyisiwe Pikoli benoThemba Dlamini for your encouragement and keen interest in my work. Thank you to Sindisiwe Xulu for her mentorship role. I give thanks to all my siblings, and acknowledge the roles and prayers of Mdu Xulu, Nombuso Xulu, Andile Xulu, Dolly Xulu, Khosi Lerata, Zinhle Dlamini, Thabisile Lerata, Mondli Pikoli, Duke Pikoli, Tholi Ngcobo, Ntoko Ngcobo, Dolly Mkhize, Mastros Xulu, Khayo Lerata, Qhwe Lerata, Themba Xulu, Bra Molf Molefe, Ndugu, Thabiso Xulu, and Senzo Xulu. Ngiyabonga. I also give thanks to Pinkie Modisane, Lisa Reynolds and Wendy Jali for your respective support.

It is fitting to also appreciate the pastors, traditional healers and iSanusi with whom I consulted on this topic, engaging the physical and metaphysical works of our Creator in the ecosystem of nature and society, chaperoned by Holy Spirit. Understanding the role of indigenous knowledge in technological advancements, innovation, buildings, societal development, and environmental preservation has been invaluable. In line with tradition, these knowledge workers and healers are not thanked directly, as thanks is given to our Creator.

One registers heartfelt gratitude to the Department of Public Works & Infrastructure, the Government of South Africa, and the built environment as a sector for their dedication to skills development of professionals, and to the realisation of the United Nations Sustainable Development Goals and a just, green economy.

I thank my academic supervisor, Prof. Mahachi for all the support throughout this research work, including the Da Vinci Business School and its staff, past and present, for co-creating an enabling environment to nurture global leadership in the management of technology and innovation.

Lastly, one would like to thank colleagues and organisations in the built environment and resource efficiency sector, for taking their valuable time to respond to this research questionnaire, and giving views based on their lived experiences as professionals, business owners, and project managers in the sector. One hopes that the outcomes of this study will contribute to our collective work towards achieving an uptake on green building, backing a shared green economy and sustainable development.

Abstract

This study examines the role of green building in the built industry, focusing on the Department of Public Works & Infrastructure (DPWI) and the Public Works Green Building Policy (2018) of the Republic of South Africa. The research assesses practices in the built industry in South Africa, focusing on resource efficiency, energy efficiency, water efficiency, and renewable energy interventions. The study also examines global, regional and local trends in the application and use of sustainable technologies and innovation in the built industry, including indigenous knowledge.

The study was conducted using the positivist research paradigm. The quantitative method is used to collect, measure, and analyse data, examining relationships between and among variables. The population size for the study was 96 employees officially assigned with responsibilities of designing, constructing, maintaining, and operating buildings in South Africa under the custodianship of DPWI. The primary data collection tool used in the study was a questionnaire.

The findings show that the implementation of the Green Building policy of the Department of Works of South Africa has led to an increased implementation of Green Building projects and the use of green technologies, leading to skills development, green jobs, enterprise development and localisation. However, not all projects in the South African built industry have implemented Green Building principles, suggesting that the sector has not fully realised its full potential.

The study recommends that an implementation framework be adopted, with key pillars for consideration in each project to support both socio-economic imperatives and project sustainability. Further research is recommended to assess the industrialisation and localisation supporting prescripts, which are focused on funding, as an enabler of sustainable Green Building related industries in South Africa.

Key words: Green building; Green policy; efficiency; renewable energy; water efficiency; indigenous knowledge; technology & innovation.

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CHAPTER ONE

INTRODUCTION

1.1. Introduction

This study assesses the existing body of knowledge, prescripts, and programmes encompassing Green Building. It investigates the effects of Green Building, as a sector and paradigm, on the creation of jobs, entrepreneurship, innovation, and indigenous knowledge in South Africa's built environment. The study therefore investigates the sector's developmental contribution at a socio-economic level, focusing on the identified areas of contribution towards the realisation of a broader green economy in South Africa.

The researcher is of the view that, in line with the established principles of Just Transitions, a concept which for over 24 years been described in various ways, including being described as a concept that centres on managing how labour and income distribution are affected by the migration from fossil fuels and unsustainable materials (Garcia-Garcia, Carpintero, and Buendia, 2020). Green Building is an essential part of sustainability, Just Transitions, and socio-economic development, which cannot be ignored in organisational strategic planning processes and building project scoping by government and industry, both locally and internationally (Garcia-Garcia *et al*., 2020) in order to maintain competitiveness, relevance, and societal acceptance. It is noteworthy that there has been no less than five themes around which the concept of Just Transitions has been discussed, namely : (1) just transition as a labor-oriented concept, (2) just transition as an integrated framework for justice, (3) just transition as a theory of socio-technical transition, (4) just transition as a governance strategy, and (5) just transition as public perception (Wang & Lo, 2021).

Accordingly, the author argues throughout recent history suggestions have been made that through the use of innovative technologies and varied indigenous methods, the construction of buildings and infrastructure has a significant potential to increase sustainability principles with local socio-economic relevance (Leza, 2020), such as the potential use of indigenous practices for low-cost mass housing construction (Odebiyi *et al*., 2010). Existing examples include sites such as the old Cairo districts, where a historic building was done with great

respect to the climatic conditions of their environment while maintaining the unique value of their indigenous architectural style (Saleh & Saied, 2017).

It has also been a modern historic view that, given the fact that infrastructure development is the pillar of economic growth and livelihoods, both economic and social infrastructure should be reimagined through green competency to rethink economic prosperity (Khoshnava, Rostami, Zin, Kamyab, Majid, Yousefpour & Mardani, 2020). Ensuring that a shared economic development is a key pillar of green economic prosperity.

The researcher holds a view that this research-backed proposition is certainly relevant to South African material conditions; and therefore, suggests that this green building and resource efficiency approach is essential to contributing towards a green economy and socio-economic development in the country.

This further serves as an essential contributor towards demonstrating the achievability of a number of United Nations Sustainable Development Goals (SDGs), given that there are several meaningful connections between green building, green economy and socio-economic development. For instance, energy and water efficiency and Renewable Energy create linkages between Green Infrastructure (GI) and Green Economy (GE) on the one end, to deliver rewards and influences in the social, environmental and economic pillars of SDGs on the other end. These key elements are vital for the sustenance of the economy especially with South Africa experiencing its worst energy crisis.

Accordingly, the researcher argues that the concept and practice of Sustainable or Green Building addresses various SDGs with similarities, such as Goal 10: Reduce inequality within and amongst countries (social), and Goal 7: Affordable and Clean Energy (social and environmental), and Goal 9: Industry, Innovation and Infrastructure (Khoshnava *et al*., 2020).

As an integral part of Green Building, understanding the role of innovation in the rollout of water and energy efficiency, waste management, renewable energy generation, sustainable building technologies, and broader resource efficiency presents unique opportunities to meet sustainable and inclusive socio-economic development imperatives. These are specific to employment and job creation, local manufacturing, enterprise and skills development (Habiyaremye, King & Tregenna, 2022). South Africa’s dire need for additional

energy sources and efficiency measures in water and energy demand-side serve as an excellent opportunity for this level of socio-economic development.

Contribution to socio-economic development is critical given that these resource efficiency measures emanate from green growth policies, which encourage sustainability investment to concurrently contribute to the economic recovery in the short term, and achieve infrastructure for a country's green economy in the mid-to-long term (Ferreira *et al.*, 2023. Machiba, 2011). The following section assesses the paradigm of sustainable development, particularly Green Building, specific to how other researchers have viewed the sector's potential as a contributor to the realisation of socio-economic development.

1.2. Background to the study

Assessing the history of the narrative, according to Irurah and Boshof (2003:244), "In the 1950s to 1970s the environmental movement coalesced after almost a century of isolated pronouncements on resource and environmental degradation arising from exponential population growth as well as increased levels of production and consumption."

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) projected that from 1970 leading up to 2004, global greenhouse gas emissions due to human activities rose by 70 per cent (IPCC, 2007). The global movement on sustainable development has since crystalised its efforts towards ensuring that the global community of nations follows a more sustainable economic development trajectory. This is through the achievement of a greener economy, as a multi-layered concept that extends to all aspects of an economy, such that a shift from a legacy economy to a green economy will affect all economic sectors (Naik, 2021). However, more important is that a green economy impacts employment and trade as sectors of an economy (Naik, 2021). At the sector-specific level, the global movement has seen the emergence of more activism in the building industry, driven by an array of environmental concerns, including the fact that according to the United Nations Environment Programme- Sustainable Building and Climate Initiative, buildings use about 40% of global energy, 40% global resources, and emit approximately one-third of Greenhouse gas emissions (UNEP-SBCI, 2014). Thus, the built environment is one of the sectors of the economy contributing towards the green economy trajectory.

In the South African context, various studies were initiated calling for redress and scaling-up of sustainability initiatives similar to those undertaken by developed countries, within the

local context (Makhado, 2005). The South African government and the sector have an opportunity to scale-up on interventions which will not only enable contribution to the international sustainable building narrative, but also establish relevant sustainable building in line with South Africa's very own socio-economic imperatives.

The South African Government has given the mandate for custodianship of the State property portfolio to the Department of Public Works (DPW), in terms of the Constitution of the Republic of South Africa, 1996 (Act No 8 of 1996). Through this mandate, DPW is tasked, on behalf of the National Government, with providing varied accommodation needs of National Government Departments and related property and construction functions, including acquisition, management, maintenance, and disposal of properties.

The functional mandate of the DPWI is crystalised through two legislative frameworks: "Creating an Enabling Environment for Reconstruction Growth and Development in the Construction Industry - White Paper" (1997) and the "Public Works towards the 21st Century – White Paper" (1997). Amongst others, the objectives of the White Papers stated that the DPW is identify key four areas of activity of the department, namely: public works programmes, property investment, property and facilities management; with the construction White Paper setting a vision to create an enabling environment for enhanced delivery, improved industry performance, and value for money (DPWI, 1997). The two prescripts are currently undergoing a long overdue review and migration process towards a Public Works and Infrastructure Bill.

Among issues covered in this dissertation is a reflection on the potential to utilise indigenous knowledge, models, skills, methods, philosophies, and materials, as applications that assists to acquire and appreciate historical and contemporary technological capability of indigenous communities (Mashiyane, 2023). The researcher appreciates that, for a long period of time, with regard to Sustainable Development, in sub-sectors such as the built environment, and other sectors of the economy, there have been little to no significant initiatives towards coherent sustainability programmes (Irurah & Boshoff, 2003) to support the position and needs of developing countries in particular. Noting the validity of positions that strategies and solutions can be employed to decolonise climate change education and attempted solutions through critical, place-based, participatory, and holistic methodologies (Mbah et al, 2021).

Accordingly, this study goes further to where a research gap is identified by the researcher, to investigate a sector-wide approach to creating a link between Sustainable Building, (referred to hereto as Green Building), and the opportunities of this phenomenon on increased contribution to socio-economic imperatives in South Africa through a structured framework. These socio-economic development areas are job creation, enterprise development, local innovation, and awareness of built environment sustainability knowledge and methods inherent to indigenous communities.

This approach is vital given that the already converted or a small group of experts cannot formulate an effective strategy for green construction in developing countries. Instead, similar to initiatives such as eco-tourism, the understanding and solutions delivered for sustainability require dialogue and participation of various stakeholders, and implementation of integrated stakeholder and collaboration theories with the triple-bottom-line concept (Wondirad et al, 2020), i.e construction industry, different spheres of Government, universities, civil society, communities, research centres, etc.

The United Nations Environment Program (UNEP) gave a definition of an inclusive and equitable green economy “as one that improves human well-being and builds social equity while reducing environmental risks and scarcities. UNEP further states that “an inclusive green economy is an alternative to today's dominant economic model, which exacerbates inequalities, encourages waste, triggers resource scarcities, and generates widespread threats to the environment and human health” (UNEP, 2018). The researcher thus looks into how Green Building can contribute to achieving such a green economy through increased contribution to the identified socio-economic imperatives.

This study also draws from views expressed in the DPWI White Paper, “Creating an Enabling Environment for Reconstruction Growth and Development in the Construction Industry” (1997:1) with regard to the construction industry, which states that “Right at the top of the list of Government’s development priorities is the provision of infrastructure in underdeveloped areas, designed to bring relief to people living there in the form of jobs, linkages to markets, assets that promote economic business development in an integrated and coherent fashion.”

In addition, the study draws from the solution-driven by the National Development Plan 2030 (2011:119) view that: "A large percentage of jobs will be created in domestic-oriented

activities and in the services sector. Some 90% of jobs will be created in small and expanding firms" (NDP, 2011). The researcher argues that whilst the White Paper was developed 27 years ago, the current structural make-up of the South African economy suggests that the views of the DPWI White Paper remain relevant.

Intrinsic to this study, the departmental mandate of the DPW further includes the provision of leadership in the economic growth and transformation of the property and construction industries, collectively referred to as the Built Environment. In this regard, transformation refers to the socio-economic context imperative espoused in the Broad-Based Black Economic Empowerment Act (BBBEE Act 53, 2003:6) "to increase the extent to which communities, workers, and other collective enterprises own and manage existing and new enterprises and access to economic activities, infrastructure, and skills development"

Linked to the historic trajectory which the researcher argues is relevant to understand current challenges, opportunities, and achievements, Makhado (2005) referred to the following definition of Sustainable Development offered by Van der Merwe in 2003: "Sustainable Development is a programme to change the economic development process to ensure that all people get basic quality of life. The process protects the ecosystems and the community systems that make life possible and worthwhile." Given the potential role of green building, as a subset of Sustainable Building in meeting government socio-economic imperatives indicated above and its role in minimising the environmental impact of development (Van Wyk, 2011). The disjuncture in the existence of sustainable building strategies in South Africa and lack of industry-wide implementation of same, incorporating socio-economic imperatives, needs to be addressed. The researcher notes that for over 18 years, the lack of integration with mainstream decision-making systems had been identified as a critical reason for such disjuncture (Du Plessis, 2006).

Considerable strides have however been achieved through private sector initiatives and through the development and implementation of the DPWI Green Building Policy, and the resultant sub-programmes i.e. the Integrated Renewable Energy & Resource Efficiency Programme (iREREP) and Eco-labelling, including advocacy in the sector, with DPWI and its entities, in partnership with sector stakeholders providing leadership (DPWI, 2016).

Part of this leadership entails work done in partnership with the Council for Scientific and Industrial Research (CSIR) in developing the Green Building Framework, commissioned by

the Department of Public Works. This study reiterates a need for South Africa to preserve natural resources and maintain a balance in scarce resources supply and demand Van Wyk (2011).

The UNEP-SBCI Education Policy Guidelines for Sustainable Built Environments (UNEP-SBCI, 2014) further states that globally, buildings as a sector are responsible for up to 30% of our solid waste production and up to 30% of all energy-related greenhouse gas emissions. In order to resolve this situation, a number of countries started to move towards embracing Sustainable Building, noteworthy at a much faster pace than South Africa (Makhado, 2005).

As part of systems thinking, South Africa has a particular challenge due to spatial designs since the apartheid era, which contribute not only to resource inefficiencies but also to social and ecological segregation. Irurah and Boshof (2003) refer to comments by Gelderblom and Kok as far back as 1994 that “South Africa’s cities are segregated and sprawled primarily as a result of racial zoning applied in the apartheid era.” Like other contemporary cities, this design is referred to as non-ecological cities (Irurah & Boshof, 2003).

Given this outlook, the researcher believes that Green Building is firstly a contributor to Climate Change mitigation actions, presenting the highest industry potential for mitigation actions (UNEP, 2011). Secondly, it is an energy and water security measure, as mechanism to usher in considerable levels of efficiency to reduce the demand for energy and water resources. Thirdly, it is an economic development intervention with the potential to significantly contribute to job creation, employment, and Enterprise Development, whilst presenting an opportunity to address the legacy of ecological deficiency of buildings. This is linked to the fact that environmental and economic development can arise from the implementation of the “green economy” as the main vector of sustainable development (Mikhno et al, 2021),

The Green Economy, linked to the Sustainable Development paradigm, is defined by UNEP as “one that improves human well-being and builds social equity while reducing environmental risks and scarcities. Further stating that an inclusive green economy is an alternative to today's dominant economic model, which exacerbates inequalities, encourages waste, triggers resource scarcities, and generates widespread threats to the environment and human health. It is low carbon, resource efficient and socially inclusive” (UNEP, 2018).

In amplifying the linkages of Sustainable Development, Sustainable Building, and the Green Economy as related paradigms, in a paper titled “State of Green Technologies in South Africa” (2014), the Academy of Science of South Africa (ASSAf) refers to Glaser who argued in 2012 that “the green economy should emphasize environmentally sustainable economic progress to foster low-carbon, socially inclusive development and investment in green jobs, clean technologies and green sectors.”

The researcher suggests that South Africa, as an emerging economy, has an increased potential to realise job creation and Enterprise Development in the built industry through Green Building. This is opposed to conventional, greenhouse gas-intensive building practices. Furthermore, it is estimated that redress to industry activities would not necessarily come at a high cost to a specific economy. This is supported by an estimate by the International Panel on Climate Change (IPCC) that the building sector could reduce its emissions by up to 30% at a zero cost or net financial saving to an economy (IPCC, 2014). With significant savings achieved through design, with less cost, as it has been found that the cost-optimal retrofit agrees with the observed market trends (envelope insulation, double-glazed windows, air-to-air heat pumps (HP) and solar thermal collectors), leading to more than 60% reduction in GHG emissions (Panagiotidou et al, 2021).

For example, at the energy consumption level, advances in design practices and know-how, technology, coupled with behavioral changes, can achieve a two to ten-fold reduction in energy requirements of individual new buildings and a two to four-fold reduction for individual existing buildings largely cost-effectively or sometimes even at net negative costs (Lucon *et al.,* 2014).

With all the existing facts, it is acknowledged, however, that given the current industry focus on traditional inefficient building in South Africa, coupled with the earlier observed slow uptake on Sustainable Construction (Makhado, 2010), this potential remains not fully realised by the sector.

As an argument towards its objectives and the potential of Green Building thereto, this dissertation cites various academic publications and industry research presented from varied perspectives on the creation of green jobs, enterprise development, local innovation, and built environment Indigenous Knowledge Systems (IKS). The dissertation presents an

argument for scaling-up Green Building projects towards increasing the sector's contribution to these socio-economic imperatives.

Primarily factors such as social, environmental and economics are part of Sustainable Construction (Makhado, 2010), material conditions necessary for the realisation of a socio-economically relevant Green Building sector for the local built environment will be reflected upon as the basis for establishing a shared green economic growth in South Africa. This is particularly given that a green economy and sustainability are much more than green technology and technical designs to the extent that it involves human well-being, ecological balance, and poverty alleviation (ASSAF, 2014).

One of the international illustrations in creating decisive local relevance in Green Building was through analysis, assessment, and consultation in developing a Green Building assessment tool for Jordan – the SABA Green Building Rating System, which suits the Jordanian context in terms of the environmental, social, and economic perspectives (Ali & Al Nsairat, 2009). Relevance of Sustainable Building and Green Building tools to the local economy, the environment, people's culture and jobs is critical given that, as Ali and Saba (2008:1) observe, "Green Building has now become a flagship of Sustainable Development in this century.

The geographic focus of this dissertation is specific to the South African economy, reflecting on the Green Building sector's potential to establish the required relevance to the local economy, as an enabler and implementer of prescripts aimed at the development and achievement of a shared green economy.

The context for this narrative is drawn from the socio-economic development narratives that shape South Africa's economic trajectory as one of the key economies in the African continent. As indicated in the earlier intercontinental cooperation, these are central to championing infrastructure development for Africa's growth agenda (NEPAD, 2001), emphasising green growth that the built environment could drive.

Similar to the description of a green economy and sustainable development, green growth is described in a paper by the African Development Bank titled "Facilitating Green Growth in Africa", as "the selection of economic activities that, at best, promote environmental and social development and, at a minimum, do not harm the environment or human welfare"

(Sperling, Granoff & Vyas, 2012). The researcher emphasises that the common theme is the requirement for promoting environmental and social development through economic activity.

In suggesting the expansion of the knowledge and skills base that makeup Green Building, Indigenous Knowledge Systems (IKS) are mentioned, given the strategic role of IKS as innovation, practice, and socio-economic proprietary green growth knowledge of indigenous communities. This world view is particularly presented given that various groups across the globe relate to and work with the environment in their own way and practices, unique to the local and indigenous context (Maweu, 2011).

Maweu (2011) refers to the following statement attributed to Berke (2000); “Indigenous Ecological Knowledge (IEK) is a cumulative body of information, beliefs and practices evolving by adaptive processes, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment (including buildings as man-made artifacts using nature).” Indigenous Ecologic Knowledge is a subset of IKS (Maweu, 2011).

Therefore, a study on Green Building's potential to increase the creation of jobs, enterprise development, and local innovation should necessarily also look into the potential role of built environment IKS to contribute to these imperatives.

In gathering data, this study shall engage various stakeholders in the sector in South Africa, such as established and emerging companies, professional councils, project managers, property owners, and institutional customers, i.e., Government Departments, State-owned Entities, to establish the extent of their respective experience on the uptake on Green Building, and its potential contribution to the highlighted socio-economic activities.

The EPWP principles on Job Creation and the International Labour Organisation (ILO) definitions are used to deal with the question of quantifying job creation and defining green jobs. The researcher suggests that predicting potential jobs from green economy activities has taken different projections since 2011 due to changing economic conditions and base assumptions by different studies.

Consequently, green jobs are thus defined as decent jobs that preserve or restore the environment in traditional sectors such as manufacturing and construction or in new, emerging green sectors such as renewable energy and energy efficiency (ILO, 2016).
Regarding the reference to descent jobs, the issue here is addressing the impact of a green economy on employment and working conditions, particularly in emerging and developing countries (Jacob, Quitzow & Baer, 2015). According to Maia and Giordano (2011), the estimated green jobs potential in South Africa for all sectors, including Green Building, are as follows:

Table 1: Estimated Green Jobs Projection for South Africa 2011-2015 (Maia & Giordano, 2011)

Short Term: 2011/12	**Medium-Term:2013/17**	**Long Term: 2018/25**
98 000 New direct jobs	255 000	Almost 462 000

More recent estimations of job creation projections came through the South African Economic Reconstruction and Recovery Plan (ERRP). It provides information on jobs related to the green economy to be created in the very short term between 2022 and 2024:

Table 2: Jobs Projection related to the green economy (ERRP, 2020)

Employment Opportunities	**Projected Jobs Number**
Environmental Programmes	50,000
Facilities maintenance, water and energy efficiency, and construction of rural bridges	1,560
Community Forestry	14,000

However, jobs and skills development aimed to be achieved through a significant rollout of resource efficiency subsets of Green Building over the 30-year programme, inclusive of

ERRP jobs number projected for water and energy efficiency, have been estimated through the Integrated Renewable Energy & Resource Efficiency Programme (IREREP) of the Department of Public Works & Infrastructure as shown below.

The IREREP estimations are as follows:

Table 3: Green Jobs to be created through Green Buildings Subsets (DPWI, 2022)

Intervention	**Estimated Number**
Green Jobs	146,000
Skills Development	117 000

The tables above demonstrate that there is indeed an intention and plans by the Government, backed by research data and commitment, to create a pipeline of green jobs through various interventions.

The dialogues and assessments on green jobs in South Africa promoted by the ILO state that green jobs associated with the green economy, in the context of the built environment, are jobs associated with building, construction and installation. These include operations and maintenance services, resulting in resource efficiency and co-contribution. Creating jobs in the Green Building sector is consistent with the understanding that a green economy should also translate into opportunities for localising manufacturing processes for certain technologies through new or existing capacity (Maia & Giordano, 2011).

This research is premised on the view that Green Building can bolster new and existing capacity in the built environment to contribute to socio-economic imperatives such as creating green jobs, enterprise development, and innovation (UNEP-SBCI, 2014).

At an operational level, this study will look at various Green Building subsets and projects being implemented, such as planning, construction, and maintenance of government buildings and facilities specific to energy and water efficiency, waste management, biodiversity management, indigenous architecture, embedded Renewable Energy generation, and building retrofitting, in general. This aims to look at the potential of each of

these subsets and projects to increase the sector's contribution to identified socio-economic imperatives.

1.3. Research Problem Statement

The South African built industry faces challenges concerning stagnant building industry growth and the ability to create more jobs. This is due to the perceived strict labour laws, slow processes to pay contractors and sub-contractors, high import costs of building materials, project costs overruns, and inefficient funding of projects (Dithebe, Aigbaboa, Oke & Muyambu, 2018). In addition, these challenges include the effects of the recent pandemic, which harmed several sectors, putting a hold on certain investment decisions by clients and resulting in tight profit margins for the sector, including Green Building activity (Musonda & Rakolote, 2022).

Conversely, given these challenges, a paradox is however presented in the sector. Green Building has one of the highest potentials to mitigate greenhouse gas emissions. As part of addressing the sector's massive 40% contribution to greenhouse gas emissions, Green Building also presents a high return on investment for investors (UNEP-SBCI, 2014), thus being an attractive investment decision, particularly for government which has a large property portfolio, including the related resource consumption (DPWI, 2018).

The researcher appreciates that many challenges persist in the residential housing market of the built environment. These are related to finding a balance between eradicating informal settlements and providing energy efficiency measures, considering the escalating cost of building materials (Mahachi, 2019). Although the focus of this paper is largely on the commercial portfolio and the government's particular use of facilities, similarities can be found between this challenge and the government's dilemma of having to address energy and water efficiency, and general Green Building, in old and existing buildings, whilst still navigating through a massive maintenance backlog and related high costs.

Notwithstanding this dichotomy, the sector has a high potential to meet cheaper resource efficiency and greenhouse gas emissions reduction measures (UNEP-SBCI, 2014), presenting a great value proposition for building owners and the local built environment. Through Green Building, the built environment contributes to resolving greenhouse gas emissions during the building and operation of buildings (Irurah & Boshoff, 2003).

The green economy has potential to contribute to economic activity and socio-economic imperatives such as localisation (Maia & Giordano, 2011), presenting an excellent opportunity to create green jobs (ILO, 2014). The contribution of Green Building and its resource efficiency subsets to the South African socio-economic development needs has not been fully structured and institutionalised.

As opposed to its technical proven value proposition, i.e., achievement of 25–30% efficiency improvements having been realised in efficiency projects at costs substantially lower than marginal supply (Lucon *et al.,* 2014), there is still a lack of a pipeline of Green Building and resource efficiency projects being implemented across the country intentionally linked to national socio-economic priorities. Moreover, in contrast to the green economy and sustainability principles, Green Building or resource efficiency projects currently being implemented are not geared to contribute to local socio-economic imperatives.

Given the above, the researcher suggests that there is no sector-wide framework to creating a link between Green Building, and the opportunities of this phenomenon to increased contribution to specific socio-economic imperatives as identified by the researcher, in order to underpin the potential, the sector has for South Africa's socio-economic development, thus potentially leading to an increased uptake.

1.4. Aim and Objectives of the Study

1.4.1. Aim of the Study

The study aims to investigate Green Building in the South African Built Environment and its relationship to Job Creation, Entrepreneurship, Innovation, and indigenous knowledge, focusing on the Department of Public Works and Infrastructure (DPWI) Green Building policy subsets and other related sustainability prescripts applicable to the sector.

1.4.2. Objectives of the Study

The objectives underpinning the study are:

i. To investigate the effect of the Public Works Green Building Policy on increasing Enterprise Development opportunities;

ii. To assess the effects of specific policy subsets, i.e., energy efficiency, integrated waste management, Renewable Energy and Indigenous Knowledge Systems, on contributing to increased job creation; and

iii. To investigate the prioritisation of Green Building projects by government and private companies, including using local content specific to materials, components and smart technologies such as Light Emitting Diode (LED) and Organic Light Emitting Diode (OLED) light bulbs, Renewable Energy, water efficiency, and innovative Green Building Technologies (GBT)/Alternative Building Technologies, among others.

iv. To develop a Green Building Project Framework Hut for implementation of projects.

1.4.3. Research Hypotheses

The presented hypotheses of this study are as follows:

1.4.3.1. Hypothesis One (H1)

H_0: Green Building practices do not have an effect on the use of Green Building Technologies (GBT).
H_1: Green Building practices have a significant positive effect on using Green Building Technologies (GBT).

1.4.3.2. Hypothesis Two (H2)

H_0: Green building practices do not have an effect on compliance with the Department of Public Works & Infrastructure (DPWI) Green Building Policy.
H_1: Green building practices have a significant positive effect on compliance with the DPWI Green Building Policy.

1.4.3.3. Hypothesis Three (H3)

H_0: Green building practices do not have an effect on the contribution to the local economic development.
H_1: Green building practices have a positive effect on the contribution to local economic development.

1.4.3.4. Hypothesis Four (H4)

H_0: The use of Green Building technologies do not have an effect on the contribution to local economic development.
H_1: The use of Green Building technologies have a positive effect on the contribution to local economic development.

1.4.3.5. Hypothesis Five (H5)

H_0: Compliance with the DPWI Green Building Policy does not have an effect on contribution to local economic development.
H_1: Compliance with the DPWI Green Building Policy has a positive effect on contribution to local economic development.

1.4.3.6. Hypothesis Six (H6)

H_0: The use of Green Building Technologies do not have an effect on compliance with the DPWI Green Building Policy.
H_1: The use of Green Building Technologies has a significant positive effect on compliance with the DPWI Green Building Policy.

1.5. Research Philosophy

1.5.1. Introduction

A research philosophy refers to the system of beliefs and assumptions about the development of knowledge (Saunders *et al.*, 2016). The research philosophy adopted contains important assumptions about the way in which the researcher views the world and undertakes investigations. This shapes the research strategy, methods, and expected outcomes.

This research adopts a positivist philosophy to investigate the potential of Green Building to promote employment and industry growth in South Africa (Creswell, 2014). Positivism applies scientific methods to measure and quantify observable phenomena and derive logical conclusions (Collins, 2010). This aligns with examining Green Building's impact on economic indicators like job creation through an objective, value-free lens.

The study adopted quantitative methods consistent with the positivist paradigm, including available statistical data on Green Building projects. Structured surveys were supplemented by the literature review to test hypotheses around Green Building and economic indicators. The goal is to determine relationships that can inform evidence-based policies and predictive models (Creswell, 2014).

While recognising critiques of positivism, this research philosophy is selected for its rigor and generalisability (Mack, 2010). Positivist methods aim to generate impartial, reliable data on Green Building's employment, job creation, and technology localisation effects.

1.5.2. Ontology

Scotland (2012) defines ontology as the nature of reality and what constitutes existence. This notion is supported by Marsh and Furlong (2002) where they posit that ontology examines our assumptions about what is real, the essence of phenomena, and the characteristics of being. Ontology forms the core component of research philosophy, underpinning how knowledge is studied and interpreted.

The researcher takes an objective ontological perspective that recognises the interconnectedness between humanity, the built environment, and the ecology of the natural world. The researcher views Green Building as an opportunity to create a balance between meeting socio-economic imperatives or needs while protecting the environment (du Plessis & Cole, 2011). As realised in recent history, the ontological orientation acknowledges that ethical-epistemological frameworks founded in mutual relationality rather than dualism between humanity and nature, provide a robust foundation from which to address the global environmental crisis, acknowledging their interdependent nature in the ecology of nature and people (O'Connor, 2022).

Furthermore, this research embraces ontological pluralism by recognising the contribution of Indigenous ways of knowing as providing valid, alternative forms of evidence that ought to inform the policymaking process and industry practice, offering unique, substantive insights (Althaus, 2020). The researcher accepts diverse cultural understandings of reality as valid on their own terms.

1.5.3. Epistemology

Epistemology concerns the theory of knowledge, specifically how we can come to know reality (Scotland, 2012). It examines the methods, validity, and scope of acquiring knowledge and constructing meaning about the world (Moon & Blackman, 2014). Epistemology is linked to ontology in forming the philosophical foundation for research.

This research adopts a positivist epistemology that applies scientific methods and empirical analysis to generate objective knowledge about green building's effect on employment and economic growth (Collins, 2010). Positivism asserts that valid, reliable knowledge should be

based on observable, measurable facts rather than subjective perspectives (Scotland, 2012).

Consistent with this epistemology, the research utilised quantitative methods like statistical analysis with hypotheses testing, and structured surveys. The goal is to test hypotheses and reveal relationships through deductive logic, allowing findings to be generalised to broader theory (Creswell, 2014). A representative sample was pursued to support statistical validity. Data was collected and interpreted in a value-free manner to ensure objectivity. While positivist epistemology has limitations in addressing contextual nuance, it provides a means of impartially assessing green building's economic outcomes (Moon & Blackman, 2014).

1.5.4. Axiology

According to Iphofen (2011), axiology examines the role of values and ethics in research. This research adopts an axiology aligned with positivism that prioritises objectivity and value-neutrality. The goal is to gather impartial data to analyse the role of green buildings on South Africans economic indicators (Ponterotto, 2005). An axiology of value-freedom avoids subjective judgments or cultural biases.

However, researchers' values implicitly shape topic selection, methods, and interpretation (Mertens, 2010). While striving for objectivity, subjectivity cannot be fully eliminated. This research acknowledges inevitable researcher bias but utilises rigorous quantitative techniques to minimise it. And while focused on statistical analysis, contextual factors are recognised in interpreting green building's economic indicators.

This research adheres to a positivist axiology that prioritises objectivity and impartiality in the pursuit of truth (Ponterotto, 2005). The aim is to produce value-free evidence to inform green building policies through rigorous quantitative methods (Sale *et al.,* 2002). An axiology of detachment avoids subjective biases and seeks to eliminate external values influencing the research process (Mack, 2010). While positivism has limits, its emphasis on factual data and measurable outcomes aligns with the objectivist ontology underpinning this study (Scotland, 2012). The research upholds an ethic of scientific responsibility but maintains that reliable knowledge derives from empirical evidence rather than cultural values or social aims (Ryan, 2006). The axiological orientation is that valid truth claims require objective proof over normative assessments (Creswell, 2014).

1.6. Justification and Significance of the Study

1.6.1. Justification for the Study

The researcher holds a view that the development of political economies is premised on the availability of local knowledge capacity and skills-set to drive such development.

As a major potential contributor to Climate Change mitigation actions (UNEP-SBCI, 2009), the construction and property sectors, collectively known as the built environment, are looking for innovative processes to increase the economic impact of their annual spend and decrease their environmental impact. However, innovation and knowledge to drive ideas for the sector appear to be imported and not emerging from local knowledge systems with local relevance, which is a concern.

According to the publicly available Department of Public Works (DPW) Annual Performance Plan (APP), a target of 1000 jobs will be created for 2015/16 under Facilities Management, which hosts the Green Building Programme. In addition, the target for Energy Efficiency over the next five years is a 1,6 billion-kilowatt hour (kWh) reduction in electricity consumption and a 23,8 million kilolitre reduction in water consumption (DPW APP, 2015). These figures suggest an urgent need for an innovative approach to Green Building to realise climate change mitigation, energy efficiency, and water efficiency objectives whilst meeting socio-economic imperatives of the South African Government and those of the Department, i.e., Job Creation and Enterprise Development.

To this end, a study is required to assess the contribution of incorporating local, sustainable building knowledge through IKS towards increasing Green Building's ability to increase Job Creation and Enterprise Development for the built environment. This is an area which has not been widely covered by research.

The view of the researcher that the incorporation of Indigenous Knowledge Systems into Green Building has not been widely researched is also historically supported by the Center for Resourceful Building Technology (CRBT, 1995:7): “The knowledge base for some of the unfamiliar techniques and materials has been largely unpublished, requiring research and experimentation on the part of the builder.”

Although the CRBT finding was published 20 years ago, the existence of recent research and global preoccupation with establishing Green Building and energy efficiency suggests that it is most likely that the lack of recognised knowledge on unfamiliar building materials, specific to indigenous materials, is still persistent to date.

One also holds a view, to be covered in the literature review, that IKS in the built environment holds a significant potential to contribute towards social cohesion as it presents an opportunity for cultural exchange, reimaging and innovation around submerged indigenous knowledge.

The researcher thus hereby suggests that a study of this nature is required as it would assist DPW, the researcher's current employer, and the local built environment in up-scaling the implementation of Green Building interventions.

1.6.2. Significance of the Study

The contribution of the built environment in general and Green Building in particular to the South African economy through skills development, enterprise development, job creation, technology, and innovation has the potential to be up-scaled to realise shared green economic growth and development.

After completion of the study, the dissertation will contribute to a broader awareness of Green Building practices and their impact on socio-economic imperatives and development. This significance includes creating an appreciation amongst stakeholders of how Green Building trends further contribute to increasing the country’s input to international sustainable building trajectory through innovation and knowledge sharing.

South Africa has committed to implementing a pipeline of multi-year infrastructure investment projects post the recent pandemic (Ramaphosa, 2021). A number of these projects have the potential to be constructed using Green Building techniques and technologies to achieve sustainability, i.e., Renewable Energy and Alternative Building Technologies. The study provides a better understanding of the contribution of Green Building in current projects. Furthermore, it assesses the potential of Green Building to increase the creation of jobs as green jobs and the use of alternative technologies and innovation. This presents opportunities for local companies to partner with international

companies, therefore creating enterprise development and skills transfer opportunities in the value chain of projects.

Beyond being a potential catalyst for increased job creation and enterprise development, Green Building can facilitate social cohesion and re-emergence of submerged knowledge and skills in the context of the 21st-century socio-economic development imperatives. This could be done by incorporating indigenous knowledge as an essential element of global climate change mitigation and adaptation (IPCC, 2007).

1.6.3. Contribution of the Study

i. **Contribution to DPW Project Managers**: After completion of the study, the researcher will contribute to assisting Project Managers in various DPWI regions and provinces across the country to understand linkages between their current built environment projects and Green Building towards increased implementation of Green Building subsets – as presented in the hypothesis of the study;

ii. **Contribution to the organisation:** The outcome of the study will enable DPW as custodian of the State construction and property functions to realise increased job creation opportunities through the implementation of the Public Works Green Building Policy;

iii. **Contribution to market/society:** The study's outcome will create more opportunities for enterprises in terms of service offering, with an opportunity for up-skilling job seekers with IKS awareness and opportunities for innovation. This includes social cohesion;

iv. **Personal Contribution:** The researcher is of the view that the study will develop knowledge, understanding, and applications of the embedded nature of socio-economic development in the built environment through Green Building. Thus, the growth of Green Building as a profession within the context of a just, green economy and global leadership will be required to meet this imperative.

1.7. Assumptions

The researcher has undertaken the following assumptions:

i. The knowledge and appreciation of the concept of Sustainable Building and Green Building are established in the local built environment;
ii. There is an increased trajectory towards the adoption of alternative sources of energy and other resources in South Africa;
iii. The success of Indigenous Knowledge Systems (IKS) institutional support and development achieved in other sectors, such as the pharmaceutical sector, has the potential to be emulated for the Green Building activities of the built industry;
iv. There is buy-in for new technologies and innovation that drive sustainability in the sector.

1.8 Theoretical Framework

This research draws upon the literature investigating green building as a strategic priority for climate change mitigation and sustainable economic development. The theoretical framework synthesises multidisciplinary perspectives on green building practices, adoption of technologies, integration of indigenous knowledge systems (IKS), policy compliance, and resulting socioeconomic effects.

Thought leaders have examined green building's emergence as a sustainability paradigm (Fuerst & McAllister, 2011), use of technologies and local innovations (Wu *et al*., 2021), incorporation of IKS for ecological and cultural relevance (Leonard *et al.,* 2013), and potential for green job creation and enterprise growth (Maia *et al.,* 2011).

These diverse streams are synthesised to conceptualise green building's capacity to reduce environmental harm from the built environment while catalysing local economic development through job creation, skills transfer, new enterprises, and use of local resources.

1.8.1 Literature Review

This literature review synthesises international, African (continental), and South African perspectives across four key themes relevant to green building and its socioeconomic development indicators:

1.8.1.1 Green Building Emergence and Innovation Trends

Green building has gained prominence as a sustainability paradigm to mitigate climate impacts from the built environment (Darko *et al.,* 2017). It encompasses resource-efficient

design, construction, operation, and maintenance over the full building lifecycle (Fuerst & McAllister, 2011). According to Kibert, (2016), green building incorporates energy/water efficiency, waste reduction and renewable energy to reduce environmental impact of construction.

In addition, Robichaud and Anantatmula (2011) posits that green building rating systems, norms, and project prioritisation drive widespread adoption. Technological innovation is integral to ensuring advancement of any industry, including Green Building with technologies such as LED lighting, solar PV, greywater systems and other solutions that reduce emissions and resource use (Wu *et al.,* 2021). South Africa has pioneered green building adoption in Africa with innovations like renewable water systems, natural lighting and recycled building materials (Van Wyk, 2017).

1.8.1.2 Integration of Indigenous Knowledge Systems

Indigenous knowledge offers lessons for resilience and sustainability, from vernacular construction to regenerative agriculture (Dei, 2002). Integrating indigenous materials and community participation promotes equitable and eco-centric development (Mercer *et al*., 2010). IKS principles of mimicking nature and holistic design can be increasingly revived through materials like rammed earth, passive cooling and community build participation (Kibert, 2016).

1.8.1.3 Green Jobs and Enterprise Development

Green building contributes to job creation, enterprise growth and local manufacturing (Maia *et al*., 2011; IEA, 2020; DPWI, 2022). Opportunities emerge across the value chain, from sustainable construction and retrofitting to renewable energy installation and maintenance (Sperling *et al*., 2012). According to Willis *et al*. (2018), sustainable infrastructure and renewable energy offer opportunities for skills development and new green enterprises. Policy incentives spur new green business models (Dean & McMullen, 2007).

1.8.1.4 Policy Drivers and Government Leadership

South Africa's National Green Building Framework mandates sustainable practices for the public sector (DPW, 2016). Municipal green building guidelines are also emerging (Greyling *et al*., 2016). Compliance with policies like DPWI's green rating requirements catalyses widespread adoption and economic development (Peng *et al*., 2015). Peng et al. (2015) also argues that green mandates and incentives accelerate voluntary action on sustainability and

according to Testa *et al*. (2016), public procurement critically enables the transition by embedding green specifications.

1.8.1.5 Conceptual framework

A conceptual framework represents the key factors, concepts, or variables for a research study and the presumed relationships between them (Miles & Huberman, 1994; Ravitch & Riggan, 2017). It provides an underlying structure mapping out the core elements to be studied and their linkages, situated within theoretical constructs that help explain or predict those relationships (Robson & McCartan, 2016; Jabareen, 2020). Conceptual frameworks evolved iteratively through evidence gathering, analysis and reflection (Jabareen, 2020).
Well-articulated conceptual frameworks define the boundaries, meanings and measures of abstract constructs and their proposed causal relationships (Smyth, 2004). They situate the research within existing knowledge and disciplinary paradigms while allowing for new discoveries that advance theory (Imenda, 2014).

Conceptual frameworks visually depict hypothesised connections between abstract concepts and observable phenomena (Jabareen, 2009). They build on existing theories and empirical evidence to propose a model for testing new hypotheses (Imenda, 2014). An effective conceptual framework clearly defines the variables, boundary conditions, mediators and moderators within the concept relationships (Antwi & Hamza, 2015).

The conceptual framework is developed to examine Green Building practices in the South African context and their connections to technology adoption, policy compliance, and socioeconomic outcomes. Green Building incorporates sustainable design, construction, operation and maintenance of the built environment (Darko *et al.,* 2017). The conceptual framework proposes that increased green building practices influence the use of innovative technologies and compliance with green policies. In turn, technology use and policy compliance enable local economic development through job creation, enterprise development, innovation, and use of local content.

The framework evolved through a review of academic literature on Green Building and its hypothesised relationships to technology, policy, and economic development. Relevant theories, empirical findings, and contextual factors were synthesised to map the concepts and linkages.

The framework was refined through empirical research to clarify relationships between concepts and boundary conditions (Leavy, 2017). Data was used to test and refine the visualised conceptual framework.

1.8.1.6 Developed Conceptual Framework

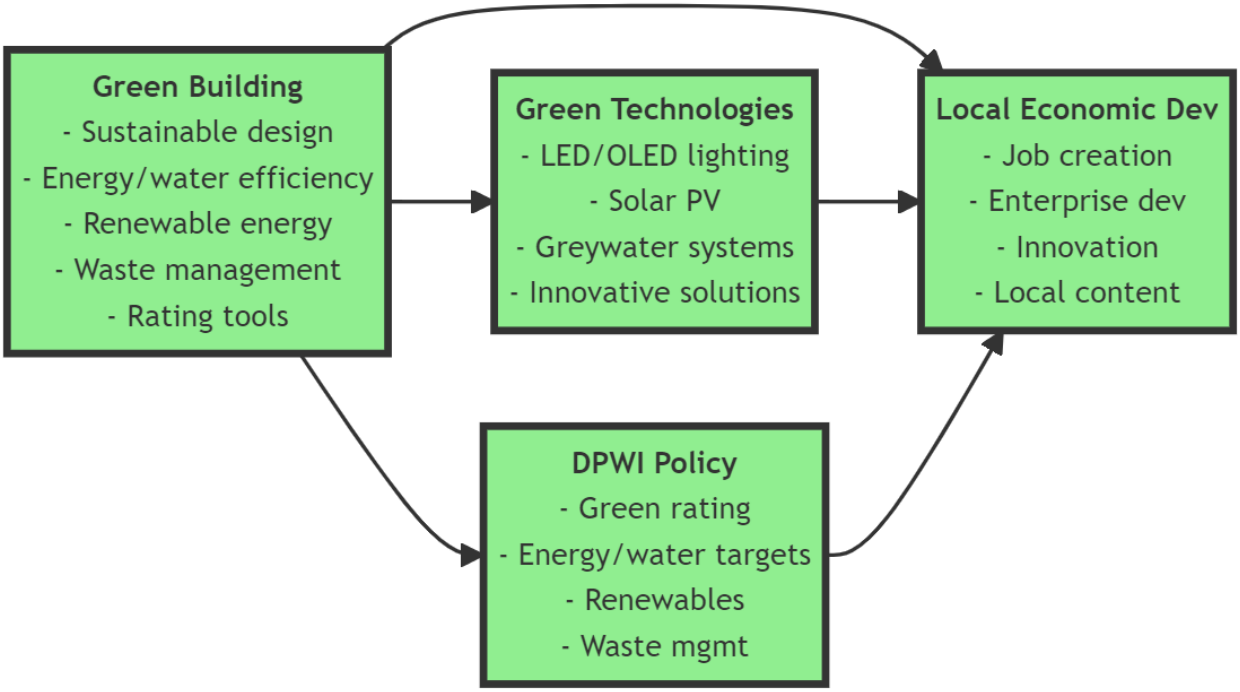

Figure 1: Green building conceptual framework

The most important element of the framework is Green Building Practices, which refer to the sustainable design, construction, operation, and maintenance of buildings over their full lifecycle (Darko *et al.,* 2017). This encompasses strategies like energy and water efficiency, renewable energy integration, waste management, and sustainable materials (Fuerst & McAllister, 2011).

The implementation of green building practices is facilitated through tools like green rating systems, norms and standards, and project prioritisation (Robichaud & Anantatmula, 2011). Research indicates that increased adoption of green building practices has a positive influence on the use of innovative Green Building Technologies (H1) (Wu *et al*., 2021) as well as compliance with green building policies (H2) (Peng *et al.,* 2015).

Green Building Technologies refer to smart and innovative solutions such as LED/OLED lighting, solar PV systems, greywater treatment, etc. (Lam *et al.,* 2009). These technologies

enable buildings to operate more efficiently and reduce environmental impact. The use of advanced green technologies is hypothesised to positively contribute to local economic development (H4) by enabling job creation, enterprise development, innovation, and use of local content (Maia *et al.,* 2011).

Compliance with national policies and mandates like South Africa's DPWI Green Building Policy is hypothesised to have a positive influence on contribution to local economic development (H5). The DPWI policy covers green rating, energy/water efficiency, renewable energy, waste management and other subsets (DPW, 2016). Policy compliance incentivises widespread adoption of green building practices (Du Plessis *et al*., 2022).

Local economic development outcomes encompass job creation, enterprise development, innovation, and use of local materials and technologies (Maia & Giordano, 2011). Green building practices (H3), technologies (H4) and policy compliance (H5 & H6) are hypothesised to positively contribute to these socioeconomic goals, in line with South Africa's development plans (NDP, 2013).

Finally, Indigenous Knowledge Systems (IKS) enable social cohesion and climate change adaptation, and can be integrated into green building through materials, technologies and processes (Gunawardena *et al.,* 2020). Incorporating IKS and local content is hypothesised to further enable job creation, enterprise development and innovation in the green building sector (Leonard *et al.,* 2013).

1.8.2. Hypotheses Testing

This research study tests the following hypothesis:

i. The implementation of Green Building practices leads to an increased utilization of green building technologies (GBT)

ii. The adoption of Green Building practices positively influences adherence to the DPWI Green Building Policy

iii. The implementation of Green Building practices positively contributes to the local economic development

iv. The utilisation of Green Building technologies positively impacts the local economic development

v. The compliance with the DPWI Green Building Policy will result into a positive influence on local economic development

vi. The incorporation of Green Building technologies will significantly enhance compliance with the DPWI Green Building Policy

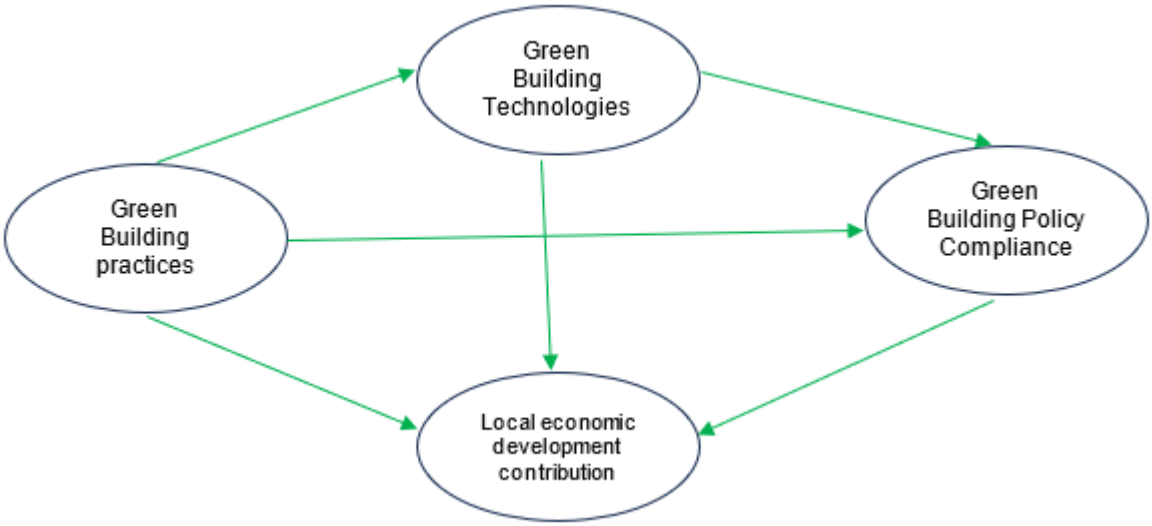

Figure 2: Hypothesis testing

1.9. Research Design and Methodology

This study is positivist, requiring the methodology deployed for the research to be a quantitative study.

This approach is necessitated by the hypothesis that Green Building Potential to increase Job Creation, Enterprise Development, local innovation, and create awareness of IKS has been established.

Gathering and objectively measured data was required to establish scientific facts for this dissertation to test the hypothesis presented.

It must be noted that because of the slow uptake of Green Building, and the limited number of actual green buildings planned or constructed in South Africa, a large and diverse set of different databases will be used to secure a reasonable range of research samples.

The research Design for this study was a cross sectional quantitative design and a survey questionnaire was used for data collection. The study applied a simple Random Probability

Sampling Technique through random sampling in databases of three relevant industry statutory organisations, the Construction Industry Development Board (CIDB), the Council for Built Environment (CBE), Agrément SA (ASA), the South African Institute of Architects (SAIA), and the Engineering Council of South Africa (ECSA). These databases constituted a wide selection for the construction industry. These organisations are statutory bodies based in South Africa, having participated in Green Building Policy development, and are not selected based on the researcher's bias.

With regard to the CBE database, a random selection of professional bodies from CBE, and a random selection of companies from the South African Institute of Architects as a professional registration body for Architects was conducted. The selection was from architectural firms registered with the Institute of Architects. In terms of the CIDB, a random selection from construction companies was targeted.

Selection included the Green Building Council South Africa (GBCSA), the Council for Built Environment (CBE), the Construction Industry Development Board (CIDB). From DPWI Property Managers, Facilities Managers, Construction Managers, Architects, and Utilities Managers were included to establish elements of Green Building which have been carried within a specific period.

The questionnaire had five measuring instruments per variable, resulting in 15 measuring instruments using an adapted questionnaire to suit the study. Data was collected through survey questionnaires and analysed using the Statistical Package for Social Sciences (SPSS) 26.0.

1.10. Delimitation and Scope of the Study

1.10.1. Delimitations

This study is unable to address the weakness that Indigenous Knowledge, in the context of mainstream built industry, is almost synonymous with submerged knowledge. As such, in South Africa built professionals and some communities may have a limited understanding or knowledge of applying IKS in contemporary and “mainstream” building industry processes.

Moreover, holistic Sustainable Building is still emerging and not yet a norm within the South African industry context (Makhado, 2010). Although some progress has been made in recent times towards development of the sector by amongst others the GBCSA (Pendleton, 2021). It is, therefore, another limitation to present the two phenomena (IKS and Green Building) in the context of an industry where neither is fully established.

To address this weakness, the researcher had to rely on drawing from work carried out by architecture academics and, to some extent, practitioners in architecture around the use of IKS in Sustainable Building and involvement of communities as knowledge holders in pilot projects.

The researcher projects that variables may suggest that Green Building generally leads to job creation, as a given, without inclusion of IKS. To address that probability, it is suggested that given the knowledge base context of South African society, there is an increased potential to achieve high job numbers and Enterprise Development through the incorporation of IKS, then would be the case through only undertaking conventional building and job creation mechanisms.

The researcher elected to use the DPWI sector stakeholder database, utilised by the Department and Departmental entities to communicate with the sector. One is mindful that the database may not represent the entire sector, but is however representative of the established and formalised sector stakeholders who constitute the South African built environment. The Department has a constitutional mandate to provide accommodation to User Departments, and to grow and transform the sector. By virtue of its mandate, the DPWI is the largest property owner and participant, together with its entities it has the largest built environment stakeholder base in the country. The database includes both the public and private sector stakeholders to limit the risk of biasness.

1.10.2. Scope of the Study

The researcher covers the Green Building subsets specific to sustainable building materials, building operation, resource efficiency, technologies, innovation, and use of natural resources over the building life cycle where IKS is applicable, focusing on the sector's potential as contributor to socio economic development. These subsets are:

i. Innovative Building Materials and Technologies;

ii. Localisation;
iii. Green Building Rating;
iv. Water Efficiency;
v. Waste Management and Recycling in buildings;
vi. Energy Efficiency;
vii. Renewable Energy; and
viii. Biodiversity.

Whilst the Green Building subsets are vast, the scope of the study is specific to incorporating Indigenous Knowledge Systems principles into each subset. Thus, the study is specific to IKS and its capacity to create jobs, Enterprise Development, and social cohesion under the auspices of Green Building.

Geographically, this study is specific to the South African built industry and Government activities in the Green Building landscape and how such activities have translated into jobs and opportunities for the IKS incorporation.

1.11. Chapter Overview

The structure of the dissertation is as follows:

Chapter One: Introduction

This chapter introduces the research study and presents a detailed discussion on the background of the study. The chapter includes the study aim, the research objectives and hypotheses. A summary discussion of the research methodology and design, and researchers' philosophical perspectives are included in this chapter.

Chapter Two: Literature Review

This chapter covers a comprehensive analyses and discussions of the body of knowledge that relates to the Green Building. The Da Vinci TIPS Framework is also be discussed in relation to Green building.

Chapter Three: Research Methodology

This chapter offers a comprehensive discussion of the research methodology and design employed in this study. The research population, sampling, data collection and data analysis techniques are also discussed in this chapter.

Chapter Four: Research Results and Discussions

This chapter presents a detailed account and analysis of the empirical research results. The results of the study are presented based on the set research objectives and hypotheses. Insights emanating from the analysis are also presented in this chapter.

Chapter Five: Conclusions and Recommendations

This chapter concludes this research study by presenting the key contributions and findings and recommendations.

1.12. Reliability and Validity

Consistent with research requirements, the reliability and validity of the research instrument must be established. Reliability refers to the consistency of a measure, considered reliable if we get the same result repeatedly. Amongst other mechanisms, test-retest is one of the methods to test reliability (Cherry, 2016). This research will test reliability by administering the research instrument assessment twice at two different points in time.

With most cases, reliability can be higher when little time has passed between tests. It is important to note that just because a test has reliability, it does not mean that it has validity. (Cherry, 2016)

Validity reflects the extent to which the test measures what it claims to measure (Cherry, 2016). This research ensures validity by conducting a literature review and using an adapted questionnaire from existing ones previously used in similar studies. Content validity will be undertaken by drawing questions from a pool of previous similar research, with two professionals from the building environment assessing strongly relevant questions for this research.

1.13. Ethical Considerations

Whilst no confidential or sensitive information will be collected, where applicable, permission for the study will be secured from the Department of Public Works as the researcher's employer, and relevant support will be secured from institutions where data will be sourced.

Issues around confidentiality with regard to funds, project proposals, and sensitive parts of project plans will not form part of the data in research. However, the purpose of the study and an indication of what the study seeks to achieve will be clarified to sampled population.

1.14 Conclusion of Chapter

Chapter one provides a contextual perspective and preamble to the research. Covering key themes around sustainability, resource consumption, the built environment as contributor, and the concept of Green Building as an intervention. A problem statement is given on the application of interventions aimed at contributing to the United Nations Sustainable Development Goals, and Green Building in relation to limitations around the use of local solutions empowered by indigenous knowledge and localisation.

The chapter provides a detailed outlook on international, regional, and local developments on sustainability and Green Building in particular, as a paradigm and practice through which specified socio-economic development imperatives can be achieved. As an academic requirement, the chapter provides for aim and justification of the research, research objectives, hypotheses, justification, research philosophy, theoretical and conceptual framework, research design and methodology, the scope of the study and its limitations, including contribution of the research. The chapter finally provides an overview of the various chapters covered throughout this research and ethical considerations addressed by the researcher.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

The Green Building concept is a subset of the Green Economy or Green Growth. In recent decades, the concept has gained wide currency among policy makers in national governments and supranational governments and bodies to reverse the effects of climate change. The conversations stem from the need to reach sustainable levels of development through a wide range of initiatives. The initiatives are bordered by efforts to limit greenhouse gas emission activities and through different mitigation measures to control global warming. Within these efforts is the need for opportunity creation initiatives of which the Green Building concept is a part. Green Building is a holistic process embracing core principles of sustainable development in all aspects of operations, products and services (Van Wyk, 2017).

From the foregoing, the literature presented here explores the subject matter as has been documented by various researchers. The section provides an understanding of greenhouse emissions: what it is and their implications for the environment. The unique emissions of greenhouse in South Africa and their consequences are discussed. The section touches on the Green Building policy framework reflecting the national and local dimensions in South Africa. Exploration of the Green Building frameworks regionally with a focus on the South African Development Cooperation (SADC) and internationally is given. The section looks at the different technologies, innovations and processes deployed in the built environment generally, but specifically examines how these are being used in South Africa. The section also examines how the green building phenomenon is enabling opportunities in enterprise development, job creation and local innovation.

2.2. Green Building Sector Technology Mobilisation, and Localisation Trends

Green Building or Sustainable Building is a subset of Sustainable Development specific to sustainable activities of the built environment. Sustainable Building interventions link directly to sustainable development through a globally derived definition that draws from the World Commission on Environment and Development (WCED) report as far back as 1987. It defines sustainable development as ‘development that meets the needs of the present

without compromising the ability of future generations to meet their own needs' (WCED, 1987:43).

Although there are researchers like Bruelisauer (2007:1) who have argued that "an overarching principle of Sustainable Development (SD) does not exist." It is also accepted that SD is generally concerned with a consistent WCED narrative, i.e., first, the satisfaction of today's essential, worldwide needs; and second, following the developmental patterns that preserve the limited resources for future generations (Bruelisauer, 2007).

Critical to this theory, therefore, will be for the researcher to create a picture for the reader that the Green Building enquiry and green jobs are an established theory, at least at an international level. The researcher will detail the research gap in investigating how Green Building brings about the relevance of the built environment in South Africa to increase the sector's job creation capacity, Enterprise Development, and local innovation.

Concerning the built environment, Sustainable Development refers to the paradigm of Sustainable Building or the more popular term adopted in South Africa, Green Building. According to Irurah and Boshoff (2003:247), "sustainable settlements and buildings envisage the emergence of cities and buildings that are responsive to the resource and sink limits of the planet."

This definition further suggests that "The resource limits entail the finite resource base, especially for some of the key inputs in the sustenance of cities and buildings. These include land and natural habitats, energy, water, construction materials and other raw materials for inputs to manufacturing and service industries" (Bruelisauer, 2007).

These considerations and bringing about the local relevance of Green Building are critical because the paradigm of sustainable development, an umbrella of sustainable building and green building, must be understood in the context of the local situation and the environment (Bruelisauer, 2007).

This study looks at various Green Building lifecycles and subsets such as planning, construction, and building maintenance: water and energy efficiency, waste management, biodiversity, indigenous architecture, building retrofitting in general, and decommissioning.

The built industry is ideal for interventions because it has an integral role in implementing Sustainable Development, given our reliance on buildings as peoples, communities, and economies (Bruelisauer, 2007). The Intergovernmental Panel on Climate Change projects that most C02 savings in the construction sector can be achieved at no or minimal cost (IPP, 2022).

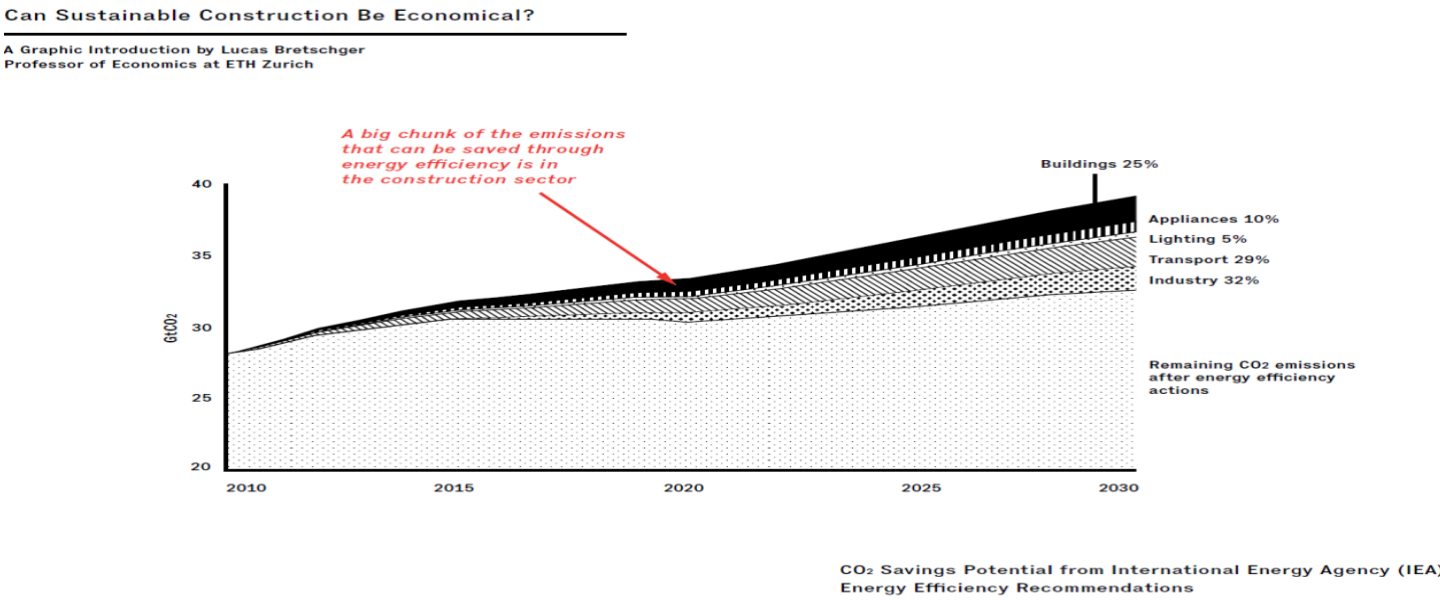

Figure 3: Energy Efficiency Savings Potential (IEA, 2020)

Through interventions such as Green Building, sustainable Development and the resultant green economy should catalyse job creation and Enterprise Development. Maia and Giordano (2011:1) argue, "A greening economy should result in expansions of productive capacity and service delivery across a wide spectrum of economic sectors, although contractions may be experienced in others. Investment activity should progressively support this and result in meaningful employment creation."

The uptake of Green Building activities in sector projects should increase spontaneously, given the amount of focus received by other environmental projects, such as environmental conservation campaigns (Makhado, 2010). The introduction of technologies such as Digital Twin (DT) applications for Intelligent Green Buildings (IGB) have improved business case for Intelligent Green Building and contributed to rapid industry growth as IGB gain interest amongst architects, engineers and owners (Yang, Lv & Wang, 2022).

Notably, this can also be realised through the commitments of industry players to achieving a return on investment, job creation and Enterprise Development as a business imperative.

However, international declarations allow all sectors to recall the essence of Sustainable Development, an umbrella for Sustainable Building and Green Building (Van Wyk, 2011). To understand Sustainable Development as declared in the Johannesburg Declaration on Sustainable Development (WSSD, 2002:1), “we assume a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development — economic development, social development and environmental protection — at the local, national, regional and global levels.”

With this understanding, the researcher suggests that the sector requires a mix of ongoing innovation in the deployment of Green Building Technologies (GBTs) and establishing long learnings from indigenous knowledge applicable to the built environment for holistic Green Building that is responsive to the socio-economic needs of South Africa and the planet. The imperative of gathering information and use of Traditional Knowledge, including in mainstream sectors of production and supply chain, is in line with, amongst others, the Convention on Biodiversity, *Post 2022 Global Biodiversity Framework* adopted as a stepping stone towards the 2050 vision of “Living in harmony with nature” (Klaimi, 2020).

Coverage is also extended to potential reasons for the slow industry uptake of Green Building. There are three main factors, the first being the perception that it costs more to undertake Green Building than greenhouse-gas intensive conventional methods. The second is the lack of appreciation of Green Building contribution to business and Government imperatives, specific to its potential for sustainable business, job creation and Enterprise Development. The third is, unlike established international economies, Green Building in South Africa is still in the early stages, with just a few examples of green buildings being constructed compared to the industry's size.

An opportunity exists to ensure that South Africa defines Green Building in a locally relevant manner, responsive to addressing socio-economic imperatives whilst ensuring climate change mitigation.

For the Department of Public Works, this means how the Department, a significant procurer of built industry services and products, adopts Green Building principles to ensure that the industry innovates, creates jobs, and supports Enterprise Development. Central to this challenge is how the DPW facilitates social cohesion through the built environment to

balance community development. Also, there is an equitable share of resources such as energy and water and a broadening of the skills base for shared green economic growth.

Given the broadness of these considerations, this study will necessarily locate the socio-economic imperatives realisable through Green Building specific to (1) Green Jobs, (2) Enterprise Development, (3) Social cohesion specific to the use of Sustainable Building knowledge and practices by indigenous peoples.

The major problem to be addressed is the question of how property owners, and government in particular, systematically and incrementally shift from a multi-billion rand annual spend on conventional property and infrastructure construction activities to adopting broadly inclusive, locally relevant Green Building to achieve the suggested socio-economic imperatives.

2.3. Understanding the concept of IKS, Built Innovations and IKS in Green Building.

"We shape our buildings, and thereafter they shape us." – Winston Churchill.

From the onset, it must be understood that notwithstanding its prominence, western-based "formal" knowledge remains but one knowledge system amongst many established and intelligent knowledge forms. There are instances where it has been observed that western moral tenets do not adapt well to African-centred milieus, as they have altered cultural traditions in various parts of the continent in different ways; culminating in social crises on the environmental, political, social and economic fronts emulated to an extent systems (Mthembu, 2021). Social crisis includes 'lip service' attempts at emulation indigenous knowledge, without necessary protection or acknowledgement for knowledge.

Boven and Morohashi (2002:6) suggest that "acknowledging these other ways of knowing leads to reconsidering many fundamental notions about development, environmental conservation, heritage protection, and access to information and education."

Traditional Ecological Knowledge is a subset of the Indigenous Knowledge Systems, as knowledge that generally largely depends on local social mechanisms of ecology environment (Sinthumele, 2020), which the researcher argues would include sustainability thereof.

The focus on IKS of this study is specific to the current use of IKS processes, locations and materials that indigenous communities used, and remain relevant, in order to ensure that built structures were in synch with the environment. For the researcher, the basis of this is that traditional communities by their nature have always considered buildings to have living energies and consciousness, therefore afforded a certain status to buildings and infrastructure. Consistent with this appreciation, phenomenal properties and energy has always been attributed to the sea, forest, soil, elements of nature, and various materials and artefacts in line with their function (Herva & Nurmi, 2009). This worldview includes residential houses and other social buildings as social artefacts.

The researcher suggests that the African and South African approach to Sustainable Building, as an industry and paradigm, must not have the same limitations as most interventions aimed at development and environmental economics, as these tend to be overly technical in orientation and exclude social and cultural elements permanently embedded in indigenous communities (Mamukwa, Lessem & Schieffer, 2014).

A more holistic approach to Sustainable Building is urgently required, particularly because during the 28th Conference of the Parties (COP28) (2023) the Global Alliance for Buildings and Construction (GlobalABC), a global platform for buildings stakeholders, reported that the United Nations Environment Programme (UNEP) and signatory governments from across the world, have made a worldwide invitation to all nations (including South Africa) to join the Buildings Breakthrough, an initiative which calls for a global effort towards near-zero emissions and resilient buildings by 2030 (GlobalABC, 2023).

It is the researcher's view that conventional mechanisms may not achieve these targets on their own and require a deliberate return to the basics to incorporate scalable methods used by traditional communities in saving resources, with a mix of technological innovation. With regard to bringing redress to socio-economic challenges, Van Wyk (2010) reminds us that poverty is recognised as a fundamental cause of environmental degradation and, therefore, (green) economic development has a crucial role in contributing to poverty alleviation. One holds a view that poverty alleviation includes engaging indigenous knowledge of beneficiary communities to deliver solutions.

In line with this paradigm, another research on the construction of buildings and Sustainable Development has suggested the existence of feedback loops that individuals have with their

built environment and the active coevolution that they necessarily share, creating a context for the agency of both inhabitants and buildings as a complex hybrid (McMaster & Wastell 2005).

In support of McMaster and Wastell, the researcher suggests that whilst constructing buildings can be addressed through technological and scientific interventions, the involvement of users - the communities and people who actually operate buildings, requires a combination of technological deployments, with elements such as the environment, culture, and IKS to complete Sustainable Building.

Consistent with the views of the researcher Velikov, Bartram, Thun, Barhydt, Rodgers, and Woodbury (2013) suggest that designers can mobilise the concept of building/inhabitant/environment as a coevolving system to promote social change, not only to increase the “intelligence” of building systems but also to increase the intelligence of their inhabitants as well.

Concerning the global shift towards the recognition of Indigenous Knowledge Systems (IKS) and the potential it has to contribute to addressing societal challenges. Agrawal (1999:2) suggests that the focus on Indigenous Knowledge and production systems heralds a long overdue move. It represents a shift from the preoccupation with the past decades' centralized, technically orientated solutions.

Research and incorporation into Indigenous Knowledge Systems as an epistemology are central to required socio-economic advancements towards creating social and economic balance amongst global communities of nations. There are several reasons why taking stock of IKS is essential. By studying “non-Western” cultures and their knowledge of nature, we contribute to understanding and conserving great intellectual traditions that are tens of thousands of years in the making (Anderson, 1992). The limited availability of IKS material and relevance of research read suggests that relevance to this research.

The Global Alliance for Buildings and Construction researcher believes that the narrative on Sustainable Development and Green Building necessitates practitioners and policymakers to clearly view IKS. This is because most indigenous peoples and communities hold rich knowledge of coexisting with the environment-specific building processes to the extent that

some of the technical knowledge in the industry, perhaps wrongly applied, originates from indigenous communities.

Anderson (1992) emphasises that recognising that even the most formally structured technical knowledge may be implicated in colonial accumulation and acquisition is long overdue.

IKS is located in the heart of how communities interact with the world around them and the historical manner in which communities marked their being and existence through man-made built structures and fossils. To this end, the role of IKS in Green Building can directly address social cohesion and cultural exchange beyond environmental considerations.

Supporting this view is a suggestion by Chambers and Gillespie (2000:232) that “by helping preserve the multiple varieties of human understanding of the natural world, we go to the heart of preserving cultural diversity-perhaps we will improve the possibility of constructive cultural reconciliation in a deeply troubled world.” More importantly is the fact that an international perspective has long been held that there is a need for “rehabilitation of traditional forms of knowledge and, above all, of the potentialities which have been stifled by the pressure of the dominant countries or groups” (UNESCO, 1981:31).

However, Chambers and Gillespie (2002:233) accept that “some have disappeared, some known only in fragments, and some involve sacred knowledge that cannot be made public.” This study must contend with this possibility, especially within the context of built environment IKS where in African communities, certain knowledge may only be for the preservation of the Knowledge Holder community concerned and not for commercial or research purposes.

The paradigm of sustainability in the built environment has an opportunity to emulate what has been achieved by the health sector in the use and institutionalisation of indigenous knowledge, for example in ethnomedicine, in order to improve and promote both alternative and collective models of building, including the sourcing, use of building materials, and services in the built environment value-chain.

Hasty, Lewis, and Snipes (2002:520) define Ethnomedicine as a society’s cultural knowledge about the management of health and treatments for illness, sickness, and

disease. Stating that the science and practice includes culturally appropriate processes for seeking health care and the culturally defined signs and symptoms of illness that raise a health concern. Highlighting that ethnomedical systems are frequently closely related to belief systems and religious practices (Hasty *et al.*, 2002). The researcher suggests it is possible for Green Building as a sector to draw from indigenous practices as part of sustainability and efficiency interventions that contribute to socio-economic development.

In this regard, this study includes investigating the incorporation of built environment indigenous knowledge into Green Building models, and related innovations towards creating jobs and foster Enterprise Development. However, this study does not undertake an investigation into the historical account of IKS in various communities.

It must therefore be clarified, what exactly constitutes indigenous materials? The Center for Resourceful Building Technology (1995:6) defines them as materials “native to a building site or its surrounding region, and indigenous methods are the particular application of those materials, as developed to suit a specific climate and culture.”

With the support of referenced works from a global perspective, the researcher suggests that IKS is an integral part of social cohesion, particularly sustainable built environment related processes, designs, and materials utilised by indigenous peoples. It must therefore be enquired as to what extent IKS has been established in existing Green Building trends, and what innovations are currently used around local content or a potential thereof, i.e., building materials and systems.

IKS principles are located in principles of Critical Regionalism. Mota (2014) refers to Frampton, who recommended as far back as 1981 that: “Critical Regionalism suggests that thinking in terms of regions brings tangible immediacy of spatial experience, as a response to climate, topography, sense of reality to the cultural meaning of architectural form, engaging local labour and skill in architectural production.”

Innovation in how the construction sector integrates with the environment is increasingly becoming more important now than ever. For the researcher, this means it is even more critical now than ever before to draw from IKS in Sustainable Building activities. We are facing a construction boom like no other in history. Over the next twenty years, we will more

than double the built space occupied today. Therefore, innovation is the foundation for sustaining life on Earth (Krygies & Nies, 2008).

The growing use of modern innovations like Building Information Modeling (BIM) and related technologies is moving the construction industry towards Green Building. With this system, user comfort is evaluated, design is modelled, energy needs are minimized, renewable strategies are found, and water use and waste are minimized to serve the needs of the building – BIM is beginning to change the way buildings look, the way they function, and the way they are built (Eastman, Teicholz, Sacks & Liston, 2011). The researcher believes that systems like these can be improved and tailored using other IKS components to ensure holistic environmental integration of a building i.e. the extent to which the local environment has been integrated into a building.

There is an increasing realisation that Indigenous Knowledge Systems are crucial in preserving biodiversity and managing natural resources – it has been noted over a period of time that the desire for environmentally sustainable development has prompted attempts to establish a dialogue between science IKS, and technology (Chambers & Gillespie, 2000).

According to the researcher, drawing on IKS to meet Green Building requirements is a fundamentally important imperative since lessons from indigenous knowledge, as held by indigenous communities, transcend management of natural resources, ecology, and biodiversity. Traditional and local knowledge systems are dynamic expressions of perceiving and understanding the world. This is particularly imperative given that in recent decades, research on the knowledge of indigenous cultures has gained more and more recognition in the field of science and technology education (Zidney et al, 2023)

Consistent with this view, the researcher holds that because IKS is a science on its own, it needs to re-emerge and be reimagined by innovators who contribute to local socio-economic development. This study suggests to the reader that this knowledge, which will continue to inform technological inputs for sustainable development and Green Building, in particular, will ensure great progress for localities and countries that produce such knowledge and therefore implements Green Building.

This view has been held through the realisation that all knowledge systems are situated in power relationships, value assumptions, and historical frameworks (Harding, 1993). Integral

to this study, the researcher urges that Economic development cannot be separated from this world view which affects all economic sectors. Puri (2007) proposes that concerning land management, it is essential to consider the sciences and knowledge communities have of their land.

When dealing with knowledge plurality, what is required is creating synergies between material characteristics of knowledge inscribed in technology and IKS from various communities – a term coined as *knowledge alliance (*Puri, 2007).

In addressing climate challenges, IKS is not a new proposition. The local population of regions such as Sahel, through IKS, have created and employed extensive mitigation and adaptation strategies, enabling them to considerably decrease vulnerability to past climate variability, surpassing forecasts by models of future climate change (Nyong, 2006).

In this section, the researcher engages literature on the application of IKS in the context of Green Building to cover what has been achieved and not achieved in creating a direct link between IKS and Green Building. This section also examines strides made from the theoretical, abstract IKS concepts to actual implementation in Green Building Business Processes.

It is the view of the researcher that Building Processes in indigenous knowledge is with an understanding that no material goes to waste. This is a fundamental concept of sustainable building and construction, which looks at the life cycle of the building process, prevalently referred to as regenerative. This concept is similar to natural ecological systems, where an output on one end becomes an input of the following process as one ecosystem of life (Capra, 1996).

IKS has many possible answers to the overreliance of conventional buildings on finite natural resources – materials like steel and copper are not available in infinite supply (Wallbaum, 2006). In fact, Bruelisauer (2007:11) argues that “the topic of material use has been fairly neglected so far. Recycling of building material is not yet very common or elaborate.”

The use of indigenous building materials promotes innovation, creativity, and experimentation on the part of builders while it helps to reduce the demand for scarce natural resources (CRBT, 1995).

Bruelisauer (2007:18) indicates the successful use of indigenous building materials for an accommodation building in a South Africa lodge. “The choice of a building structure was a load-bearing straw bale structure. Numerous reasons include readily available wheat bales from nearby farms with superb insulation values, possibly low-cost, low-tech building techniques, and labour-intensive building processes.” For the researcher, project managers would be delighted to have a project with low input and transport costs, which allows for registering more job numbers at less cost.

This type of indigenous knowledge material has an international footprint, with indigenous communities in different parts of the world deploying its use. For example, in Nebraska, USA, settlers would use straw bales lying around to build temporary shelters. They benefited from thermic insulation from the burning sunlight, and insulation from the cold and winds (Bruelisauer, 2007).

Reflecting on indigenous materials, the Center for Resourceful Building Technology (CRBT, 1995:5) noted that “homes built in indigenous materials are unique-they are individual representatives of a region, climate, and culture. At the same time, they have the potential to be comfortable, functional, durable, and energy efficient.” This view draws into focus the embedded nature of built IKS into the climate, locality, and people.

This study needs to establish an in-depth understanding of IKS innovations around building materials and processes. One is of the view that based on what has been achieved in developing indigenous materials, more applications are possible to the extent of commercial buildings.

Through the study, the researcher will assess the type of indigenous materials deployed to Green Building projects to assess the construction spend on such materials. What supports the sustainable building nature of indigenous materials and therefore creates an entrenched link between Green Building and indigenous materials is the fact that, in most instances, the innovative use of indigenous materials is through making use of everyday materials and the local environment, including innovative use of things people formally considered scrap or waste (CRBT, 1995). To the researcher, this is consistent with the cradle-to-cradle paradigm of sustainable building, as Capra (2006) suggested.

With regard to cost, which is increasingly becoming an issue for consideration for most building commissioning customers, the researcher holds a view that most indigenous materials cost less than industrial materials, which also tend to be energy intensive during their manufacturing (Oruwari, Jev & Owei, 2002). It should be accepted, however, that indigenous ways are not for everyone, given that constructing with this type of material tends to be labour-intensive (CRBT, 1995). This attribute should, however, serve as a positive for private companies and Governments who seek to realise more jobs from their Green Building spend.

One will also investigate the fact that women undertake most use of built IKS. Therefore, incorporating IKS in Green Building presents an opportunity to foster women's empowerment as recognised practitioners with readily available skills and those with the potential to be developed further for technology innovation. Another example of women's role in built IKS is that rural architecture designs are generally acknowledged as women's products and have remained their preserve in rural areas until now (Frescura, 1990) This includes mud or rammed earth schools and social infrastructure across villages which have lasted for decades.

For the reader, it is imperative to note that built IKS approach to natural elements offers more than building materials for Green Building activities. In Africa and undoubtedly many other regions across the globe, indigenous communities understood the concept of building processes mimicking nature and the ecosystem. For example, Yeang (2008:2) refers to the processes of building eco-skyscrapers as “buildings which integrate with nature in a benign and seamless way over its life cycle, by imitating the structure, processes and properties of the ecosystem, an approach referred to as ecomimesis.”

The researcher suggests that this is a process also deployed by indigenous communities in different locations through Africa, including South Africa during construction of buildings or social infrastructure for specific purposes i.e. healing, teaching, hosting gatherings and other activities. This paradigm is also found in biomimicry, defined by the Biomimicry Institute (BI, 2015) as “an approach to innovation that seeks sustainable solutions to human challenges by emulating nature’s time-tested patterns and strategies.”

The interconnectedness of Sustainable building is established in various cultures, consistent with the IKS building model. By way of example on interconnectedness and sustainability

through IKS, Hawaiian sustainability was founded upon the island worldview, which places an intrinsic value on the interdependence of all life, with a sense of the sacred permeating the entire natural world (Chirico & Farley, 2015). This has mostly been the nature of life in other regions, including the African countries.

Through observations of such paradigms, the researcher suggests that Green Building works only through a system thinking approach similar to IKS.

The researcher suggests that for Green Building, systems thinking goes beyond interconnectedness around organisations linking technology, people, and innovation. It includes management of and preservation of the environment and cultures through bio-integration and socio-integration in the manner we build buildings and infrastructure.

This approach will allow the Department of Public Works, other spheres of Government, and the private sector to look beyond one building being constructed or maintained to include an ecosystem of buildings imitating how nature functions through Green Precincts. We must ultimately change our cities into green ecocities, all of our manufacturing industries, and all forms of transportation and human activities. In making these green transformations, we must integrate them seamlessly with the natural environment (Yeang, 2008).

In carrying out this study, the researcher will investigate if the Green Building sector can be professionalised and function as a unit formed to facilitate research and development and ongoing engagement at a people-to-people level to meet job creation and Enterprise Development. At its most fundamental, integrating IKS in Green Building is innovation at an enterprise or organisational level. However, at a micro level, it is a realisation that the practical function of innovation depends on the nurturing and integration of new knowledge within an organisation (Addison, 2005).

It must be noted that such use of indigenous knowledge and Critical Regionalism lends itself to the emergence of trade secrets potential for South African communities and entities. Supporting this view is a suggestion by Addison (2005:78) that “Virtually anything that is not generally known and that gives the originator a competitive business advantage may be called a trade secret.”

Yeang (2008) suggests that addressing the current state of environmental impairment has to be carried out at all levels of our human world, globally, regionally, locally, and individually (mind, heart, and spirit). Changes must be made at the physical level of our built environment and at the political, community and business levels by devising and implementing green legislation, and at the societal level through redefining how we sustainably live our lives.

The researcher holds a view that at a practical level, implementation of Indigenous Knowledge (IK) in Sustainable Building can be made practical by adopting what Boven and Morohashi (2002) refer to as a model of UNESCO/MOST for Best Practice Indigenous Knowledge (IK), whose register includes 22 projects from African countries.

Table 4: UNESCO/MOST register for IK Best Practice. IK shows characteristics considered best practices in IK-identified projects (Boven & Morohashi, 2002).

BEST PRACTICE INDIGENOUS KNOWLEDGE (IK): CHARACTERISTICS
They are innovative A Best Practice has developed new and creative solutions to common problems of poverty and social exclusion.
They make a difference *A Best Practice demonstrates a positive and tangible impact on the living conditions, quality of life or environment of individuals, groups or communities concerned.*
They have a sustainable effect A Best Practice contributes to the sustained eradication of poverty or social exclusion, especially through the involvement of participants.
They have the potential to be a source of inspiration to others A Best Practice could serve as a model for generating policies and initiatives elsewhere (for implementation).

In concluding this section, the researcher is encouraged by Maila & Loubser (2003:202) to recall the assertion of Vilakazi (1999) as early as 5 years into the democratic South Africa that “the notion of a civilisation is an embodiment of the knowledge systems of a people, arguing that civilisation is: a complex culture; language or languages; a certain technology; an identifiable pattern in art, music, architecture, poetry, literature and dance; a certain body

of knowledge, science, medicine, and values; a certain cuisine, manner of dress and general habits."

This profound observation is enough for the researcher to create relationships of true sustainable buildings of all forms, as a symphony of cultures, spirituality, peoples, technology, and the environment.

2.4. Creation of Green Jobs and Enterprise Development in Green Building.

The current global environmental situation means that climatic changes will affect all societal and economic sectors. According to the South African National Planning Commission (NPC, 2010), rising energy prices, a desire for energy security and the threat of climate change will continue to drive changes in how societies work. The NPC diagnostic document continues to project that beyond their direct impact on South Africa; these drivers will have profound effects on our economy and society, both offering opportunities and posing threats.

The researcher believes that addressing climate change challenges through the built environment presents opportunities for the entire value chain of Green Building, including environmentally friendly, innovative, and indigenous materials. There is an opportunity for up-and-coming entrepreneurs in South Africa to claim the Green Building space, particularly through opportunities presented by localisation potential in the sector. As observed in countries such as Nigeria, regarding materials for the built environment in general, developing countries seem to be facing a problem with the supply of building materials, pushing up their costs (Oruwari, Jev & Owei, 2002).

Whilst there is a shortage of materials, it is estimated that the value of gross output accounted for imports at up to 30 per cent and comprised up to 60 per cent of all materials used in Africa (Nordberg, 2001). This means up to 60 per cent of building materials used in Africa may not originate from the continent. Nevertheless, Africa is rich in natural resources and has the potential to produce indigenous materials, particularly for building activities within the continent.

This area presents increased consulting and supplying opportunities for development at the Enterprise Development for Green Building. This study will cover the extent of manufacturing and procurement of local materials for construction projects, particularly Green Building.

Through this research, the researcher will specifically assess current use and opportunities in the planning, building, and maintenance of buildings. Focus on this will be the brief given by DPW as a client for the construction and maintenance of State properties and the requirements the Departments put for using local resources and content.

With reference to the energy front, South Africa is experiencing major power shortages, which demand innovative solutions that increase entrepreneurs' opportunities. For electricity consumers, exposure to blackouts and rising prices has triggered an awakening to alternative possibilities for energy supply. This reality, together with the expansion of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), is adopting sustainable solutions at a rate that the sector could have only dreamed of ten years ago (Brown, 2015).

The Department of Public Works is currently required to meet an energy consumption reduction target of 1.6 Billion kWh, whilst the National Energy Efficiency Strategy (NEES, 2005) currently under review set a 15% energy demand reduction target for public buildings. Furthermore, the jobs target for the current financial year is 1000 (DPW APP, 2015/16). To this end, the researcher believes this provides opportunities for entrepreneurial partnerships in planning, constructing, and operating buildings that do not consume as much energy as their existing counterparts.

Concerning other Green Building subsets, the localisation component will focus on using water and waste resources to achieve efficiency. This element will include current initiatives on IKS elements such as rainwater harvesting. This study will also cover the international perspective in other countries, such as China, which have retained IKS and cultural elements in design and building, and reflect on this paradigm in the African continent and South Africa. This includes biodiversity in planning for construction, water harvesting, waste recycling and building arts and culture, which present opportunities for locally driven Enterprise Development.

When industries emerge, such as the Green Building sector, managers in incumbent firms must decide whether to enter the new field (Henn & Hoffman, 2013). With this view, the researcher suggests that Small, Medium, and Micro Enterprises (SMMEs) in South Africa must be able to assess the emergence of this industry and make an entry which will benefit the market and their companies. Green Building creates opportunities for individuals and

companies by introducing innovative and new approaches to construction and property industries. Entrepreneurial studies and scholars in the field have defined enterprise or firm creation as resulting from the nexus of the individuals and an opportunity or potential in the market they see (Shane & Venkataraman, 2000)

The role of innovation is immense for Government to create an enabling environment for industry to grow and facilitate the entrance of new participants. Successful companies in countries with established Green Building, such as the United States of America, firms saw an opportunity, where others saw risk, to create a venture that would not only provide them with financial benefit but also would achieve a higher moral purpose and benefit society (Henn & Hoffman, 2013).

This study will look at current linkages of Green Building with other programmes aimed at facilitating and enabling a developmental environment for Small, Medium and Micro Enterprises, such as property/construction incubator programmes to provide skills, academic training, and organisational development.

Schaper (2010) refers to Warren Buffet, who stated in 2007 that a phenomenon referred to as a ‘cleantech boom’ may ultimately be more enduring than the dot.com boom that preceded it. For the researcher, this provides considerable opportunities in Green Building industries such as water and energy efficiency and manufacturing of related technologies, which the South African government and built environment can utilise to develop emerging entrepreneurs.

Like in most regions in the world, Sustainable Development and the Greening of industry are based on many different arguments but frequently overlook the perspective – yet it has opportunities for entrepreneurs who are prepared to be innovative and adopt different business models (Schaper, 2010).

Consistent with this view, Dean and McMullen (2007:50) point out that “Environmental Economics conclude that environmental degradation results from the failure of markets, whereas the entrepreneurship literature argues that opportunities are inherent in market failure.”

Sustainable entrepreneurship can emerge because environmentally relevant market failures represent opportunities for achieving profitability while simultaneously reducing environmentally degrading economic behaviours (Dean & McMullen, 2007).

According to the researcher, a move towards the trajectory held by Dean& McMullen (2007) above, entrepreneurs would have to pursue innovative measures, including IKS. Leaders and managers must weave their operations commensurate with funding, parent, and host institutions, which also have divergent interest (ikendi & Reta, 2023)

In terms of leadership management principles, the researcher suggests that Green Building presents South African enterprises and Government with an opportunity to create congruence in Management Leadership as identified in the Four Frames of Organisational Analysis (Bolman & Deals, 2003) encompassing the South, North, East, and West frames.

Together with other frames on Management Leadership, this will ensure a move towards holistic and relevant companies, which enables companies to adopt principles of the South, such as cooperation, ubuntu/humanist, shared values, community, and pragmatism, with principles of the West and North which are competitive, institutional; and principles of the East which include being holistic, inter-organisational – with principles being knowledge-driven. This study suggests that knowledge would encompass economic, societal, cultural, indigenous, spiritual, technological, and science-driven knowledge.

One is of the view that the holistic worldview in approaching Green Building imperatives, beyond profit and conventional science, is important. This is because green Buildings meet a triple bottom line, good for all people and the environment and are responsible for the economics of their clients and communities. These three areas, referred to as People, Planet, and Prosperity, are commonly called the three legs of the sustainability stool (Krygiel & Nies, 2008). Drawing from Triple Bottom Line accounting, entities would consider their environmental and social performance in addition to their economic performance (Elikson, 1998).

Training and development of people, teams, and organisations are critical to ensuring critical growth and development in green building. Through Guidelines on Education Policy for Sustainable Built Environments (2010:6), UNEP-SBCI states that the environmental impact of the built environment “highlights the urgent need for education that supports the eco

settlement and sustainable building". Sustainability education for the building sector is fundamental to the creation of sustainable urban and rural settlements.

Figure 4: Synthesis by UNEP-SBCI for Guidelines on Education Policy

The researcher believes that in line with the DaVinci Institute's principles of Management of People, various role players are included in driving required capacity development. The model can be emulated in the South African context and that of DPW in partnership with other spheres of government, including Green Building industry stakeholders.

2.5. Greenhouse emissions overview in South Africa and internationally

Greenhouse gas (GHG) emissions are a crucial concern of global warming as the conversation for climate change gains momentum to manage it. Davis, Ahiduzzaman and Kumar (2018) stated that GHG primarily concerns environmental, political, cultural and technological interventions. The scholars argue that understanding and managing GHG sources towards reduction can help mitigate the catastrophic impact they already impose on the climate (Davis *et al.,* 2018). GHG are gas compounds in the atmosphere capable of absorbing infrared radiation, trapping and holding heat in the atmosphere, ultimately leading to global warming (Lallanilla, 2019).

There are several sources of GHG emissions. A report by Environment and Climate Change Canada (2016) indicates that human-induced activities are the major contributors to the current climate change predicament. The United States Environmental Protection Agency (US EPA, 2017) supports this view by stating that the most significant contributors to GHG emissions are burning fossil fuels for electricity, heat emerging from commercial and

residential energy use, transportation, industry, agriculture, land use and forestry. Developed countries are cited as the major emitters of GHG. China, the United States and the European Union all combined accounted for about 49.1% of GHG emissions in the world in 2013. Arce, López and Guan (2016) observe that China's entry into the World Trade Organisation (WTO), for example, embodies the mass production of internationally traded goods and services, whose GHG linkage makes China the world's largest emitter. China's contribution to GHG emissions is evidenced by the coal-based energy sources and the increasing energy demands imposed by massive urbanisation.

South Africa, as the focus of the study, is ranked 12th in the world and, by this token, emerges as the number one emitter of GHG on the African continent (Grewer, Bockel, Galford, Gurwick, Nash, Pirolli & Wollenberg, 2016). The country's energy demands, which have been increasing since 1994 and are also characterised by heavy dependence on low-cost and abundantly available coal, imported crude oil and little reliance on renewable energy, are responsible for the ranking among the largest GHG emitter in the world (Khobai & Le Roux, 2017).

In the spectacle of these statistics, the GHG emissions predicament becomes more worrying. The Paris Agreement set 35% as the global warming baseline to eliminate emissions and to also control them below the prescribed threshold of 20c (Rogelj *et al.,* 2016). Newell, Raimi and Aldana (2019) state that practices like the heavy reliance on fossil fuel, which primarily made up 82% of global energy consumption in 2015, can only make the GHG emission worse by 2040, helping to surpass the Paris Agreement thresholds.

Increased concern about GHG emissions has prompted more conversation and response from governments and international organisations towards its reduction. Over the years, the United Nations has been at the forefront of its reduction in its broader response to tackling climate change. The United Nations Framework Convention on Climate Change (UNFCCC) adopted in 1992 has mainly influenced articulating responses. Article 6 of the framework pertains to education, training, creating public awareness, allowing public access to information and calling upon public participation and international cooperation in addressing climate change and its effect (UNFCCC, 2016). Article 10(e) of the UNFCCC adopted the Kyoto Protocol in 1997 to commit international action to the reduction of GHG emissions by 5.2% in the period 2008-2012 through a top-down approach and promotion of domestic GHG emission mitigation actions (Kuriyama & Abe, 2018).

The Paris Agreement adopted in 2015 is another key component corresponding to Article 12 of the UNFCC. The agreement deals with GHG emissions mitigation, adaptation, and finance. Key features of the Paris Agreement are used to monitor the risks and effects of climate change, i.e., to manage the global average temperature to below 2 C; and to limit its increase to 1.5 C (Phillips, 2015). The Paris Agreement takes effect in 2020 (Hickmann, Widerberg, Lederer & Pattberg, 2019).

The United Nations (UN) is also instrumental in spearheading Sustainable Development Goals (SDGs), adopted in 2015, as one cornerstone for managing GHG emissions. The SDGs show consideration for the global environment to address climate change, biodiversity, world heritage and wetland conservation (Kawamoto & Kanie, 2019). Governments and international organisations have been prompted to intertwine sustainable development initiatives with climate change concerns as critical components. Other than governments and non-governmental organisations, the private sector is one of the key stakeholders that could add impetus and shoulder the fundamental responsibility of accelerating the SDGs implementation process (Rashed & Shah, 2021).

In a more pragmatic approach, the UN has also recognised the contribution of private business participation as a key element in realising sustainable development. The UN is mindful that business activities affect the environment through production, operations, value chains, and processes (Martinuzzi & Schönherr, 2019). Corporates now pay attention and report on their own environmental footprint (Siregar & Zulkarnain, 2021). In terms of this recognition, corporate entities are undertaking critical efforts through their corporate sustainability strategies to make decisions that consider environmental protection (Kolk, 2016).

In addition, considerable response towards eco-friendly and ethically traded products ranging from ethical fashions, organic and fair-trade foods, eco-friendly cosmetics and detergents to ‘green’ funeral services are taking place as climate change concerns (Martinuzzi & Schönherr, 2019).

2.6. Unique greenhouse emissions in South Africa

South Africa was the most polluting country in Africa in 2021. In that year the country emitted nearly 436 million metric tons of carbon dioxide (CO2) (Sasu, 2023). The country’s negative

position among the global emitters is not farfetched. South Africa is solely responsible for 42% of GHG emissions on the continent (Bekun, Emir & Sarkodie, 2019).

This is a recent period of economic activity prior to the global interruption by the pandemic and lockdown period.

The high carbon footprint is linked to the country's economic production processes and growth (Seymore et al., 2014). In their study, Bekun *et al*. (2019) found a high affinity among energy consumption, carbon dioxide emissions, and economic growth. They conclude that high economic growth directly links to high energy consumption and invariably high environmental degradation from GHG emissions. Holgate (2007) as far back as 17 years ago had also found this relationship compelling because the level of economic growth can determine the level of energy intensiveness of any country.

Since 1994, the country has experienced increased GHG emissions due to increased energy consumption. The surge in emissions is fortified by heavy dependency on fossil fuels, characterised by low-cost and abundantly available coal and imported crude oil with limited reliance on renewable energy (Khobai & Le Roux, 2017). As many scholars agree, the dependency on coal translates into the intense levels of South Africa's carbon footprint.

Domestically, statistics show that South Africa has a reputation for being the most intensive GHG emitter, yet it is a non-oil-producing developing country (EIA, 2010). Coal provides over 75% of the country's total energy requirements as it generates 91% of the country's electricity (Holgate, 2007). Low-cost energy production patterns are not only unique to South Africa but are reflected in many emerging economies. Arce et al. (2016) observed that reliance on emission intensities linked to cheaper but more polluting energy sources tends to be higher in developing countries than in developed countries.

The road transport sector also worsens the South African GHG emissions predicament. Tongwane, Piketh, Stevens and Ramotubei (2015) showed that in terms of incidence, the sector emits an estimated 43.5 million tons, putting its contribution to ¾ of the total transport emissions and 10% of the total emissions in the country generally. Road transport emission is linked to the sector's heavy consumption of petrol and diesel. However, by 2009 the country had about 8 million registered cars, with an estimated increase of 4% cars per year (RTNC, 2010). The estimated percentage increase of cars reflected in (RTNC, 2010) falls

short of the recent developments in increasing cars per year. However, it helps to illustrate the increase in statistics from the electronic National Administration Traffic Information System (eNatis), also quoted on the Wheels24 website (date), indicating that by 2017, South Africa had above 12 million registered vehicles (Van der Post, 2017). With these statistics yet again, the carbon footprint can only be projected to increase unless innovative solutions are devised to manage the GHG predicament in the country.

The connection between South Africa's economy and GHG emissions is similarly linked to the country's industrial activities, as presented by high levels of the manufacturing sector and urbanisation. The country's economic growth intensity revealed in its manufacturing prowess shows a high scale of environmental degradation, as already seen in the foregoing paragraphs. Nasr, Gupta and Sato (2015) hypothesised that the level of economic output, especially in developing countries, is directly proportional to the level of environmental degradation and declines after reaching a certain threshold. The scholars' hypothesis supports what other scholars collectively call the Environmental Kuznet Curve (EKC) (Esso & Keho, 2016). The above assumption fits South Africa's economic growth trajectory, which, as shall be seen, is done at the expense of environmental concerns.

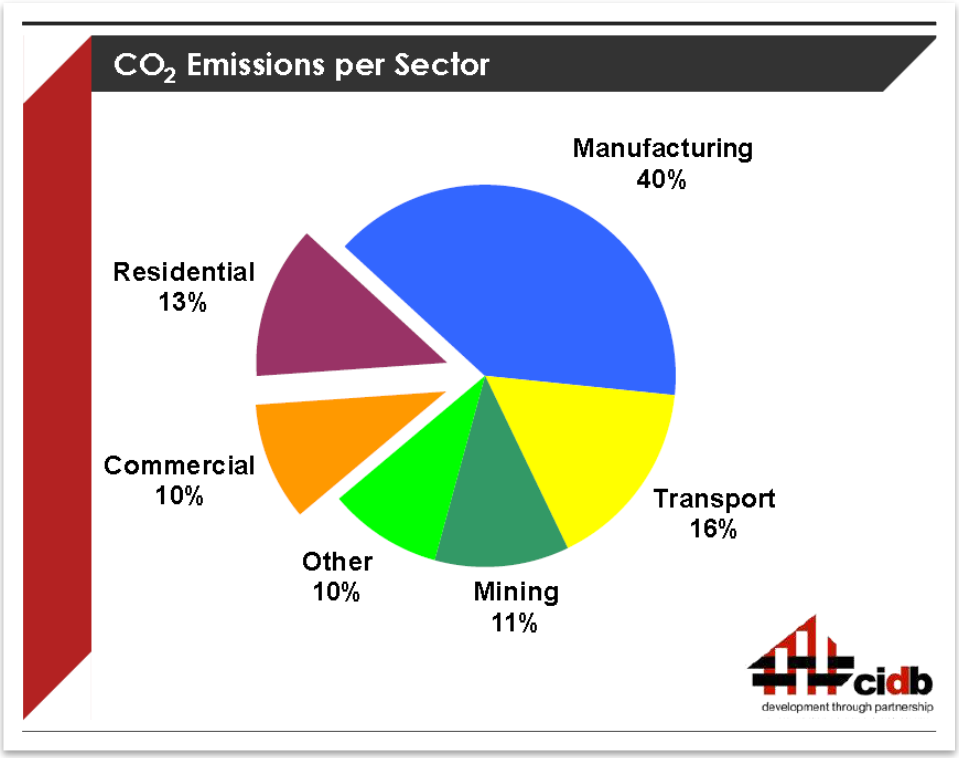

Figure 5: South Africa GHG emissions per sector (Source: Milford, 2017:7)

The country's industrial activities, reflected in its mining and manufacturing, show that the government is, in practice, more concerned with employment demands and income than the environment (Nasra *et al.,* 2015). Linked to economic growth is increased energy consumption due to urbanisation and urban population concentration. Although previously confirmed through a plethora of various studies prior, as far back as 17 years ago Holgate (2007) also noted that South Africa follows global urbanisation trends with high population concentration in urban places. The scholar continued to indicate that about 58% of the South African population resides in cities and that by 2030 the figure is projected to grow much farther to 64%. The implication of this trend is the association of high population densities with high vehicle ownership and traffic congestion, which also imposes rigorous GHG emissions. The correlation between urban concentrations, increased energy consumption and increased carbon footprint cannot be disputed. Dhakal (2010) shows that concentrated urban places such as those in China, the USA and Europe, as depicted by energy usage of 85%, 80% and 69%, respectively, correlate with the adverse effects of the carbon footprint those countries experience.

2.7. Consequences of greenhouse emissions in South Africa

The GHG emission matter captivates the world in terms of its direct and indirect consequences, not only in global climate change terms but also its condescending impact on economies, famine, drought, and ecological and health consequences. Unanimous consensus points to GHG emissions as having dangerous effects and diverse direct and indirect effects not situated to particular borders.

GHG emissions are varied, and their effects are multidimensional. The heavy dependency on coal for electricity generation makes it a dirty source of energy in South Africa due to its massive carbon footprint on the economy (Borel-Saladin, 2013; Shongwe, 2018). Because of this, the present study mainly focuses on the effects of fossil-fuel consumption and coal having a considerable share.

Globally, coal power generation is the primary cause of GHG and toxic airborne emissions. The World Health Organisation reported in 2006 that coal is a leading contributor to pollution and its toxicity a major cause of human deaths. The fine Particulate Matter ($PM_{2.5}$) released by its combustion is responsible for causing cancer and stroke in coal-energy-dependent

economies like South Africa. A range of respiratory and cardiovascular diseases from coal combustion have similarly been found to lead to morbidity and premature mortality (Oberschelp et al., 2019).

Studies prove that coal combustion continues to be more hazardous than anticipated. WHO (2006) reveals that the sulphur-dioxide (SO_2) released in its combustion is associated with respiratory and all-age mortality, which have been a consistent burden to workers in coal industrial point places. Studies continue to reveal that GHG emission-induced effects are diverse. Mercury, another highly toxic element associated with natural but mainly industrial point anthropogenic sources such as fossil-fuel-fired power plants, non-ferrous metals manufacturing, cement production and caustic soda production, is known for its potential to affect child brain development (Pirrone *et al*., 2010).

Although the economic impact would differ from country to country, it is argued that the significant reduction in coal use and the concomitant closure of coal mines and coal-burning power plants will result in substantially cleaner air, reductions in respiratory problems such as asthma, less heart disease, fewer hospitalizations, and other health benefits (Finkelman, 2021). The mining method, whether opencast or underground, aids the release of methane, which is listed as one of the GHGs, and is found to be more potent than carbon dioxide in terms of effect. Dunes and solid waste created after mining and mine backfills continue releasing methane in the atmosphere and water bodies where leakages exist.

Munnik, Hochmann, Hlabane and Law (2010) found coal mining consequences disturbing and destructive to the environment. The scholars particularly find opencast mining very destructive in so many ways to recount. The mining removes volumes of soil and rock overburden to get to coal seams and destroys regional aquifers. Leachate, a waste from coal heaps, is acidic, adding to the dangers of finding itself in mine drainage, which also interferes with underground and surface water.

Coal processing also has its dangers of waste and ignition. For example, solid waste dunes created after mining are susceptible to spontaneous combustion (Munnik *et al*., 2010). Commercial coal combustion has attracted concerns as it leads to GHG releases, including carbon dioxide, which are enormously fed into the atmosphere from activities such as intensive electricity generation. The concerns around these emissions have recently been highlighted by even the refusal of banks and other funding sources to provide financial

support for coal-related projects (Finkelman, 2021).

Coal is also a major input for electricity generation; most of it is used to power coal-fired plants. Coal dependency has had resultant negative consequences for many years. Lloyd (2002) estimated that coal combustion released about 170 million tons of carbon dioxide in the atmosphere annually, 0.7 million tons of Nitrogen oxide and 1.5 million tons of sulphur oxide. To date, electricity generation dependency on coal remains the single most dominant factor of air pollution. The latest patterns showing an increase in its use to sustain economic growth (Khobai & Le-Roux, 2017) means that GHG emission levels also move in tandem with it unless green solutions are sought to control the emissions.

The Department of Environmental Affairs and Tourism reported as far back as 18 years in the 2006 report indicated that the heavy industrial use of coal for steel and alloyed products manufacture, its transportation, and indoor heating and cooking is acknowledged as a significant health hazard (DEAT, 2006).

2.8. The DPWI's National Green Building Policy Framework

Environmental degradation caused by human activities has become evident in the actual effort by national and supranational governments, businesses and influential persons to prevent it. Climate change, mainly depicted and spearheaded by the United Nations (UN) and its related protocols, occupies conversations on sustainable development to manage adverse effects from human activity that could easily put the world in more peril.

The above observations have offered impetus to Green Building as one of the concepts that solicit a response to activities that endanger the environment regarding the construction industry (Kibert, 2016). Response to environmental degradation initially focused on land use, industrial, manufacturing and transportation activities. However, Windapo and Goulding (2015) highlight that mitigation measures have equally shifted to the construction sector to recognise not only its contribution to economic development but also the negative effect its activities impose on the environment.

In the context of established industries, Green Building is a relatively new concept in the much-publicised global concern for sustainable development. Its definition varies, but its intended strategic outcomes towards its achievement are in sync (Nhamo & Nhamo, 2014),

as they are all intended to mitigate environmental degradation. Similarly known as Green Construction or Sustainable Building, the concept refers to processes, structures and applications, which are environmentally responsible and resource-efficient throughout a building's lifecycle. Its processes relate to planning, design, construction, operation, maintenance, renovation and demolition (EPA, 2016). Kolev and Creation (2009) also stress that Green Building is a concept that relates to buildings designed to use fewer resources yet are durable and recyclable once their purposes have been served (Windapo, 2014).

The Department of Public Works and Infrastructure (DPWI) in 2011 through the National Framework on Green Building in South Africa (NFGBSA) expounded on this understanding that Green Building is part of the broader Green Economy canvas that seeks to improve human beings as well as their social equity while significantly reducing on environmental risks and ecological scarcities. The DPW (2011) continues to affirm that the centrality of buildings and the built environment requires that they be factored, as one of the initiatives, into sustainable development and the green economy. This understanding has triggered focus and ratification of legislations and policies towards its proper implementation (Rovers, 2003).

Besides the need for environmental sustainability, other critical drivers for Green Building worth noting in South Africa are exceptionally linked to socio-economic challenges, including unemployment and the high carton footprint in the country (Borel-Saladin & Turok, 2013).

Studies citing drivers for Green Building have been done in other countries besides South Africa. For example, in the US, Kibert (2016) notes that the rapid growth of the Leadership in Energy and Environmental Design (LEED) Green Building rating system, increase in Green Building council membership, government, and private sector incentives, strong government leadership, expansion of state and local Green Building programs and advances in the Green Building technology are the key drivers to the green movement.

In New Zealand, green building is driven by the sustainable development of commercial properties, environmental impact, tenant demand, financial benefits, and corporate social responsibility (Bond & Perrett, 2012).

In Australia, tenants and investors seem to influence Green Building considerably. Bond (2010) documented that the tenants' demand for Green Buildings is high but is not matched

by their willingness to pay for the additional investment. He adds that Green Building is a key dynamic for investors as a value add because its inclusion in construction boosts property sales (Bond, 2010). Kibert (2016) corroborates this view when he finds that the green building movement embeds itself in standards for long-term business opportunities for designers and builders. Of note, however, is the consensus that in the desire to achieve sustainable development, policies addressing green buildings differ from country to country due to differences in regional-specific requirements (King & King, 2004).

Recognizing the risk of environmental degradation and global warming, South Africa committed to these challenges through Green Policy formulation (Agyepong & Nhamo, 2018). The Green Building Framework was adopted in 2011 and later migrated to a DPWI Green Building Policy, which is the official position towards Green Building for the government in the built environment. The three-tier Green Building Framework applies to national, provincial and local governments (van Wyk, 2012). The three-tier arrangement is meant to align future developments of national estates following sustainable building. In its ambit, the framework necessitates that all activities occur within the country's legal, regulatory, and administrative frameworks.

The Green Building Framework is aligned with other legislative and policy frameworks and international conventions of which South Africa is a co-signatory (van Wyk, 2012). Regarding the international convention, the framework is aligned with the Rio Declaration (Agenda 21) of 1992, the Kyoto Protocol of 1997 and the Paris Agreement on SDGs of 2015 as the fundamental conventions. To national legislation and national policy frameworks, NFGBSA is aligned to the Energy Efficiency Strategy (DEAT, 2002; DoE, 2012), the “National Climate Change Response White Paper” (DEAT, 2011; DPW, 2011) and other key policies such as the New Growth Path and the Industrial Policy Action Plan and Integrated Development Plan (IDP).

As per the constitutional mandate, The Department of Public Works and Infrastructure (DPWI) is the custodian of the State-owned property portfolio, responsible for the accommodation of national Government Departments (DPWI, 2021). In addition, the DPWI provides strategic leadership in the property and construction industries, ensuring compliance with policy and legislative prescripts particularly related to managing state-owned and leased-in immovable assets. Thus, The Department is an authority on Green Building, further guiding Provincial Departments of Public Works & Infrastructure through

the Green Building Policy, which applies to National and Provincial Departments. The policy implementation and reporting are done through the DPWI Green Building Programme, which encompasses the following subsets (DPWI, 2016):

1. Green Building planning and rating;
2. DPW Green Building Norms & Standards;
3. Energy Efficiency and Water Efficiency;
4. Embedded Renewable Energy generation;
5. Sustainable Waste Management;
6. Building Retrofitting;
7. Indigenous Knowledge Systems (IKS) & Biodiversity; and
8. Eco-labelling of building materials and fittings (ecoASA).

The DPWI Green Building Policy in South Africa is also linked to the following policies and prescripts (DPWI, 2016):

i. National Environmental Management Act (NEMA) 107 of 1998 (Government Gazette, 2009);
ii. National Environment Act: Waste Act 59 of 2008;
iii. National Building Regulation and Buildings Standards Act 103 of 1977 (Government Gazette, 1985);
iv. National Climate Change and Adaptation Strategy;
v. National Energy Efficiency Strategy; and
vi. National Development Plan Vision 2030.

In a local sphere of government, the city of Cape Town pioneered the principle of incorporating Green Building guidelines. However, the pathway to meeting this objective is challenging (Greyling, Patel & Davison, 2016). Other cities such as the City of Johannesburg, City of Tshwane, Ekurhuleni, eThekwini and Nelson Mandela Bay, together with the City of Cape Town, have their respective environmental policies as depicted in the table below:

Table 5: Environmental policies in key cities of South Africa (Source: Agyepong & Nhamo, 2017)

Metropolitan	Name of environmental policy	Year
City of Cape Town	Integrated metropolitan environmental policy	2003
City of Johannesburg	Environmental management framework	2000
City of Tshwane	Tshwane integrated environmental policy	2005
Ekurhuleni	Environmental policy	2006
Ekurhuleni	Environmental policy and implementation plan	2013
eThekwini	Environmental policy (construction)	2002
eThekwini	Environmental management policy	2005
Nelson Mandela Bay	Integrated environmental policy	2012

In line with the global outlook, as a developing country, South Africa has a vast potential to achieve balance in the sustainability of its environment whilst achieving development for its people through economic activities of the built environment (IPCC, 2007).

According to the 4th Assessment of the Intergovernmental Panel on Climate Change, the building sector also has the greatest potential for delivering substantial reductions in emissions at low or no cost or net savings to developed and developing countries (IPCC, 2007).

Various national policies and prescripts have been implemented to ensure that South Africa achieves nationally determined mitigation actions and a clear trajectory towards a Green Economy and provides for sector-based interventions such as Green Building. In addition, through the National Development Plan, vision 2030, the Green Economy has been identified as a pathway to achieve development and a shared economy for the country (NDP, 2013).

There remains vast potential for a rapid increase in the rollout of Green Building interventions such as embedded Renewable Energy (RE) generation, which is energy generation for use in the same facility where RE technology is installed. This is based on the fact that there is increasing uptake of the technologies on the back of appreciation that there have been reduced costs associated with Renewable Energy technologies over the years, including its ability to offer cheaper costs per kWh generated. Global uptake of Renewable Energy has grown by 45% in 2020 (IEA, 2021). The International Energy Agency predicts positively that Renewable Energy installations will become the new normal.

With South Africa experiencing rolling power blackouts, commonly referred to as load

shedding, Renewable Energy rollout in the country is also projected to grow exponentially. For instance, the Government recently released an emergency plan to gain private sector support for independent power production. With an undertaking, the country would significantly increase its Renewable Energy procurement to more than 5,000 megawatts and increase incentives use of rooftop solar panels (Ramaphosa, 2022).

2.9. Green Building Policy Frameworks in the SADC Region and Internationally

Green Building has stopped being considered a passing fad but a universal concept resonating well with countries seeking to meet environmental degradation challenges through sustainable development initiatives.

Unlike developed countries, emerging economies, especially those in Africa, fall short of the necessary expertise for Green Building and its successful implementation (CAD & GIZ, 2016). In addition, most sub-Saharan African populations are poor, heavily reliant on crude biomass sources for energy requirements, and lack awareness because the concept of green building is still evolving (du Plessis, 2005). Nonetheless, a strong case for Green Building exists as a deliberate and significant part rather than a by the way ingredient of the Green Economy. Unfortunately, only selected countries have strived towards this achievement in Africa, while many rely on international donors for the required investments (Nhamo & Nhamo, 2014).

This recognition, although pertinent to individual countries, applies to regional bodies, and the Southern African Development Community (SADC), an intergovernmental organisation comprising 16 countries of the Southern African block (Schenoni, 2018).

SADC's commitment to sustainable use and management of the environment in the fight against poverty and food insecurity is unwavering. The body's commitment to sustainable development is reflected in participating, endorsing, and ratifying major Multilateral Environmental Agreements (MEAs).

SADC also endeavours to put in place implementation mechanisms for MEAs, with the key ones noted as the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), and United Nations Convention on Biological Diversity (CBD) (SADC, 2012).

SADC's Green Building is not specifically pointed out but is broadly interwoven in the Green Growth Paradigm, which draws from the strong notion of sustainability (Nhamo & Nhamo, 2014). As a critical imperative of SADC member states, Green Growth hinges on environmental sustainability, economic well-being and social equity. While this intergovernmental body seeks to mobilise member governments to reframe policies to build a sustainable pathway for growth and contribute to green investment, job creation, poverty eradication, and resource efficiency, this broad reference is where SADC comes closer to Green Building.

Internationally, besides the supranational organisation such as the UN, individual countries such as the US depict a well-conceived green building concept. In Yudelson's (2016) readings, the green building movement has become a marvel considering its success and the numerous lessons towards its achievement in the US. Government agencies are credited for their lead role in helping establish LEED, the country's prime green building rating system (Yudelson, 2016). This success is credited explicitly to the United States Green Building Council (USGBC), which managed to influence the formulation of legislation and policies and remains influential in lobbying the government for incentives, regulations and policies backing LEED. LEED is widely acknowledged for its tremendous work aiding the certification of about 3,350 projects in the country.

2.10. Green Building Technologies and Innovations in South Africa

Green building has recently become a widely accepted phenomenon for implementing sustainable development. As it evolves, it becomes a key concern in the construction sector, especially in South Africa.

The World Commission on Environment and Development (WCED, 1987) defines sustainable development as the development that seeks to meet the present needs without compromising the ability of future generations to meet their own needs. Therefore, the impetus for Green Building Technologies (GBT) as part of the green economy phenomenon in the construction sector can be drawn from the definition. Furthermore, the case for GBT can be motivated by the statistics representing the negative impact the built environment renders on the environment in general. Darko, Chan, Ameyaw and Olanipekum (2017) state that the built environment can be significant in how it impacts the environment in either

positive or negative ways, depending on the technologies used in construction, maintenance, and refurbishment.

Yudelson (2007) gives statistical evidence that the built environment can be hazardous and dangerous to the environment and every living creature subsisting in it. The scholar shows that buildings account for 40% of all global carbon dioxide emissions due to their energy and other resource dependency levels.

This view is also corroborated by the findings of the World Business Council of Sustainable Development (WBCSD, 2007) on the resource dependency of buildings in the US. Comstock (2013), in tandem with (WBCSD, 2007), shows that globally, buildings account for 40% of energy use, 38% of greenhouse gas emissions, 12% of potable water and 20% of solid waste streams in developed countries. Darko *et al.* (2017) show that in the US, buildings consume about 68% of all electricity, 80% of portable water supplies, 12% of fresh water supplies, 40% of raw materials and that they are responsible for 20% of solid waste streams. The US EIA (2010) also projects that the situation will worsen when it is indicated that by 2030, the GHG global emissions by buildings will increase by 43% from the lower statistical levels depicted in the 2007 studies.

The above statistics are very concerning, but justifiably, they give credence to sustainable innovations in the construction industry to address the disparities. In their wide-ranging categories, green building initiatives are technologies, innovations, and processes that efficiently use water, electricity, land, and other materials as key resources. Green building initiative aims to enhance health, environment, productivity and economic performance (USGBC, 2003).

GBTs are said to be evolving radically. Studies show that their promotion as part of meeting the sustainable development challenges stimulates their development (Zhang, Platten & Shen, 2011a; Zhang, Shen & Wu, 2011b). Scholars concede that GBTs are an offshoot of innovation and need to be recognised as part of the green building narrative. Lam, Chan, Chau, Poon and Chun (2009) note that GBT innovations relate to green specifications; Potbhare, Syal and Korkmaz (2009) to green building guidelines; while Love, Niedzweicki, Bullen and Edwards (2011) relate GBTs to wind turbine and solar panels.

Nevertheless, Darko *et al*. (2017) observe that GBT innovations stem from the need to meet prerequisites such as those meeting energy efficiency, environmental friendliness, and water and electricity efficiency. Some of the examples fitting this prerequisite include highly efficient windows, green roofs, solar shading devices, solar water heaters, greywater treatment plants and highly efficient Heating, Ventilating, and Air Conditioning (HVAC) systems —now highly considered in the construction industry (Koebel, McCoy, Sanderford, Franck & Keefe 2015).

The GBTs utilised in South Africa do not differ very much from the examples given above. What needs to be noted is that the country has one of the best solar resources, also complemented by wind energy in some areas. Other technologies evolving to supplement the energy mix and attractive to green building in the country are the biofuel and biogas industries (Maia *et al*., 2011).

In their report on green jobs, Maia et al. (2011) also help to understand the reasons for GBTs' choice in the country. From their report, Green Building Technology adoption in the country is driven by energy generated from sustainable, renewable and other energy sources with low GHG emissions. Their report also reveals that the GBT choice in the country is driven by energy efficiency aimed at reducing energy consumption. GBTs meeting this requirement are solar water heating, industrial equipment and public transport. Other GBT choice influences are emission and pollution mitigation, together with natural resource management (Maia *et al.,* 2011).

Regarding GBT adoption, South Africa surpasses many countries worldwide, especially those on the African continent. In the Green Building Handbook for the country, van Wyk (2017) reveals several innovations that have been undertaken to deal with the sustainability dilemma. For example, in most commercial buildings such as malls, it is divulged that designs for the construction are orientated towards the environment, integrating rainwater harvesting systems to meet water shortages in the country, natural lighting and energy-efficient lighting to reduce energy consumption, energy efficient mechanical ventilation and fuel-efficient vehicles for transportation. This includes human or user comfort and experience interacting with the buildings.

During construction, waste production is minimised, repurposed and diverted from landfills to own recycling facilities to implement waste and recycling management plans (van Wyk,

2017).

By way of example, Menlyn Shopping Mall, located in Pretoria, South Africa, said to be the biggest and largest in Africa, received certification from the Green Building Council of South Africa (GBCSA) for sustainable interventions. The mall provides ample space for shopping, socialising, dining and recreation, thus tapping into some level of increasing consumer green product adoption activism (Makhitha, 2021). This look and feel widen to the adjoining Menlyn Maine precinct, designed as a green precinct.

Another example is clay bricks, which are an architectural heritage on construction sites in South Africa. Their adoption from production to use reflects their response to sustainable construction. Clay bricks are acclaimed for their tenacity against rot, tarnish, puncture, fade, rust, scuff, peel, erode or burn—qualities that can make them last for over 100 years. Claybrick.org (n.d.) gives an elaborate list of benefits of using clay bricks in construction. For instance, clay bricks are known for their structural integrity due to high load-bearing capacity, high dimensional stability and compression strength that limits cracking, making them last for an aeon. Testimony to this benefit is the Bell Tower at the Castle of Good Hope in Cape Town, built with clay bricks and still standing since 1684 (Claybrick.org, n.d.).

Clay bricks are incombustible, making them resistant to the start or rapid spread of fire; they are water resistant, impervious to all kinds of weather, and durable under severe climatic zones and industrial areas where high acid and alkaline discharge occur. These qualities help them fetch low maintenance costs during their lifecycle, equally helping mitigate the carbon debt associated with painting, refurbishment and replacement. Furthermore, their thermal mass makes them self-regulating in terms of temperature. This makes them adaptable to all kinds of weather. When exposed to cold weather, they become warmer; the reverse is true during hot weather. This adaptability could also yield health benefits but, most importantly, reduces energy consumption and its attendant costs. Regarding style, bricks offer diverse bonding relating to patterns, shape, texture and colour (Claybrick.org, n.d).

Another key benefit of using clay bricks is their flexibility, which winds down costs. Claybrick.org (n.d.) prides itself in clay bricks for their modular sizes that enable speedy construction, less use of mortar, ease in transportation in any transportation mode, ease in relocation onsite, construction waste minimisation and above all, recyclable.

The case for Green Building is heavily embedded in the efficient utilisation of resources, be it in energy, water or other materials. With low annual rainfall and limited groundwater due to porous aquifers, South Africa considers renewable water sources as one of the sustainable construction methods to supplement water scarcity in the country. In Cape Town, the numerous renewable water initiatives are deemed a conservation management option to water shortages in the city. van Wyk (2017) affirms that renewable water initiatives, as depicted in Cape Town, can also be a future trend for other cities in South Africa. Water scarcity coupled with climate change projections of a hotter and drier future has triggered new water conservation methods and efficiency measures.

To understand how this works, FAO (2017) defines renewable water sources as those with an average annual water inflow from surface water and groundwater. Based on that knowledge, several water sources have been harvested for recycling and reuse. These include rainwater, stormwater, greywater, and groundwater and condensate water. In addition, non-conventional resources have also been explored, including producing freshwater by desalinating brackish or salt and reusing waste. In this category, there is also black water harvesting, the practice of harvesting water from toilets and sinks (van Wyk, 2017).

The shift in use from Ordinary Portland Cement (OPC) to metakaolin (MK) is another ingenious global innovation in the construction sector. To appreciate this shift, it must be mentioned that OPC production has a high energy intensity related to GHG emissions, especially carbon dioxide (Suryawanshi *et al.,* 2015). Rashad and Zeedan (2011) posit that OPC production is highly toxic. The scholars estimate that for 1 ton of OPC generated, 0.8 ton of carbon dioxide is launched into the atmosphere.

The cement industry is also attributed to contributing to 5-7% of total carbon emission globally (Krajči *et al.,* 2015), which the scholars admit needs to be replaced with sustainable production materials that can eventually lead to reductions in both energy consumption and GHG emissions. The solution has been found in Supplementary Cementitious Materials (SCM), scoring high on energy consumption reductions and low GHG emissions. Dinaka (2013) and Rashad (2013) share that SCMs such as fly ash, silica fume and ground granulated blast furnace slag significantly boost the strength and durability characteristics of concrete in comparison to ordinary Portland cement (OPC) alone. In South Africa, SCMs materials are abundantly available despite the geographical problem associated with their

availability. For example, in the “Green Building Guideline” edited by Van Wyk (2017); Dumane and Mapiravani (2017) report that fly ash can be found in Mpumalanga, and slags and silica fumes are localised to smelters in the Gauteng and North West provinces.

The use of MK globally, and particularly in South Africa, is seen as a perfect solution for OPC. This is because MK has pozzolanic properties (Si-Ahmed, Belakrouf & Kenai, 2012) that are found to increase strength and durability, mitigate alkali-silica reactivity and improve the workability of concrete (Aiswarya, Prince Arulraj & Dilip, 2013).

Specific to the use of environmentally sustainable construction, Indigenous Knowledge Systems and Technologies have been used for millennia by indigenous communities in Africa and the world but have found little to no application in formal built environments, particularly in South Africa. The researcher suggests there is a case for the incorporation of rammed earth in Green Building projects. Rammed earth is an immediate and natural sustainable alternative building material comprising sub-soil as a primary constituent, i.e. clay: 15-25%, sand: 50-60%, gravel: 15-20%, water: 8-12%, with or without stabilizer like cement: 3-5%. All are rammed into required formwork and walls, consuming much less energy, water and other resources than brick and mortar (Khadka, 2020).

Based on lab results and site application, the stability and strength of rammed earth (1.5 – 6.5 MPa), including other benefits such as sound and water resistance, make it a viable option for application in housing and specific commercial construction applications (Khadka, 2020). The researcher believes that in South Africa, this application could include constructing facilities such as police stations, schools, community halls and recreational facilities, and certain military facilities.

Through the Department of Public Work’s Green Building Programme, an Eco-labelling scheme for building materials has been established under a DPWI entity, Agrément South Africa. This entity is responsible for assessing and certifying non-conventional innovative building materials. As part of the initial nine materials to be specified for eco-labelling, rammed earth has been identified for specification under EcoASA, with the participation of sector stakeholders and promoted for use by the sector (Agrément SA, 2022).

This trajectory represents a critical paradigm shift and presents a vast potential for skills development, enterprise development, and creating green jobs working with communities

with indigenous knowledge and skills building with earth. There are projects across the globe (including South Africa) where this ancient indigenous building art has been successfully combined with modern engineering in structural design, thermal modelling, mix design, and construction methodology (Dobson, 2015).

Moreover, rammed earth buildings present an amazing complexity and beauty, with long life, fire resistance, nil toxicity, and fast to build (Dobson, 2015).

Real challenges are associated with the South African construction sector's dependence on conventional legacy models. Like in other regions across the globe, people's biggest expenditure and investment is in the built environment, for example, in purchasing a house, given that a house fulfils a fundamental need for human habitation (Mahachi, 2021).

There is, however, a massive housing backlog in South Africa's subsidized housing market, standing at around 2.3 million houses, further complicated by the high cost of building materials and a general reluctance by the construction industry to embrace innovation and technological advancements needed for the fast delivery of housing and other public facilities (Mahachi, 2021). As a result, there is an almost unique slow uptake of using Alternative Building Technologies in South Africa compared to other countries.

However, a real opportunity exists for the built environment (through Green Building) to use sustainable and innovative construction technologies, including 3D printing, to fast-track delivery of construction projects, such as quality housing and public facilities, whilst reducing the impact on the environment coursed by conventional materials. For example, the production of 1 ton of cement is accompanied by the release of 1 ton of carbon dioxide into the atmosphere (Mahachi, 2021). A reduction of the use of cement thus carries with it significant benefits for the environment.

Moreover, unlike the housing market, the researcher suggests that the commercial property sector, State-owned entities, and infrastructure departments such as DPWI have an opportunity to increase their demand for the construction sector to offer Green Building innovations and technologies.

This section showed the different innovations and technologies in the construction sector. It also showed that the numerous technologies and innovations deployed in the built

environment to respond to sustainable construction are inexhaustible. South Africa, as it was indicated, remains the leading country in Africa in spearheading green building initiatives because the green building sector is also growing exponentially (Rogerson, 2014).

Markedly, the section showed that adopting Green Building Technologies and their related innovations underlies the core principle of sustainable development in all aspects of its operations, products and services, with the view of increasing and optimising efficiencies and minimising costs. The following section explores the green building phenomenon imbibed into the socio-economic imperatives of the green economy concept.

2.11. Green Building Impact on Enterprise Development and Job Creation

The green economy concept has moved beyond environmental boundaries to politics and business in response to the crisis predisposed by global climate change and economic crises (Borel-Saladin & Turok, 2013).

Orientating the economy towards greening in South Africa is particularly an imperative aimed at achieving different objectives besides mitigation of the impact of GHG emissions on the economy. Resnick, Tarp and Thurlow (2012) state that Green Building, an offshoot of the broader green growth concept, has emerged to meet other valued outcomes such as addressing exceptional unemployment levels South Africa is currently experiencing, poverty alleviation and high economic growth. Ahn, Pearce, Wang and Wang (2013) also make a case for Green Building and its benefits beyond the environmental ones, arguing that numerous opportunities in reduced lifecycle costs, poverty eradication, and job creation will be experienced.

Coupled with an increasing interest in overall Green Building projects by property owners seeking to improve the overall economic value and performance of their buildings in South Africa (GBCSA, 2022), the sector is geared for an overall increase in its potential to significantly improve its contribution to the South African economy specific to the number of green jobs, skills development, and enterprises developed, including the use of innovations and technologies.

In this regard, the DPWI Green Building Policy remains a significant prescript in providing leadership to the built environment as a sector in meeting its contribution to realising a developmental and sustainable green economy.

Aligned to the researcher's ontology, it has been noted that for a long time, African countries have been (and some continue to be) developmental states in their aspirations and economic performance (Mkandawire, 2001). A lot more certainly needs to be done since that observation, particularly post the recent pandemic, has taxed global economies. Nevertheless, one holds a view that many more opportunities have since opened up, and the race for providing clean energy, food, and water security allows many African countries to become such developmental states.

One further suggests that identifying and understanding the link between a developmental state and a Green Economy trajectory is essential for development. In this regard, a developmental state has two critical elements to consider: capacity and commitment to development (Routley, 2014). It has been postulated that although a developmental state does not always lead to economic growth, establishing one remains vital for development, given other unforeseen external shocks to the system (Mkandawire, 2001). Similarly, it is upheld that achieving a Green Economy and meeting SDGs is critical to combat climate change (UNDP, 2015), with the researcher emphasizing that even if such a green economy were not to translate to economic growth immediately.

One holds that these two concepts and undertakings, namely achieving a developmental state and a green economy, remain relevant and necessary for South Africa and other global economies for the development and coexistence of people and the planet, whether such development does or does not immediately attract economic growth. These remain an existential necessity.

However, it is mutually beneficial for government, industry, and the community that a Green Economy trajectory, notably Green Building, attracts significant savings and a return on investment whilst offering increased socio-economic opportunities through Enterprise Development and the creation of Green Jobs (UNEP-SBCI, 2014).

The trajectory towards a green economy, through many interventions, including Green Building, provides South Africa with an opportunity to achieve development and diversification of economic activity.

Key amongst these socio-economic imperatives is the achievement and creation of green jobs, enterprise development, localisation, innovation, technology mobilization and skills development whilst achieving a balance between societal development and sustainability of the environment (UNDP, 2015).

In the NPC National Development Plan Vision 2030, a case for leveraging the green economy to create new employment opportunities, deeper industrialisation and energy efficiency potentially and significantly, and its likely trade-offs is underpinned (NPC, 2011).

Musango, Brent and Bassi (2014) see the green building concept as pertinent in shaping development strategies and economic growth due to its potential to attract funding, which can support enterprise development and job creation. In light of funding opportunities, NPC (2011) notes that funds from the National Treasury, the Department of Economic Development and the Department of Energy will be earmarked to catalyse investment in the public and private sectors. This will be particularly important for and in the renewable energy sector, manufacturing capacity development across a range of technology options, infrastructure grants to local government and public-private partnerships.

Similarly, the Industrial Development Corporation (IDC), in line with NGP, established Green Industries Special Business Unit in 2011 to provide funding for industries in the realm of clean production methods, clean energy generation, increased energy efficiency, pollution mitigation, waste reduction and biofuel development to mention but a few (IDC, 2011).

It is envisioned that one of the job creation opportunities brought by sustainable construction, for example, will involve higher local content, especially in the energy sector. However, trade-offs will be experienced in fossil-fuel-based economic activities. As already seen, the need to cut down on GHG emissions warrants lessening dependence on fossil fuels, especially coal, which will likely affect job creation.

Increased use of clay bricks as an architectural heritage for sustainable South African construction also helps prove the point for local content. Van Wyk (2017) and Claybrick.org

(n.d.) show that brick production helps utilise local materials and labour in local environments. The same opportunities are envisaged in the production of metakaolin cement due to the abundant availability of supplementary cementitious materials (SCMs) for its production in Mpumalanga, Gauteng and the North West Provinces (Van Wyk, 2017).

The issue of skills development is equally aligned with greening, which on its own can yield broader benefits (Musango, Brent & Bassi, 2014). Resnick, Tarp and Thurlow (2012) reinforce this view when they divulge that transferring technology and technical skills can be essential for catalysing growth and bolstering local job creation. They continue to illustrate that paying attention to facilitating the transition to new production techniques can be significant for growth but recommend paying more attention to reducing resistance to transitions like these among losers of reform.

NPC (2011) affirms new initiatives in agriculture and conservation efforts pertinent to green economies to create new opportunities potentially. Already in South Africa, Green Economy zones are showing great potential to create Green Jobs, as NPC (2011:281) says, “Where short-term state intervention could leverage significant private development. In addition, it is indicated that areas such as the Northern Cape are offering the potential for solar and wind energy (NPC, 2011).

In one of their six priority objectives, the New Growth Path (NGP) cites huge potential towards job creation in the green economy. As a policy initiative, NGP aims to drive economic growth towards more labour-intensive industries in their quest to achieve about 5 million jobs by 2020. To achieve this, a ‘Green Economy Accord’ was signed in 2011 by stakeholders with the government as the principal, private businesses, labour unions and civil society. The accord aims to create about 300,000 jobs in activities related to the Green Economy by 2020 (Department of Economic Development, 2011).

The category of opportunities cited fall in the realms of manufacturing, construction and installation of renewable energy plants and equipment such as solar panels, trackers, mirrors, metal frames, glass, wind-turbines blades, towers, turbines and turbine components, electricity inverters and electricity co-generation. Others in this category include local manufacture and installation of solar water heaters. Furthermore, in the recycling sector, the opportunity will arise from the creation of small enterprises to beneficiate landfill sites, turning construction rubble into bricks, plastic into planks and

garden compost and agricultural fertilisers, retrofitting existing buildings with energy-efficient equipment, biogas and biofuel, among others (Department of Economic Development, 2011).

The Industrial Policy Action Plan and the “National Climate Change Response Strategy” white paper also outlined the need to improve energy efficiency and develop green industries, with opportunities for enterprise development and job creation.

In their preliminary assessment of the impact of the green economy on jobs in South Africa, Borel-Saladin and Turok (2013) argue that the impact of the green economy has had due consequences for both job gain and job loss. They argue that jobs in fossil-fuel-based industries will be lost due to Greening Policies. Nevertheless, they also observe that many jobs will be created in the short term, especially in the construction, manufacturing and installation phases of various Green Technologies.

The researcher suggests that the question worth pondering is the sustainability of green jobs growth and how many jobs will be created over time. However, one holds that industries and processes will likely produce new opportunities because of the innovation required to sustain the Green Economy, including diffusion and transfer of technologies (Eaton, 2013).

On the use of Indigenous Knowledge Systems, there is again a real opportunity to attract a labour-intensive model in the use of rammed earth for the construction of certain public facilities, given that with rammed earth, it is easy to work with local labour through easy to transfer skills (Dobson, 2015).

Using Green Building technologies does not remove job creation but provides opportunities through the construction value chain. With 3D printing, for example, the walling system is possibly about 30% of a completed house. Therefore, labour is still required to excavate and prepare platforms, roofing, carpentry, and electrical installation. Consequently, the role of the community and opportunities for Green Jobs is still applicable even when using a 3D printer to print the walls (Mahachi, 2021).

Moreover, the concept of Green Building comes with an element of Green Roofs, which provide several environmental benefits in urban cities and can also create habitat for living organisms, thus enhancing biodiversity (Hui & Chan, 2011). Biodiversity is a specific SDG

goal, implying the protection of local life and plant species (UN, 2015). This provides an opportunity to work with local communities, to upskill people in the management of their local biodiversity in order to supply to the built environment and Government during the construction and maintenance of green buildings and facilities.

Given the potential to create jobs and develop skills using an array of innovative materials and technologies, including indigenous architecture, for instance, rammed earth. One suggests that disruptive Green Innovation and Technologies are fundamental in enabling the built environment to contribute to development, economic growth, and socio-economic imperatives beyond technical advancements.

2.12. The Da Vinci TIPS Managerial Leadership Framework in Context of Green Building

As part of literature review the researcher engaged literature on a model through which various paradigm, propositions, learned project experiences on sustainable building from diverse feeders can be consolidated, understood with linkages created, and managed. As a cornerstone of managerial leadership, the DaVinci School of Business has developed a unique Managerial Leadership Framework, which has a focus on cooperative engagement and enables leaders within organisations to apply managerial leadership through the lens of the management of Technology, Innovation, People and Systems (TIPS) (DaVinci, 2018).

Through the TIPS Managerial Leadership Framework, sectoral and community engagement, at local, regional, and global community is possible to achieve organisational learning, development, and use of elements such as culture as a strategic architecture (Viljoen, 2018). Organisations in this regard gain an advantage in understanding the use of technology, innovation, people, and systems as a competitive edge, beyond financial performance (TT100, 2019).

The technology component draws from an understanding of doing things better, with continuous improvements, using tools and metrics, computer software and/or high-tech, hand-held tools referred to as gadgets, to project management, all geared at best positioning a company or organisational product or service in the market (TT100, 2019).

The management of innovation component is concerned with how an organisation stimulates and capitalises on an innate human attribute such as ideation, an imagination and application of things which are not as if they were, to develop or improve innovative products, systems, and services with commercial or social value (DaVinci, 2019).

The ‘p’ in TIPs pertains to human interface, at the level of end users, employees, and the various stakeholders. The Management of People (MoP) includes change management, capacity development, training and upskilling, motivation, diversity management, couching, customer services, including the management of end-user experience (UX) (TT100, 2019).

The final element of the TIPS Managerial Leadership Framework is Management of Systems, which entails organisational activities and performance being used to find solutions, and re-engineered is implemented to create a hyper-competitive redesign of the environment can be created (DaVinci, 2019).

TIPS system provides for paradigms such as ‘**agility**’, which integrates the dynamics of Management of Technology, and Management of Innovation. Agility requires organisations to improve and adapt as an organisation develops, it also improves and adapts technology needs and appropriate innovation is designed to get better market value and profitability of the business concerned (DaVinci, 2019).

The systems further provide for ‘**alignment**’, which specifically links the imperative of Management of Technology and Management of People, as it provides for up-skilling, this element is measured in terms of total up-skilling costs, achieved through development or recruitment of relevant skills. This is to ensure that organisation can at any time offer the best human capacity to produce relevant or best in market technology and innovation (DaVinci, 2019).

TIPS has the element of ‘**engagement**’, which one argues is the most important. Engagement seeks to assess the level of commitment and motivation of people in the workplace, and is specifically a link between the Management of People and the Management of Innovation. Engaged people are measured by how they take initiative and accountability. It is also measured by incentive cost of the organisation (TT100, 2019).

The Framework promotes the appreciation of varied levels, such as understanding the Meso

and Exo environments in order to establish the required ‘agility’ as an organisation with entrenched collaboration. The Micro and Macro contexts are drawn upon to promote when it comes to organiations being ‘aligned’ and engaged.

In context, whilst a number of propositions and offerings have been presented on Management Leadership, the TIPS Framework has a unique approach in how it consolidates the various elements and interrelations with each other. Such as the Management of Technology and Management of People being indicative of engaged people, whilst the Management of Innovation and Management of People reflect engaged people in an organisation. In application, Meso, Exco, Micro, Macro are scales that can be mobilised in Social analysis (Serpa & Ferriera, 2019).

To understand the application of the analysis and scales in relation to micro and macro levels, Serpa and Ferriera (2019) state that “micro-macro relationships cease to be a dual counter position and become hypothetical poles of a scale of magnitudes, intentionality and objective consequences of the action that crosses transversally all the orders and processes of society, as well as its theoretical summaries.”

In social sciences a minimum or closer unit is thus recognised as micro and a maximum or broader unit as macro (Serpa and Ferreira, 2019). The macro is broad and represents the socio-cultural contexts such as the laws and social structures (Mc Guckin, 2019).

Mc Guckin (2019) specifically refers to the micro system in social ecology as a ‘centre of gravity’, that refers to the relationship between a person and their immediate environment, including physical features, activity, social roles and interpersonal relationships, including face-to-face relationships (Mc Guckin, 2019).

Serpa and Ferriera (2019) state that that between micro and macro levels, there are intermediate level, such as meso, seen as an intermediate unit of analysis in decision making. It is thus concluded that the meso social level is, in some perspectives, mobilised by focusing mainly on the group or the organisation, or company level, as an intermediate bridge between, and applied with, the other two micro and macro levels (Serpa and Ferreira, 2019).

Exo level denotes person’s experiences of social or market system which they are not

directly involved with, yet experience the ‘indirect’ effect of the systems (Mc Guckin, 2019).

The application of the TIPS Managerial Leadership Framework allows organisations to thus appreciate the context within which a product or service is offered at different social levels, and actions required at each level (DaVinci, 2019).

By way of example, at Micro level leaders are able to focus on building personal knowledge mastery, and computational thinking, in order to achieve required ‘alignment’ as an interaction between Management of Technology and Management of People, and cooperation thereto (DaVinci, 2019).

At Meso level, organisations and leaders have to embrace problem probing, operational ideation, and transdisciplinary learning in order to establish an enabling environment experimentation and celebrate synergised accomplishment, in the Management of Innovation and Technology, thus remain ‘agile’, with ongoing coordination (DaVinci, 2019).

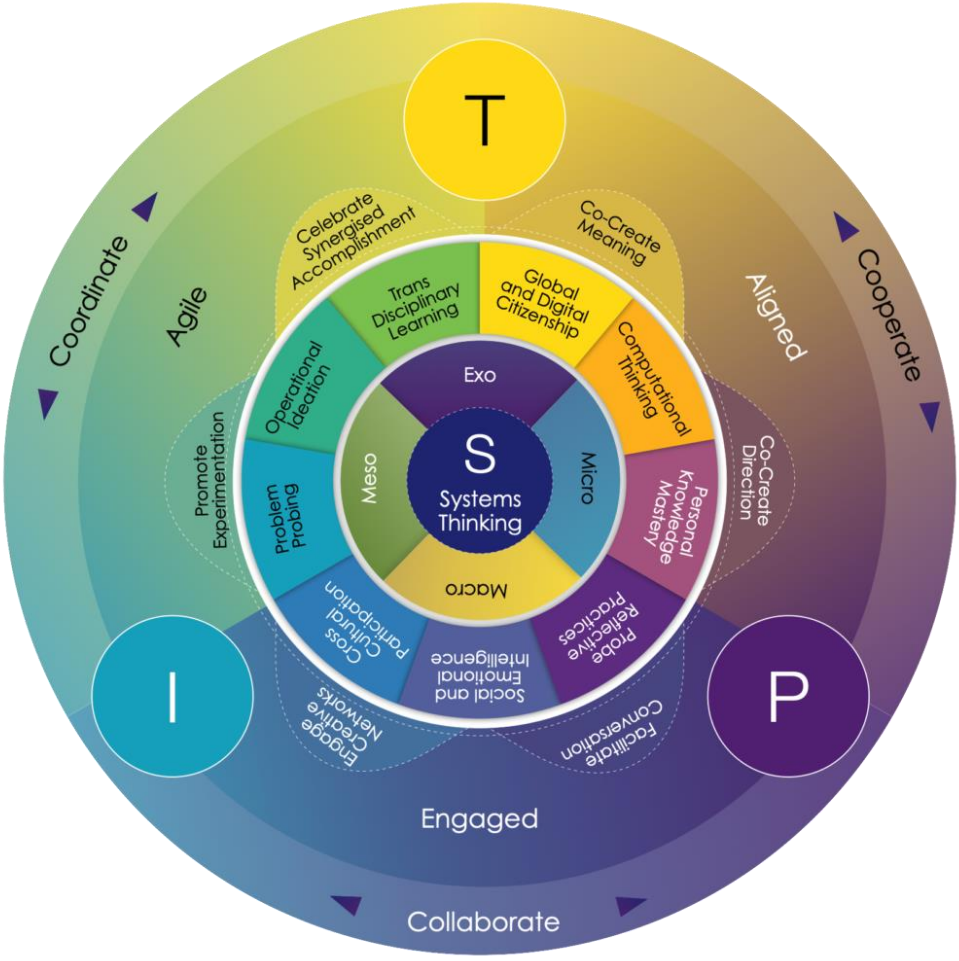

Figure 6: TIPS Managerial Leadership Framework by DaVinci Business School (2018)

2.13. Conclusion

The Green Building concept has become widely publicised in recent decades as one of the initiatives within the broader green economy spectrum to steer the world towards sustainable development. As a result, its embodiment and leadership within the wider understanding of the green economy were ascertained.

From the perspective of different scholars, the Green Building concept has been proved to be one of the most plausible measures to combat the global warming phenomenon because the current built environment contributes immensely to greenhouse emissions. The section dealt with the greenhouse gas emissions phenomenon globally and specifically the unique GHG emissions to South Africa and the impact they render. South Africa was shown as the number one country in the continent to take sustainable development seriously, given its national response as evidenced in the policy frameworks and prescripts.

In the ambit of regional cooperation, the section showed a positive response from SADC, although a lot needs to be done. The section looked at the different technologies, innovations and processes deployed in the built environment generally but specifically examined how these are being used in South Africa through Green Building. In keeping with the global community of nations' understanding that climate change mitigation and adaptation cannot happen without taping into and using indigenous knowledge.

The section also dealt with selected IKS areas applicable to sustainable and Green Building strategies. Finally, the section also examined how the Green Building phenomenon enables opportunities for enterprise development and job creation in South Africa.

The TIPS Managerial Leadership Framework discussed in this section provides for an impactful tool for the assessment of various levels within which organisations and leaders operate, and actions required to keep their products competitive and relevant in the market place.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Introduction

The section herein represents the approach used for the study's design to evaluate the impact of Green Building in South Africa and how Green Building technologies can be used to increase job creation, enterprise development, local technological innovation and awareness of Indigenous Knowledge Systems (IKS).

3.2. Area of the study

The study has primarily been conducted within the National Department of Public Works and Infrastructure (DPWI) of the Republic of South Africa and the South African built environment as a sector, to establish the extent of, and respective experience of professionals on, the uptake on Green Building, and its potential contribution to the identified socio-economic activities

The Department’s employees and sector professionals currently responsible for related tasks such as design, construction, management, and/or maintenance (Facilities Management) of the buildings occupied by the Government were identified as qualifying respondents. These include emerging companies, professional councils, project managers, property owners, and institutional customers, User Departments, and State-owned Entities (SoEs). The buildings and organisations that were selected for the study are all located in South Africa.

3.3. Research paradigm

For this study, the researcher utilised the research paradigm of positivism. Proponents of this paradigm (Creswell & Park, 2011) uphold causality and hold that phenomenon must be investigated from a deterministic prism of cause and effects. The aforementioned paradigm

guided the research investigating the application of the Public Works Green Building Policy and resource efficiency technologies in the targeted property portfolio.

The researcher also considered three other dominant research paradigms for the research design: constructivism, transformative and pragmatism. The proceeding paragraphs below briefly explain the definitions and use of the paradigms identified above.

The constructivist paradigm advocates for using lenses in which a researcher seeks an understanding of the world in which they live and work so that they develop subjective meanings of their experiences. Bryman (2016) asserts that social phenomena and their meanings are continually accomplished by social actors and their interactions that are always in a constant state of revision.

In the transformative paradigm, research practitioners hold that empirical research must be linked to a change agenda to identify and control oppression and bring about social-economic equity. A set of assumptions and procedures are used for the transformative mixed methods paradigm. For example, Creswell (2014) identifies the following themes: underlying assumptions that rely on ethical stances of inclusion and challenging oppressive social structures, an entry process into the community that is designed to build trust and make goals and strategies transparent and dissemination of findings in ways that encourage the use of the results to enhance social justice and human rights.

Practitioners of pragmatism hold that true knowledge is a summation of actions, situations, and consequences, not predetermined conditions. Researchers using this paradigm identify the research problem and embark on knowledge discovery using various methods drawn from constructivism and transformative paradigms. Creswell (2014) states that pragmatism is not committed to one philosophy and reality system. This applies to mixed methods research in that inquirers draw liberally from quantitative and qualitative assumptions when they engage in their research.

The researcher adopts the positivist design to study the implementation of the Green Building Policy and programme, linked to its implication on technology innovation and entrepreneurship, and Enterprise Development in the Department of Public Works & Infrastructure. There is an appreciation that the phenomena exist externally to the researcher, and their properties are multifaceted in terms of their animated (individual and

group behaviour) and inanimate existence (buildings and structures). According to Bryman (2016), Positivism is an epistemological position that advocates the application of the methods of the natural sciences to the study of social reality and beyond. It entails the following principles:

i. Only phenomena and hence knowledge confirmed by the senses can genuinely be warranted as knowledge.
ii. The purpose of theory is to generate hypotheses that can be tested, thereby allowing explanations of laws to be assessed.
iii. Knowledge is arrived at by gathering facts that provide the basis for laws.
iv. Science must be conducted in a value-free way.
v. There is a clear distinction between scientific and normative statements and a belief that the former is the true domain of the scientist.

3.4. Research Method

In this study, the researcher followed the quantitative method. This is the plan that the researcher used to collect, measure and analyse data for the study. The existence of several variables affecting the outcomes of the phenomenon served as an impetus to the researcher in the quest to arrive at quantifiable determinations of the phenomenon under study. That is, the implementation of the Green Building Policy and its possible application for technology innovation, creation of green jobs, and Enterprise Development by the Department of Public Works and the sector in South Africa. The use of the quantitative method reflects post-positivist philosophical assumptions. Creswell (2014) suggests that examining the relationships between and among variables is central to answering questions and hypotheses through surveys and experiments. The reduction to a parsimonious set of variables, tightly controlled through statistical analysis, provides measures for testing a theory.

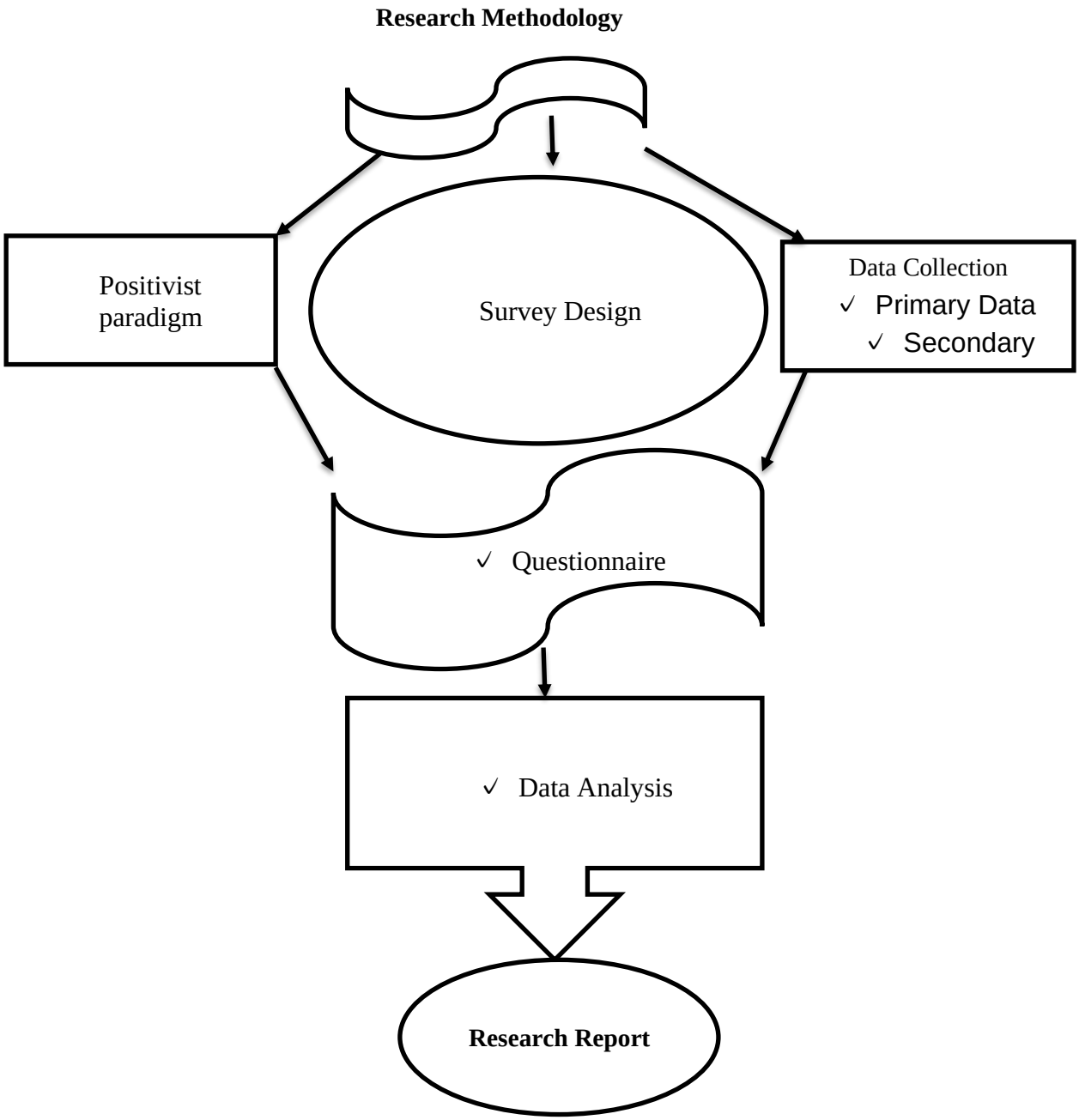

Figure 7: Green Building concept Research methodology adopted from Creswell (2014)

3.5. Data Collection

This study employed a census approach, gathering data from all 96 professionals responsible for the design, construction, maintenance, and facilities management of government buildings under the Department of Public Works and Infrastructure (DPWI) in South Africa. This included individuals working directly for the department, its affiliated entities, and relevant professional organisations. Unlike traditional sampling methods, a census aims to collect data from the entire population of interest (Moser & Kalton, 1979; Lohr, 2010). This approach offers several advantages, including:

- Enhanced representativeness: By including all relevant individuals, the study findings directly reflect the perspectives and experiences of the entire population under investigation (Cochran, 1977).
- Reduced sampling bias: The risk of introducing bias through sample selection is eliminated, leading to more reliable and generalisable conclusions (Moser & Kalton, 1979).
- Increased confidence in findings: The comprehensive nature of a census strengthens the validity and credibility of the research results (Lohr, 2010).

Despite the census having the above advantages, it is critical to recognise the possible limitations associated with conducting a census in a research study. These include:

- Resource intensiveness: Collecting data from the entire population can be time-consuming, expensive, and logistically challenging (Lohr, 2010).
- Non-response: While the study included all eligible individuals, only 52 (54.2%) participated. Reporting the response rate provides transparency and allows for potential considerations regarding non-response bias (Keating & Groves, 2017).

3.6. Study Participants

The research involved all 96 respondents from the official database of varied professionals and Project Managers responsible for the design, construction, maintenance, and facilities management of Government buildings in various regions across the country, including professional organisations under the DPWI. They included individuals working directly for the department, its affiliated entities, and relevant professional organisations.

3.7. Data Access

The data collection utilised the official database maintained by the DPWI which contains individual details of all professionals fulfilling the aforementioned roles. This ensured access to complete information from the target population.

3.8. Response Rate

Out of the 96 eligible professionals, 52 individuals (54.2%) participated in the study by completing the survey questionnaire. While a full census was achieved, acknowledging the response rate provides transparency regarding data collection efforts.

3.9. Data collection tool

The primary method used to collect data in the study was the questionnaire. A survey questionnaire is the prescribed mechanism for systematically collecting data in studies that utilise the quantitative method.

The size of the total population sampling necessitated a standard and structured questionnaire to be provided to the respondents for their completion.

The questionnaire collected pertinent data from several respondents due to the ease with which it could be self-administered. In addition, respondents could complete it when they found time from anywhere.

3.10. Data collection approach

The researcher contacted the individual respondents telephonically and by email. In some instances, they were approached physically. The purpose of the initial contact was to ensure that respondents were made aware of the purpose of the study and also served the dual purpose of acquiring their consent to participate in the survey.

Upon obtaining consent from the initial contact, the researcher would provide the potential respondent with a brief on how to complete the questionnaire.

Using the questionnaire approach had its disadvantages: lack of opportunity to prompt respondents if specific fields were unclear, the researcher could not probe respondents for clarifications on expressed opinions, and low response rates due to recent lockdown and pandemic as employees were returning to offices gradually after working from home.

The problem of non-response, which is endemic to surveys led by questionnaires, was mitigated by the researcher sending a message, email or phone call to the individual respondent to kindly remind them to complete the questionnaire.

To gain the confidence of the respondents to increase the rate of participation, the researcher emphasised to the respondents that their inputs had a significant impact on the value of the study, and were a significant contribution to understanding the socio-economic development potential in the adoption and further uptake of Green Building, particularly in buildings and facilities occupied by the Government.

3.11. Data analysis and interpretation

The study used descriptive and correlation analysis to analyse and interpret data. The computer program is the IBM Statistical Package for Social Sciences (SPSS), version 26.

The data analyses procedure is a step-by-step process that was conducted as follows:

i. Code data on Excel
ii. Import data onto SPSS
iii. Descriptive statistics analysis
iv. Reliability analysis
v. Correlation analysis

3.12. Data Validity and reliability

Validity in the quantitative study has to do with establishing whether a measurement of a concept measures what it is supposed to measure (Bryman, 2012). Reliability is the extent to which the data collection techniques generate a coherent result, which is checked by utilising Cronbach's alpha and composite reliability values.

Creswell (2014) explains external validity as issues concerned with the generalisability of the results of a study beyond the sampled population. For example, in the case of this study, one should ensure that the findings could be replicated in studies similar to this one. Internal validity addresses whether the study and its conclusions align with the study's aim – particularly where there is a causal relationship between two or more variables.

Data reliability addresses the consistency of measure and has three areas that need addressing. They are as follows:

- Stability – is the measure stable over time?
- Internal reliability – are the scales or indices consistent?
- Inter-observer consistency - is there subjectivity or lack of consistency?

3.13. Hypothesis Testing

Correlation analysis explains the relationships between variables and measures, which was undertaken to test the study's hypothesis. Once the data was collected, it was analysed to determine Spearman’s rho coefficient, which indicates the extent of the relationships between constructs.

3.14. Pilot study

The questionnaire was presented to 10 respondents randomly drawn from the sample frame. The returned questionnaires were tested for question validity and response reliability. These were analysed for consistency, and changes to the master questionnaire were made before distribution to the 96 global population of the sample.

Findings in the pilot study were documented, and changes made to the study instrument were highlighted.

3.15. Ethical considerations

Ethical issues were thoroughly observed, and considerations focused on the following:

3.15.1. Ensuring participants have been given informed consent

Participation in the study was voluntary, and respondents who wished to withdraw during the study had the choice to do so. An informed consent form was attached to the questionnaire for the respondents who agreed to participate. In addition, the participants were informed that they have a right to cooperate or not to cooperate with the researcher as per the approved Ethical Clearance for this study.

3.15.2. Ensuring no harm comes to participants

The researcher ensured the study was conducted without exploiting the respondents or damaging their reputation with their employer departments/organisations.

3.15.3. Ensuring anonymity and confidentiality

Privacy, anonymity and confidentially conditions were disclosed to the interviewees.

3.15.4. Ensuring permission is obtained

Permission for conducting the study was obtained as per the applicable Ethical Clearance.

3.16. Conclusion

In this chapter, the overview of the research methods is presented. Then, the research paradigm, research design and research methods are explained. Lastly, the ethical considerations of the entire study are extensively discussed. The next chapter presents and discusses research findings.

CHAPTER FOUR
RESEARCH RESULTS AND DISCUSSION

4.1. Introduction

The target population for this study was 96 respondents, therefore, the study involved the whole population resulting in the distribution of 96 questionnaires. These respondents were from the built environment, project managers drawn from various regions, provinces, and statutory bodies linked to the Department of Public Works and Infrastructure and other sector stakeholders. A total number of 52 responses were received as feedback, representing 54% of the population. The data analysis report from received responses, per statement presented to participants in the questionnaire, is as follows:

4.2. Reliability Test

The researcher used Cronbach's alpha to assess the measuring instrument's internal consistency. The goal was to determine how closely related the items were to each research construct. According to Cho and Kim (2015), Cronbach's alpha measures the scale's reliability.

According to DeVellis (2016), reliability is the consistency of an instrument's measurement or the extent to which it measures the same way each time it is used under the same conditions with the same subjects or conditions.

The reliability of the identified constructs was tested using Cronbach's alpha reliability tests. As shown in Table 6 below, four constructs/variables were formed by five questions each.

The overall Cronbach Alpha value for reliability, according to DeVellis (2016), can be interpreted as follows:

Table 6: Acceptable Values of Cronbach Alpha (DeVellis, 2016)

Alpha coefficient	**Implied reliability**
Below 0.6	Unacceptable
Between 0.6 and 0.65	Undesirable
Between 0.65 and 0.70	Minimally acceptable
Between 0.70 and 0.80	Respectable
Between 0.80 and 0.90	Very good
Much above 0.90	Consider shortening the scale.

4.3. Constructs/Variables Cronbach Alpha values

As can be seen from Table 7 below, all four variables/constructs are reliable, with Cronbach Alpha values ranging from 0.70 to 0.91. This implies that the questionnaire measured what it was supposed to measure.

Table 7: Constructs/Variables Cronbach Alpha values

Constructs/Variable	**Number of Items**	**Cronbach's Alpha**
Green building practices	5	0.73
Use of green building technologies	5	0.91
Compliance with green building policy	5	0.70
Contribution to local economic development	5	0.877

4.4. Green Building Practice

4.4.1. Integration of Green Building Principles in DPWI Construction

The table below illustrate the statement, "*The DPWI's new building construction is undertaken with considerations for Green Building*". Most respondents, 53.8% (28), agreed with the statement. This was followed by 23.1% (12) of those who strongly agreed. In addition, those who were neutral and disagreed with the statement tied at 11.5% (6), respectively.

The higher number of respondents agreeing with the statement, as per 53% of respondents, appears to be representative of Project Managers who are familiar with the pipeline of new construction projects which have recently been implemented or are planned for implementation, including those who are directly responsible for budgeting and commissioning projects as represented by the 23% in solid agreement. This is a positive result regarding Green Building planning and opportunities, which should directly impact other elements of this research.

This result is also consistent with the recent introduction of new Strategic Integrated Projects (SIPs) announced by the State President to revive the economy post the recent lockdown period, as most projects are related to achieving a green economy.

These interventions encompass a pipeline of infrastructure projects which have green building principles.

Table 8: Integration of Green Building Principles in DPWI Construction

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	12	23.1	23.1	23.1
	Agree	28	53.8	53.8	76.9
	Neutral	6	11.5	11.5	88.5
	Disagree	6	11.5	11.5	100.0
	Total	52	100.0	100.0	

In relation to literature review of this research, the high agreement that DPWI incorporates Green Building considerations in new construction is consistent with literature showing increased prioritisation of sustainability in public infrastructure projects. Peng *et al.* (2015) found that government green building policies incentivize sustainability across project lifecycles. Darko *et al.* (2017) note that rating tools like LEED and BREEAM drive the widespread adoption of green building practices in construction. The South African government's commitment to a green recovery through new strategic projects aligns with the global shift towards low-carbon, climate-resilient development (Maia *et al.,* 2011). Thus, the survey results reflect a broad recognition of the growing emphasis on sustainability within DPWI and the wider construction sector.

4.4.2. Promotion of Responsible Resource Used for Green Building

The table below illustrate the statement, *"Green Building developments promote responsible use of energy, water, and waste minimisation".* Of most of the respondents, 73.1% (38) of the respondents strongly agreed with the statement. This was followed by 19.2% (10) of those who agreed with the statement. In addition, those who were neutral and strongly disagreed with the statement tied at 3.8% (2), respectively.

The overwhelming number of respondents, 73.1% agreeing with the statement that *Green Building developments promote responsible use of energy, water, and waste,* is indicative of the increased general awareness of the principles of Green Building amongst sector stakeholders and the positive impact the practice has in the responsible management of resources and sustainable management of buildings.

This awareness appears responsible for the increased adoption of Green Building projects, as indicated in this feedback and the question above.

This constitutes a positive awareness and adoption of the Public Works Green Building Policy.

Table 9: Promotion of Responsible Resource Use for Green Building

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	38	73.1	73.1	73.1
	Agree	10	19.2	19.2	92.3
	Neutral	2	3.8	3.8	96.2
	Strongly Disagree	2	3.8	3.8	100.0
	Total	52	100.0	100.0	

In relation to literature review, the strong agreement that green building enables responsible energy, water and waste management aligns with research showing sustainability benefits over the building lifecycle. Green building practices such as energy retrofits, greywater systems and solar PV measurably improve efficiency and reduce environmental impact (Darko *et al.*, 2017; Wu *et al.*, 2021). For example, Fuerst and McAllister (2011) found that certified green buildings used 18% less energy and decreased CO2 emissions by 35%. South Africa's green building incentives encourage widespread adoption of strategies like renewable energy, water harvesting and waste recycling (Du Plessis *et al.*, 2022). The survey results reflect growing recognition that green building principles substantively improve resource management.

4.4.3. Conservation Benefits of New Government Green Developments

The table below illustrates the statement, *"New building developments by the Government are helping to conserve the environment".* The majority of the respondents, 57.7% (30), agreed with the statement. This was followed by 23.1% (12) of those who strongly agreed with the statement. In addition, those who disagreed were 11.5% (6), and 7.7% (4) were neutral.

Consistent with feedback on the experience and awareness of Project Managers, there is both agreement and strong agreement on the positive impact of Green Building projects on the environment, based on the observations of respondents.

The higher number of positive responses in agreement with the statement potentially points

to the availability of data, i.e., energy and water efficiency together with solid waste management in the respective projects they are involved with.

This would potentially be the same data used when reporting on official reports such as the ones for Environment, Social, and Governance (ESG).

Table 10: Conservation Benefits of New Government Green Developments

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	12	23.1	23.1	23.1
	Agree	30	57.7	57.7	80.8
	Neutral	4	7.7	7.7	88.5
	Disagree	6	11.5	11.5	100.0
	Total	52	100.0	100.0	

Linked to literature review, the agreement that government green building developments aid environmental conservation reflects the measurable sustainability benefits these projects provide. Research shows certified green government buildings consume significantly less energy and water compared to conventional buildings (Darko & Chan, 2018). Green procurement policies allow governments to lead by example and mainstream sustainability (Testa *et al.*, 2016). For instance, Peng (2015) found that green public buildings in China reduced lifecycle CO2 emissions by up to 65%. South Africa's green building incentives encourage government adoption of renewables, efficiency measures and waste management that tangibly reduce environmental impact (Du Plessis *et al.*, 2022). The survey responses indicate growing recognition of the conservation outcomes from green government projects.

4.4.4. Occupant Welfare Enhancement through Green Building

The table below illustrate the statement, *"Green Building developments enable improved working and living conditions for occupants, i.e., indoor environment quality (IEQ)".* The majority of the respondents, 57.7% (30), strongly agreed with the statement. This was

followed by 38.5% (20) who agreed with the statement. Of the remainder, 3.8% (2) of the respondents were neutral.

Similarly, the high responses in agreement with the statement that "*Green Building developments enable improved working and living conditions for occupants, i.e. indoor environment quality (IEQ)"* is consistent with the earlier statement put to respondents that "*New building developments by the Government are helping to conserve the environment" as they both relate to the indoor and outdoor environment, whilst perhaps more related to the concept of user experience (UX) by building occupants and Project Managers.*

Table 11: Occupant Welfare Enhancement through Green Building

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	30	57.7	57.7	57.7
	Agree	20	38.5	38.5	96.2
	Neutral	2	3.8	3.8	100.0
	Total	52	100.0	100.0	

The strong agreement that green buildings enhance occupant comfort and wellbeing is consistent with research demonstrating better indoor environmental quality (IEQ). Green building strategies like low VOC materials, ample daylight and passive climate control tangibly improve air quality, thermal comfort, lighting, and other IEQ parameters (Darko & Chan, 2017; Wu *et al.*, 2018). For instance, a study of LEED certified offices in the US found a 15% improvement in occupant satisfaction compared to conventional buildings (Abbaszadeh *et al.*, 2006). Enhanced IEQ has measurable human health and productivity benefits that further justify sustainable investments (Thatcher & Milner, 2016). South Africa's green building rating tools include IEQ as a criteria, encouraging widespread adoption of greens strategies that create quality indoor environments.

4.4.5. Job Creation and Business Opportunities Enabled by Green Building Policy Implementation

The table below illustrates the statement, *"The DPWI Green Building Policy has enabled the*

creation of new work and business opportunities". The majority of the respondents, 42.3% (22), strongly agreed with the statement. This was followed by 23.1% (12) of those who agreed and neutral, respectively. The remainder 11.5% (6) of the respondents disagreed with the statement.

There are strong views from the responses that new work opportunities are created through implementing the Public Works Green Building Policy through green jobs. These are defined as jobs emanating from projects aligned with principles of the United Nations Sustainable Development Goals or from Green Economy projects. This view is, however, met by an increased number of respondents who disagree with the statement at 11.5%. This suggests that more must be done to create green jobs linked to project planning and scoping.

Key amongst these must be a more dedicated focus during scoping of projects to set unambiguous socio-economic development guidelines to be implemented during the rollout of each Green Building and infrastructure project, providing for an outline of Green Jobs projected to be created.

This will include a projection on local content and other socio-economic development interventions to be achieved and accounted for, such as Enterprise Development which contribute to further jobs created in the value chain.

Table 12 Job Creation and Business Opportunities Enabled by Green Building Policy Implementation

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	22	42.3	42.3	42.3
	Agree	12	23.1	23.1	65.4
	Neutral	12	23.1	23.1	88.5
	Disagree	6	11.5	11.5	100.0
	Total	52	100.0	100.0	

The strong agreement that DPWI's green policy creates new work and business opportunities aligns with research on the employment potential of green building. Studies show sustainable construction generates direct jobs in areas like renewable energy installation, retrofitting, and maintenance (Willis *et al.*, 2018). Green building strategies also enable growth for emerging green enterprises through innovation and local content requirements (Schaper, 2010). However, realising these benefits requires deliberate planning and tracking. Peng *et al.* (2015) note comprehensive policy monitoring and disclosure is critical to assess sustainability outcomes. South Africa can further leverage green procurement mandates to catalyse widespread adoption while maximizing socioeconomic impact (Maia *et al.*, 2011). Tightly integrating job creation and small business goals with green policy implementation will amplify local economic development.

4.5. Use of Green Building Technologies

4.5.1. Energy Efficiency Technology Implementation in Project Scoping

The table below illustrate the statement, *"Project scoping ensures that buildings and facilities are fitted with energy-efficiency technologies".* The majority of the respondents, 50% (26), agreed with the statement. This was then followed by 26.9% (14) of those who were neutral. In addition, for those who strongly agreed with the statement, 15.4% (8) and 7.7% (4) for those who disagreed.

Whilst the statement attracted 50% of respondents who agreed with the statement, the 26.9% of respondents who were neutral strongly indicates the imperative of a reengineering project process. The aim is to put in place internal systems and structures in the Department like DPWI for managing resource efficiency projects and provide for the important mechanism of independent Measurement and Verification (M&V). This allows Project Managers to identify and verify installed energy-efficiency technologies as part of scheduled audits throughout project timelines, including during operations and maintenance. However, the 26.9% seems to reflect the extent to which Project Managers do not immediately have internal mechanisms to verify installed technologies, including energy-efficient technologies, assisted by independent M&V.

To this end, Project Managers are aware of interventions; however, they may not be able to immediately list and verify actual installed technologies beyond reported, thus remaining neutral on confirmation of fittings. Nonetheless, the situation should greatly improve post-

DPWI reengineering the Utilities Management function using Green Building principles in deploying systems, technologies, and innovation through a new Integrated Renewable Energy and Resource Efficiency Programme (iREREP).

The move towards the new process should migrate the 26.9% neutral to either agree, currently at 50%, or to strongly agree, currently at 15.4%.

Table 13: Energy Efficiency Technology Implementation in Project Scoping

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	8	15.4	15.4	15.4
	Agree	26	50.0	50.0	65.4
	Neutral	14	26.9	26.9	92.3
	Disagree	4	7.7	7.7	100.0
	Total	52	100.0	100.0	

Linked to literature review, the mixed response on ensuring facilities are fitted with energy efficient technologies points to a need for robust monitoring and verification (M&V). Research shows comprehensive M&V is critical for validating energy savings and performance of green investments (Lee *et al.*, 2015). South Africa's green public procurement mandates can further integrate M&V requirements to track sustainability outcomes over project lifecycles (Maia *et al.*, 2011). For instance, Peng (2015) demonstrates how building information modelling aids continuous energy assessment. By institutionalising robust M&V protocols tied to green procurement, DPWI can strengthen verification that efficiency technologies are performing as intended during scoping, installation and operation (Du Plessis *et al.*, 2022). This will provide greater confidence in meeting policy goals for reducing energy consumption across facilities.

4.5.2. Water Efficiency Technology Adoption in Project Scoping

The table below illustrate the statement, *"Project scoping ensures that buildings and facilities managed are fitted with water efficiency technologies".* The majority of the respondents,

42.3% (22), agreed with the statement. This was then followed by 34.6% (18) of those who were neutral. In addition, those who strongly agreed and disagreed with the statement were 11.5% (6), respectively.

The responses to this statement are directly similar and trend responses to the above statement on energy efficiency technology fittings. Although there are more respondents, 34.6%, as opposed to the energy technology installations, 26.9% of respondents remained neutral. This is because of the somewhat complex process of verifying water efficiency technologies, which may include underground or concealed installations requiring specialised management, maintenance, and verification.

Similarly, as with energy efficiency technologies, for water efficiency technologies, the current process of reengineering Utilities Management through the introduction of iREREP by DPWI should improve institutional arrangements. These should include the related systems, thus providing Project Managers throughout the organisation with better insight into the verification of installations and maintenance thereof.

Table 14: Water Efficiency Technology Adoption in Project Scoping

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	6	11.5	11.5	11.5
	Agree	22	42.3	42.3	53.8
	Neutral	18	34.6	34.6	88.5
	Disagree	6	11.5	11.5	100.0
	Total	52	100.0	100.0	

The mixed response on water efficiency technology integration reflects a need for improved monitoring and benchmarking. Research shows Green Building rating systems boost water performance when proper verification is in place (Darko & Chan, 2018). South Africa can strengthen implementation by integrating water use tracking in project delivery and

operations (Peng, 2015). Institutionalising water monitoring provides data to inform decisions and quantify efficiency benefits of green investments (Wu *et al.*, 2021).

4.5.3. Efficient Waste Management in New Buildings and Facilities

The table below illustrate the statement, *"The buildings and facilities recently developed have implemented systems for efficient solid waste management".* The majority of the respondents, 50% (26), were neutral to the statement. This was followed by 30.8% (16) of those who agreed with the statement. In addition, those who disagreed with the statement represented 15.4% (8), and 3.8% (2) strongly agreed.

Whilst there are similarities with the statements mentioned above regarding energy and water efficiency technologies fittings, solid waste management and recycling in DPWI facilities is in its infancy and has only been implemented in one Region. All other regions rely entirely on Municipal waste removal and systems with the Municipality. Essentially, Municipalities do not record data for recyclable waste collected at sites.

This situation is confirmed by many respondents who either remained neutral, 50.0% or disagreed with the statement, 15.4%. The 30.8% who agree with the statement indicate pockets of interventions which can be called up in line with iREREP to improve sustainable waste management throughout Government facilities.

Table 15: Efficient Waste Management in New Buildings and Facilities

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	2	3.8	3.8	3.8
	Agree	16	30.8	30.8	34.6
	Neutral	26	50.0	50.0	84.6
	Disagree	8	15.4	15.4	100.0
	Total	52	100.0	100.0	

The uncertainty around solid waste systems points to gaps in waste data and reporting. Studies show robust waste auditing, sorting and recycling programs are essential to monitor

and improve building waste management (Kibert, 2016; Darko *et al.*, 2017). South Africa's green public procurement mandates can further emphasize waste tracking and recycling to validate performance (Du Plessis *et al.*, 2022). This provides accountability and highlights areas for optimizing solid waste programs.

4.5.4. Efficient Resource Utilisation through Implemented Technologies

The table below illustrate the statement, *"The systems and technologies listed above have enabled the efficient use of resources".* The majority of the respondents, 38.5% (20), agreed with the statement. This was then followed by 30.8% (16) of those who were neutral. In addition, those who strongly agreed and disagreed with the statement were 15.4% (8), respectively.

Feedback on the statement reflects a response consistent with the response on energy, water, and waste installations above. Respondents confirm that these technologies have enabled efficient use of resources, with 38.5% agreeing and 15.4% strongly agreeing, reflective of regions that have successful projects, including data verification. There is, however, a sizeable number of respondents who are neutral, with no view, indicating regions that have not put in place verification systems to know the impact of projects on the use of resources. 15.4 disagreeing indicates regions that have not had positive use of resources or impact as a result of resource efficiency Green Building projects implemented.

The concern presented by the respondents is that although there are resource efficiency interventions, there is an inconsistency or lack of uniformity in the management of data during project implementation, to the extent that respondents are at different levels of confidence on the extent to which there is efficiency. Nevertheless, the figures achieved represent the positive impact of the responsible use of resources.

The iREREP is again envisioned to offer reengineering of the situation to provide for increased confidence on the amount of resource efficiency achieved through verifiable data and uniform reporting that can be benchmarked against best practices.

Table 16: Efficient Resource Utilisation through Implemented Technologies

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	8	15.4	15.4	15.4
	Agree	20	38.5	38.5	53.8
	Neutral	16	30.8	30.8	84.6
	Disagree	8	15.4	15.4	100.0
	Total	52	100.0	100.0	

The moderate confidence in resource use reductions indicates potential for enhanced verification. Research recommends comprehensive metering, sub-metering and audits to quantify efficiency outcomes (Peng *et al.*, 2015). South Africa can mandate building-level monitoring and disclosure of resource savings for all resources to strengthen green policy implementation (Maia *et al.*, 2011) similar to the mandatory display of Energy Performance Certificates (EPCs). This incentivised investments in efficiency measures while providing data to continuously improve building performance.

4.5.5. Client Updating of Resource Efficiency Technologies

The table and figure below illustrates the statement, *"Our clients, such as DPWI, regularly implement new technologies for efficient use of resources in the buildings under management".* The majority of the respondents, 38.5% (20) of the respondents were neutral to the statement. This was followed by 34.6% (18) of those who agreed with the statement. In addition, those who disagreed with the statement were 19.2% (10), and 7.7% (4) strongly agreed.

Whilst there is consensus on the general use and adoption of Green Building, there is a consistent response on either not knowing or disagreeing with the extent to which DPWI implements actual technology fittings. The statement is consistent with earlier responses received above related to the respondent's awareness of the actual installation of technologies to achieve energy, water, and waste efficiency. In this regard, most respondents are neutral, at 38.5%, followed by those who disagree with the statement at

19.2%.

A lesser number of respondents, 34.6%, agree with the statement, confirming pockets of regions and provinces with some form of awareness and knowledge that there is an implementation of new technologies, which is information most likely verified by participants. This includes a smaller number of respondents in strong agreement. This is potential for calling up and determining best practices in projects to establish a general and increased awareness of newly installed technologies and the impact thereof in verifiable data and processes.

Increased collaboration and a significant increase in the number of projects are required to change this current status. This further points to poor reporting levels and sharing of best practices among stakeholders.

Table 17: Client Updating of Resource Efficiency Technologies

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	4	7.7	7.7	7.7
	Agree	18	34.6	34.6	42.3
	Neutral	20	38.5	38.5	80.8
	Disagree	10	19.2	19.2	100.0
	Total	52	100.0	100.0	

The uncertainty around technology adoption emphasizes the need for transparent benchmarking. Studies show green rating tools must be tied to robust validation systems to track sustainability investments (Cole & Valdebenito, 2013). South Africa can boost compliance by integrating monitoring and disclosure of new technology implementations (Du Plessis *et al.*, 2022). This gives stakeholders confidence in meeting policy goals for continuous improvement in building efficiency.

4.6. Compliance with the Green Building Policy

4.6.1. Green Building Implementation in all DPWI Managed Buildings and Facilities

The table below illustrates the statement, *"All buildings and facilities managed by the DPWI have implemented Green Building initiatives".* The majority of the respondents, 42.3% (22), disagreed with the statement. This was then followed by 34.6% (18) of those who were neutral. In addition, those who strongly disagreed with the statement were 11.5% (6), and 7.7% (4) agreed. The remainder, 3.8% (2) of the respondents, strongly agreed with the statement.

This response suggests that the DPWI and the sector still need to do more to promote and increase the number of Green Building projects. The South African current status for the built environment is similar to that of the green economy projects in general, which is a concern shared globally. According to the United Nations Department of Economic and Social Affairs, the journey by the global community of nations to implement various interventions aimed at achieving the United Nations Sustainable Development Goals (SDGs) is underway, albeit insufficient, with many targets not likely to be met by 2030 (UN DESA, 2020).

One of the challenges in the built environment, globally and locally, is the refurbishment of existing buildings to be green buildings. Whilst interventions are put in place through various projects to ensure that these buildings are resource efficient, this challenge and backlog are significant for property owners with considerably large portfolios. For instance, the DPWI has a portfolio of around 100 000 (one hundred thousand) buildings, covering an estimated 37 million square meters (sqm) and a massive maintenance budget shortfall.

Feedback regarding the DPWI portfolio sharply reflects this situation, with 42.3% of respondents disagreeing with the statement that "*All buildings and facilities managed by the DPWI have implemented Green Building initiatives*", whilst 11.5% strongly disagree with the statement, and 34.6% were neutral in response.

A smaller percentage, 7.7% of respondents who agree and 3.8% who strongly agree with the statement are most likely exposed to more new facilities and buildings planned and constructed as green buildings from the commencement, which represents a small percentage in the total number of buildings and facilities in the DPWI portfolio.

Table 18: Green Building Implementation in all DPWI Managed Buildings and Facilities

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	2	3.8	3.8	3.8
	Agree	4	7.7	7.7	11.5
	Neutral	18	34.6	34.6	46.2
	Disagree	22	42.3	42.3	88.5
	Strongly Disagree	6	11.5	11.5	100.0
	Total	52	100.0	100.0	

The limited green building initiatives to date highlight barriers in retrofitting existing buildings. Research identifies split incentives and payback uncertainties as key obstacles to voluntary adoption (Darko & Chan, 2017). South Africa can accelerate retrofits by strengthening incentives, such as 12L tax incentive for energy efficiency, and integrating lifecycle costing in public procurement (Maia *et al.*, 2011). This helps overcome upfront cost barriers while ensuring operations and maintenance savings are considered.

4.6.2. Mainstreaming Green Building in Planning and Design Phase

The table below illustrates the statement *"In line with Green Building Policy, I ensure the Government integrates Green Building mechanisms in the planning and design phase before the development of new facilities or maintenance of existing ones".* The majority of the respondents, 38.5% (20) of the respondents agreed with the statement. This was then followed by 34.6% (18) of those who were neutral. In addition, those who strongly agreed with the statement were 19.2% (10), whereas 7.7% (4) disagreed.

Green Building elements are included for almost all construction of new buildings or refurbishing existing buildings and facilities for new projects. This is regardless of the current seemingly small impact these initiatives have on the whole portfolio.

This fact is represented by 38.5% of respondents who agree with the presented statement and 19.2% who strongly agree.

Some respondents are neutral, likely resulting from the fact that these stakeholders may feel overwhelmed. Most likely because they have no broad overview or knowledge of the impact Green Building projects are making, given the extent of the total portfolio, which is not green. This neutral group is also considerably represented by 34.6% of respondents.

Table 19: Mainstreaming Green Building in Planning and Design Phase

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	10	19.2	19.2	19.2
	Agree	20	38.5	38.5	57.7
	Neutral	18	34.6	34.6	92.3
	Disagree	4	7.7	7.7	100.0
	Total	52	100.0	100.0	

The integration of green mechanisms during planning and design demonstrates growing commitment, consistent with studies showing sustainability considerations have greatest influence early in projects (Robichaud & Anantatmula, 2011). South Africa's leadership in voluntary certification indicates rising awareness of green building in inception (Windapo & Goulding, 2015). However, research recommends expanding requirements to cover all public projects, not just voluntary participation (Peng *et al.*, 2015). While the survey results reflect progress, literature emphasizes mandating consideration of green options during planning for the mainstream built environment beyond self-selection into rating schemes.

4.6.3. Contribution to National and Global Sustainability Goals

The table below illustrates the statement, *"I am aware of Government initiatives and commitments towards United Nations Sustainable Development Goals, resource efficiency, and achievement of a green economy for SA – which the DPWI Green Building Policy contributes to".* Most respondents, 65.4% (34), agreed with the statement. This was followed by 30.8% (16) of those who strongly agreed with the statement. Of the remainder, 3.8% (2) of the respondents were neutral.

From the received responses to this statement and earlier statements on awareness-related questions, there is an overwhelming consensus that stakeholders are aware of South Africa's commitments to the global community and the country itself to meet sustainable development goals, resource efficiency, and an environmentally friendly growth path. 30.8% of respondents confirm this through strong agreement with the statement, and an additional 65.4% of respondents agree.

A very small percentage of stakeholders seem to be unaware, therefore remaining neutral, with no disagreement received.

Table 20: Contribution to National and Global Sustainability Goals

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	16	30.8	30.8	30.8
	Agree	34	65.4	65.4	96.2
	Neutral	2	3.8	3.8	100.0
	Total	52	100.0	100.0	

The strong awareness of sustainability goals and the green economy aligns with studies showing national policies are raising the profile of these issues (Deat, 2014; Musango *et al.*, 2014). However, research emphasizes awareness must now accelerate concrete actions towards established commitments (Kaggwa *et al.*, 2013). Tight integration between green building mandates and national sustainability plans enables measurable progress (Du Plessis *et al.*, 2022). While the survey results indicate clear comprehension, literature stresses the imperative to translate understanding into implementation, monitoring and disclosure. This helps realize the potential of strategies like green public procurement.

4.6.4. Awareness of Green Building Policy Requirements and Sustainability Principles

The table below illustrate the statement "*I am aware of Green Building Policy requirements and DPWI's commitments to sustainability principles".* The majority of the respondents, 57.7% (30), agreed with the statement. This was then followed by 38.5% (20) of those who strongly agreed with the statement. The remainder, 3.8% (2) respondents, disagreed with the statement.

Similarly, consistent with the respondents understanding and knowledge of the national macro position on the Green Economy accord, there is a significant understanding of the DPWI Green Building Policy requirements and DPWI commitments to sustainability principles. This is confirmed by 57.7 % in agreement and 38.5% in strong agreement.

Table 21: Awareness of Green Building Policy Requirements and Sustainability Principles

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	20	38.5	38.5	38.5
	Agree	30	57.7	57.7	96.2
	Disagree	2	3.8	3.8	100.0
	Total	52	100.0	100.0	

The significant understanding of DPWI's Green Building policy indicates effective formal communication, consistent with studies emphasising that clear dissemination is critical for successful implementation (Kibert, 2016). However, research cautions comprehension alone is insufficient without rigorous compliance systems (Peng *et al.*, 2015). South Africa can boost outcomes by complementing awareness-building with robust monitoring, auditing and disclosure of sustainability metrics and outcomes (Maia *et al.*, 2011). This helps realize the potential of strategies like green public procurement.

4.6.5. Undertaking of Green Building Training

The table below illustrates the statement, *"I have participated in Green Building training*

offered to sector stakeholders and senior management". The majority of the respondents, 46.2% (24), strongly agreed with the statement. This was then followed by 34.6% (18) of those who agreed. In addition, those who disagreed and strongly disagreed with the statement were 7.7% (4), respectively. The remainder, 3.8% (2) of the respondents, were neutral.

Established awareness of the DPWI Green Building Policy and Green Building as a practice is strongly demonstrated by the number of respondents who have participated in Green Building training in one form or another. Training represents a significant skills development tool for managing and implementing Green Building projects to transform the portfolio going forward. The extent of training that has taken place is also indicative of the institutionalisation of Green Building in the DPWI and the sector, with 46.2% of respondents strongly agreeing and attending training, followed by 34.6 per cent who also agree and attended the training.

Table 22: Undertaking of Green Building Training

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	24	46.2	46.2	46.2
	Agree	18	34.6	34.6	80.8
	Neutral	2	3.8	3.8	84.6
	Disagree	4	7.7	7.7	92.3
	Strongly Disagree	4	7.7	7.7	100.0
	Total	52	100.0	100.0	

The widespread participation in training indicates growing institutional capacity, consistent with studies showing education builds required Green Building expertise (Robichaud & Anantatmula, 2011; UNEP-SBCI, 2014). However, research also emphasizes applied learning translates knowledge into practice (Wu *et al.*, 2021). The South African built industry can supplement formal training with communities of practice, mentoring and real-world project experience (Fuerst & McAllister, 2011).

Tailored skills strategies also enable wider participation in the green economy (Sperling *et*

al., 2012). While the survey reflects strong formal training uptake, literature recommends ongoing efforts to embed learning through applied mentorship and on-site development. For DPWI this provides an opportunity for Extended Public Works Programme (EPWP) focused on hands-on skills development.

4.7. Contribution to local economic development

4.7.1. Local Employment Creation through Green Building Policy Implementation

The table below illustrates the statement, *"Since 2015, the Green Building Policy implementation and interventions have led to the creation of employment opportunities for local businesses in the area where State-owned buildings are located".* The majority of the respondents, 38.5% (20), agreed with the statement. This was then followed by 34.6% (18) of those who were neutral. In addition, those who strongly agreed with the statement were 15.4% (8), and 11.5% (6) disagreed.

One of the most critical aspects of the green economy trajectory is the creation of green jobs and increased economic activity. From their experience, 38.5% agreed with the statement that Green Building has created jobs for local businesses around areas where DPWI facilities are located, whilst 15.4% strongly agreed.

There are, however, the DPWI regions and provinces where projects have not yielded required jobs for local businesses, most likely due to Green Building projects either still in the planning phase or not yet being implemented. This is represented by the 34.6% of respondents remaining neutral and 11.5% disagreeing with the statement. This is consistent with earlier feedback suggesting insufficient projects are being implemented in line with the potential of Green Building and the green economy.

Table 23: Local Employment Creation through Green Building Policy Implementation

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	8	15.4	15.4	15.4
	Agree	20	38.5	38.5	53.8
	Neutral	18	34.6	34.6	88.5
	Disagree	6	11.5	11.5	100.0

Total	52	100.0	100.0	

The moderate confidence that Green Building is creating local jobs and enterprise opportunities highlights implementation gaps. Research covered herein shows that realising socio-economic benefits requires deliberate planning, tracking and disclosure (Willis et al., 2018; Maia *et al.*, 2011). Many sustainability policies lack detailed job creation mandates and monitoring (Du Plessis *et al*., 2022). South Africa can strengthen outcomes by integrating robust measurement of local impacts into green procurement requirements (Peng *et al.*, 2015). This incentivises contractors to maximise community participation, whilst providing data to continuously improve projects' local economic contribution. Tightly coupling Green Building initiatives with local development goals can unlock the full potential of sustainability investments.

4.7.2. Enterprise Development Opportunities from Green Building Interventions

The table below illustrates the statement, *"The Green Building interventions provide economic opportunities to local enterprises where Government facilities are located".* Most respondents, 38.5% (20), agreed with the statement. This was then followed by 30.8% (16) of those who were neutral. In addition, those who strongly agreed with the statement were 23.1% (12), and 7.7% (4) disagreed.

There is an intrinsic link between how Green Building interventions positively impact the creation of jobs for local businesses and their people and how Green Building interventions provide economic opportunities to local enterprises. Given that economic opportunities provided to local enterprises enable them to create jobs. Accordingly, respondents' views in how they respond to both statements are similar.

It is therefore confirmed that there are visible economic opportunities for local enterprises resulting from Green Building projects in Government facilities, with the question of Green Building interventions providing economic opportunities attracting respondents who agree at 38.5%, and 23.1% stating that they strongly agree. It is, however, clear that more needs to be done to achieve further economic opportunities in Regions and Provinces where few

may be currently created, as represented by 30.8% of respondents who remained neutral and 7.7% who disagree.

Table 24: Enterprise Development Opportunities from Green Building Interventions

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	12	23.1	23.1	23.1
	Agree	20	38.5	38.5	61.5
	Neutral	16	30.8	30.8	92.3
	Disagree	4	7.7	7.7	100.0
	Total	52	100.0	100.0	

The moderate confidence that Green Building enables local economic opportunities highlights implementation gaps found in research. Studies emphasise the need for deliberate planning, tracking outcomes, and policy disclosure to maximize socioeconomic benefits (Du Plessis *et al.*, 2022; Peng *et al.*, 2015). Many sustainability strategies lack detailed job creation mandates and monitoring (Willis *et al.*, 2018). South Africa can strengthen Green Building's local impact by integrating robust measurement of community participation, small business engagement and skills transfer (Maia *et al.*, 2011). Tight coupling with socioeconomic development goals through procurement and ongoing assessment helps realize the full potential of investments (Sperling *et al.*, 2012). The survey indicates recognition of this potential but a need for greater realization through comprehensive planning, disclosure and monitoring.

4.7.3. New Skills Development in Green Building

The table and figure below illustrate the statement, *"Implementation of Green Building technologies has led to the development of new skills that did not exist before".* Most respondents, 46.2% (24), agreed with the statement. This was then followed by 30.8% (16) of those who were neutral. In addition, those who strongly agreed with the statement were 19.2% (10) and 3.8% (2) disagreed.

As a global and local trend, Green Building, also called sustainable or high-performance

building, has attracted increased levels of innovation and the use of groundbreaking technologies, Green Building Technologies (GBTs) (Meena, Kumar, Jain, Rehman, Mishra, Sharma, Bajaj, Shafiq & Eldin, 2022) which have brought about new areas of learning about socio-economic development, including skills development as facilities/property managers learn to operate and maintain new technologies. This applies to building construction and operation using Alternative Building Technologies (ABTs), GBTs, and related resource efficiency to save energy and water and manage waste. Confirmation of this trend in local Green Building projects is confirmed by 46.2% of respondents who agree with the statement that the implementation of GBTs has led to the development of new skills that did not exist prior implementation of projects.

This is further supported by an additional 19.2% of respondents who strongly agree with the statement. An opportunity to scale up on new skills development exists, as some regions and provinces have not seen the trend's emergence and thus have chosen to remain neutral. Implementing projects with a clear skills development plan would migrate the neutral responses to agree.

A positive development from this question is the encouraging feedback on skills development through Green Building Technologies, in that those who disagreed with the statement are only 3.8%, which suggests an overwhelming confirmation of skills development interventions taking place in various regions across South Africa, together with the potential thereof. This is undoubtedly a vital intervention for post-pandemic and post-lockdown economic growth.

Table 25: New Skills Development in Green Building

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	10	19.2	19.2	19.2
	Agree	24	46.2	46.2	65.4
	Neutral	16	30.8	30.8	96.2
	Disagree	2	3.8	3.8	100.0
	Total	52	100.0	100.0	

The agreement that Green Building technologies are enabling new skills development aligns with research showing sustainability strategies require new expertise. Studies emphasize training programs to build capabilities in areas like renewable energy, retrofitting, and green materials (Robichaud & Anantatmula, 2011; IEA, 2020). South Africa's green public procurement mandates can spur learning by requiring contractors to integrate emerging solutions like alternative building technologies, digital twining of buildings, energy efficiency systems, and waste recycling (Maia *et al.*, 2011). On-the-job experience with technologies coupled with formal training maximizes impact (Darko *et al.*, 2017). Targeted skills strategies also enable marginalised groups to participate in the green economy (Sperling *et al.*, 2012). Thus, the survey results reflect recognition of green building's role in expanding South Africa's skills base beyond conventional construction

4.7.4. Enhancement of Localisation and Transformation

The table below illustrate that *"Green Building has increased the DPWI implementation of localisation regulations and BBBEE scorecard".* The majority of the respondents, 50% (26), were neutral to the statement. This was followed by 23.1% (12) of those who agreed with the statement. In addition, those who disagreed with the statement were 15.4% (8), and 11.5% (6) strongly agreed.

Whilst the imperative of creating economic opportunities and Green Jobs constitutes some of the Green Building's socio-economic development impact areas, this does not automatically translate to beneficiary companies doing well on Black Economic Empowerment (BBBEE) rating. The BBBEE scorecard to meet empowerment requires a dedicated determination of targets to be met during project scoping, which may not have been done in most projects in the industry given that 50% respondents of remained neutral in their response to the statement on BBBEE.

Given that the Green Building sector is also still emerging, there are generally few companies and Accredited Professionals and seemingly even fewer of those are BBBEE-rated companies, as reflected by 15.4% of those who disagreed with the statement.

However, there are areas where BBBEE and localisation are incorporated as key requirements, given that 23.1% of respondents agreed with the statement and 11.5%

strongly agree. This is positive for creating opportunities for balanced BBBEE ownership in main contractor companies and allocation for Enterprise Development and supplier development, which are some of the crucial elements of the BBBEE scorecard.

However, those who have been able to implement BBBEE and localisation remain lower in percentage terms, which suggests a lot more can still be done to create opportunities.

Table 26: Enhancement of Localisation and Transformation

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	6	11.5	11.5	11.5
	Agree	12	23.1	23.1	34.6
	Neutral	26	50.0	50.0	84.6
	Disagree	8	15.4	15.4	100.0
	Total	52	100.0	100.0	

The uncertainty around Green Building's BBBEE impact highlights that socio-economic tracking is critical to maximise opportunities (Maia *et al.*, 2011). Research shows sustainability policies often lack mandates and monitoring on issues like local content and empowerment (Du Plessis *et al.*, 2022). Tightly integrating and disclosing BBBEE and small business participation helps realize green building's full potential (Willis *et al.*, 2018) which is achievable through intentional scoping in procurement processes.

4.7.5. Expanded Local Sustainability Procurement within the Green Economy

The table below illustrates the statement, *"Since 2015, there has been increased procurement of locally manufactured sustainability products and technologies due to the Government's Green Economy trajectory".* The majority of the respondents, 46.2% (24), were neutral to the statement, followed by 30.8% (16) of those who agreed. In addition, those who disagreed with the statement represented 11.5% (6), and 7.7% (4) strongly agreed. The remainder 3.8% (2) of the respondents, strongly disagreed with the statement.

The statement is directly linked to Tables 24 and 25 on economic opportunities created for local companies through Green Building and new skills created by introducing Green Building technologies. Based on these responses, there seems to be some correlation between responses to the question related to the use of locally manufactured and innovative technologies and the question of creating economic opportunities for local enterprises and developing new skills.

On this specific statement, 46.2% of respondents remained neutral, as it seems they may not have quantified or do not know the geographic origins of technologies and products used in the various Green Building projects. 11.5% disagreed with the fact that technologies and products used in Green Building projects are manufactured or originate locally. Thus, the outcome is overwhelming feedback that local manufacturing has either not been tracked or that most products and technologies originate outside South Africa.

Pockets of excellence are emerging where local product and technology manufacturing occurs. Given that, 30.8% agree with the statement, and 7.7% strongly agree that, since the introduction of the Green Building Policy in 2015, there has been increased procurement of locally manufactured sustainability products and technologies.

Although it is in the minority, this view is consistent with the recent focus and achievements of a State-owned entity such as Agrément SA, which has a mandate of certification of non-standardised construction products and Alternative Building Technologies, which are mostly sustainable products used in Green Building projects. Over the same period since 2016, the entity has been able to certify more locally innovated and manufactured green/sustainable Alternative Building Technologies and products.

The 30.8% of respondents in agreement is also likely resulting from the Government designation of local content at the procurement policy level, i.e., Solar Water Heaters. Increased implementation of such policies would increase positive feedback and experience in using local technologies and products.

Regulations are being implemented to bolster data collection, reporting on resource consumption and promote the implementation of resource efficiency. These also can boost local innovations and procurement of locally manufactured technologies.

Amongst these is the mandatory display of Energy Performance Certificates (EPCs) in government-owned buildings, which are 1000m2 and above and privately-owned buildings which are 2000m2 and above (DMRE, 2021).

EPC regulations are championed by the Department of Mineral Resources and Energy (DMRE), and DPWI supports their development.

Table 27: Expanded Local Sustainability Procurement within the Green Economy

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	4	7.7	7.7	7.7
	Agree	16	30.8	30.8	38.5
	Neutral	24	46.2	46.2	84.6
	Disagree	6	11.5	11.5	96.2
	Strongly Disagree	2	3.8	3.8	100.0
	Total	52	100.0	100.0	

The weak procurement of local technologies and products reflects gaps found in research on green industry development. Studies emphasis clear local content requirements and monitoring (Sperling *et al.*, 2012), financing for new green enterprises (Schaper, 2010), and incubators to boost innovation (Dean & McMullen, 2007). Robust implementation frameworks maximise local benefits from sustainability policies, such as Department of Trade and Competition localisation policies and initiatives.

4.8. Cross-Sectoral Collaboration on Green Building

The table below shows the responses to the question, *"In your view, does the DPWI collaborate with other Government departments and industries to implement the Green Building Policy?"* The majority of the respondents, 88.5% (46), answered "Yes", only 11.5% (6) answered "No", and 3.8% strongly disagreed.

As enshrined in the United Nations Sustainable Development Goals (SDGs), the

cornerstone of sustainable development is *Partnerships to achieve Sustainable Development Goals,* listed as Goal 17. In recognising this apex SDG goal, the DPWI Green Building Policy has implemented projects and principles based on creating partnerships with other Government departments, industries, and the sector, both locally and internationally. The commitment and achievements by DPWI on creating partnerships and collaborations in implementing the Green Building Policy are confirmed by an overwhelming 88.5% of respondents.

This level of collaboration between the Government and the sector allows for better implementation, monitoring, and reporting on economic development policies, particularly those related to Green Building and green economy, contributing to socio-economic development imperatives and economic growth.

Table 28: Cross-Sectoral Collaboration on Green Building

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	No	6	11.5	11.5	11.5
	Yes	46	88.5	88.5	100.0
	Total	52	100.0	100.0	

The overwhelmingly strong collaboration aligns with studies emphasising that there are partnerships between government, industry, and communities to mainstream sustainability (Hwang & Tan, 2015). Multi-stakeholder participation enables knowledge sharing, capacity building, and coordinated action (Peng *et al.*, 2015). However, research also stresses that collaboration must be tied to robust monitoring and disclosure to ensure accountability in meeting policy goals (Du Plessis *et al.*, 2022) to translate to increased projects and socio-economic opportunities

4.9. Piloting and Implementation of New Technologies in Projects

The table below shows the responses to the question, *"Have projects you have undertaken piloted and implemented new Green Building technologies?"* The majority of the

respondents, 61.5% (32), answered “Yes,” and 38.5% (20) of the total respondents answered “No”.

Linked to the trend and responses based on similar statements regarding the development of new skills resulting from the use of new technologies, i.e., Table 25, 61.5% of respondents to this statement agree that projects have indeed implemented or piloted the use of new Green Building Technologies.

The increase in the view that there is the use of new technologies is significant in that whilst Project Managers may not have gone much into the detail of registering the use of local technologies. However, they acknowledge the use of new technologies in projects, which could be technologies from various parts of the globe, including local ones. The use of new technologies does support the development of new skills and the creation of green jobs.

Table 29: Piloting and Implementation of New Technologies in Projects

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	No	20	38.5	38.5	38.5
	Yes	32	61.5	61.5	100.0
	Total	52	100.0	100.0	

4.10. Increased Opportunities from Green Building

The table below shows the responses to the question, *“Do Green Building projects lead to training, development, and more employment opportunities?”* The majority of the respondents, 84.6% (44), answered “Yes”, and only 11.5% (6) answered “No”. 3.8% (2) respondents did not answer the question.

Put slightly differently from other earlier statements on skills development, this statement attracts 84.6% of respondents who agree, demonstrating that there are indeed more training opportunities, development, and more employment opportunities from Green Building projects. The trend is consistent with those who agree that Green Building projects create more economic opportunities for local enterprises, train opportunities, and employment of more people.

This outcome further aligns with the principle of *Just Transitions* promoted in the transition towards a Green Economy and its use of Renewable Energy and related technologies. Just Transitions promotes a balance between new and old technologies whilst ensuring training and skills development on new technologies. The aim is to create Green Jobs as a transition occurs, ensuring fairness and equal opportunity in the green economy.

Table 30: Increased Opportunities from Green Building

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	No	6	11.5	12.0	12.0
	Yes	44	84.6	88.0	100.0
	Total	50	96.2	100.0	
Missing	System	2	3.8		
Total		52	100.0		

4.11. DPWI Leadership on implementation of Green Building Initiatives

The table below shows the responses to the question of the DPWI offering effective leadership to the Government in the implementation of Green Building initiatives. A slight majority of the respondents, 53.8% (28), answered “Yes”, and 46.2% (24) of the total respondents answered “No”.

One DPWI Green Building Policy principle is the commitment to offer leadership to the sector and the Government on adopting and implementing Green Building. 53.8% of respondents who agree to the question confirm this leadership's visibility and effectiveness. This level of response, however, is still low and suggests more needs to be done by the DPWI in providing leadership to the Government and the sector. As evidence, we can see that a considerable 46.2% believe that the DPWI does not provide such required leadership.

Regarding stakeholder management and engagement, the DPWI needs to bring all Government Departments and sector stakeholders to buy in and support the implementation

of its Green Building Policy to ensure economies of scale and uptake in project rollout. Intergovernmental cooperation does exist to provide for improved leadership through the Green Economy Accord and the South African Climate Change Response Strategy.

Table 31: DPWI Leadership on implementation of Green Building Initiatives

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	No	24	46.2	46.2	46.2
	Yes	28	53.8	53.8	100.0
	Total	52	100.0	100.0	

4.12. Factors influencing Green Building practices in South Africa

Table 32: Factors influencing Green Building practices in South Africa

No.	Factors influencing Green Building practices	Total	Rank
1	**Unwillingness to change and attachment to old technologies and legacy business**	408	1
2	**Perceived risk associated with uptake of new practices**	384	2
3	**Green Building design guidelines and South African National Standards (SANS) construction**	312	3
4	**Lack of Expertise to undertake Green Building projects**	312	3
5	**Economic conditions**	306	5
6	**Business and social activism for sustainability**	306	5
7	**Risk of job loss from labour resulting from lack of awareness of green jobs**	306	5
8	**Government support and incentives**	302	8
9	**Green Building education programmes**	292	9
10	**Cost of Green Building**	274	10
11	**Green Building Regulations and Policies**	230	11

A list of possible factors was given to respondents to establish as to which factors, in the opinion of respondents, affect most the adoption of Green Building and its practices in South

Africa. This was out of a list of 11 factors scored in sequence, from one with the highest to one with the lowest impact on Green Building practices.

The responses provided a mix of expected and unexpected feedback on factors impacting Green Building practices. However, this is also consistent with the respondents' perceptions, who stated in earlier questions that they have not included Green Building scoping in projects, seemingly based on the same factors.

These respondents seem to have control of larger budgets and, therefore, more projects where Project Managers have not included Green Building and resource efficiency in scoping. Another possibility is where respondents feel that more Green Building projects should be done but are affected by the listed stated factors impacting the decisions on whether to implement Green Building on either the User/Client Department or Project Managers during scoping.

According to respondents, the highest factor negatively influencing the uptake of Green Building practices and, therefore, the implementation of Green Building Policy and its related projects is the “Unwillingness to change and attachment to old technologies and legacy business” on the part of Project Managers, decision-makers, and clients. This factor scored the highest, with 408 respondents. The view is consistent, for example, with a lower than expected uptake of using Alternative Building Technologies (ABTs) as experienced by manufacturers of innovative, non-standardised green construction materials certified by one of the DPWI entities, Agrément SA.

This factor was followed by “Perceived risk associated with the uptake of new practices” as the second highest-rated factor scoring 384 respondents. This factor is also consistent with the lower-than-expected use of green ABTs and other innovative, efficient equipment used in buildings. This is opposed to a high potential for their use, given that the built environment has one of the highest potentials for reducing Greenhouse Gas emissions and contributing to the realisation of a Green Economy.

Other factors scoring high are “Green Building design guidelines and South African Standards (SANS) construction” and “Lack of expertise to undertake Green Building projects”, which respondents scored 312 each.

The ranking of these factors by respondents explains why there is a high number of projects that have not rolled out Green Building. The rankings further point to key areas and opportunities to be addressed as part of sector engagement and advocacy to improve Green Building implementation.

It is clear that a mixed intervention is required to address any gap that may be left by applicable prescripts and address the issue of further skills development beyond the current impact whilst engaging in a Change Management process to address uncertainty and perceptions, using best practice examples where there is Green Building rollout.

4.13. Familiarity with SA National Development Plan Vision 2030

The table below show the responses to whether respondents were familiar with the principles of the South African National Development Plan (NDP) Vision 2030. An overwhelming majority of the respondents, 92.3% (48), answered “Yes”, and only 7.7% (4) of the respondents answered “No”.

This question ascertained if respondents were familiar with the broader high-level prescripts and policies aimed at migrating South Africa towards a green economy in every other sector, beyond the Green Building, given that most sectors of the economy are feeders to each other, therefore impacting on each other economically and environmentally. An overwhelming 92, 3% of respondents agreed and confirmed that they are familiar with the National Development Plan Vision 2030 principles.

This is a very positive development given that the NDP provides strategic interventions in the identified paths or scenarios and collaborations amongst the Government Department and sector stakeholders.

There is a level of concern, however, regarding 7.7% of respondents who do not know of the principles of the NDP. This remains an important group of professionals, decision-makers, and Project Managers who are expected to plan and implement sector projects supporting the principles and provisions of South Africa’s National Development Plan.

Table 33: Familiarity with SA National Development Plan Vision 2030

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	No	4	7.7	7.7	7.7
	Yes	48	92.3	92.3	100.0
	Total	52	100.0	100.0	

4.13.1. Awareness of the Green Economy Principles

As a follow-up to the question in Table 33 the table and figure below show the responses to whether the respondents were aware of the green economy principles the NDP calls for, which the DPWI Green Building Policy seeks to meet. The majority of the respondents, 88.5% (46), answered “Yes”, and only 11.5% (6) of the respondents answered “No”.

There is an overwhelmingly positive response amongst respondents aware of NDP calls, which the DPWI Green Building Policy seeks to achieve. This means the sector can draw parallels between existing green economy prescripts and principles thereof. This level of awareness should translate to more projects meeting Green Building principles. However, there is a concerning 11.5% of respondents who said “No”, which could also affect the number of projects with Green Building consideration if this 11.5% is responsible for more decision-making or more projects.

Table 34: Awareness of the Green Economy Principles

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	No	6	11.5	11.5	11.5
	Yes	46	88.5	88.5	100.0
	Total	52	100.0	100.0	

4.14. Experience in the implementation of Green Building Technologies innovations and resource efficiency

The table below shows responses to the question of respondents having experience working with a team implementing Green Building technologies, innovations, and resource efficiency (Renewable Energy, including water, energy, and waste efficiency).

The majority of the respondents, 76.9% (40), answered “Yes”, and 23.1% (12) of the respondents answered “No”.

There is a good level of exposure amongst sector stakeholders to Green Building projects, based on the response from the random selection, with 76.9% of respondents having participated or having worked with a team implementing Green Building in one form or another. This is positive for both awareness and experience amongst sector stakeholders on Green Building practices.

There is, however, a concern that a considerable 23.1% of respondents have not had work with a team implementing Green Building. This does talk to the fact that the sector has not seen its full potential regarding the rollout of Green Building, and that this crucial practice has not yet become as widespread and a norm as it should be in every project. This is also consistent with the response of participants who, for example, are unfamiliar with broader Green Economy prescripts such as the NDP, as per Table 33.

This response suggests that there is an entrenched awareness of Green Building activities. However, some teams may still face challenges to implement or manage Green Building projects due to potential challenges such as capacity contractions, budget shortages, and lack of skills.

Table 35: Experience in the Implementation of Green Building Technologies innovations, and resource efficiency

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	No	12	23.1	23.1	23.1
	Yes	40	76.9	76.9	100.0
	Total	52	100.0	100.0	

The available experience with working with Green Building teams reflects growing expertise, consistent with literature on training, mentorship and communities of practice to build capabilities (Robichaud & Anantatmula, 2011). However, studies also recommend expanding practical learning beyond pockets of excellence through policy incentives, communities of practice and real-world projects (Maia *et al.*, 2011). Mainstreaming green skills requires tailored strategies and participatory approaches (Sperling *et al.*, 2012).

4.15. Consideration of Green Building Policy in Recent Projects

The table and figure below show the responses to the question of the Green Building Policy being considered in all the respondents' private and public sector projects that have been completed in the past six (6) years. The majority of the respondents, 61.5% (32), answered “No”, and 38.5% (20) of the respondents answered “Yes”.

The response presents serious concerns in that not every project in the past six years has incorporated Green Building principles by considering the Green Building Policy provisions. A vast number of respondents, 61.5%, confirm that although the policy is implemented through various projects, not every project has had Green Building considerations. This may be linked to apathy, reluctance, or unawareness amongst those unfamiliar with prescripts like the NDP and the Green Building Policy, as per Table 33.

What this could also mean is that in terms of the actual number of projects, those not familiar with provisions of NDP and Green Building Policy, together with those who have not worked with Green Building teams, as per Table 34, could be responsible for a large number of projects and budget, as opposed to those who are aware and have experience working with Green Building teams.

Alternatively, this feedback may suggest that the private sector does not consider the DPWI Green Building Policy as they rely on internal or industry processes. Moreover, for the public sector, the DPWI policy requires ongoing advocacy. This means more work is required to create awareness and agency amongst decision-makers and commission a larger number of projects in the public sector.

As a positive development, South Africa continues to present opportunities for the required

increased uptake of Green Building, improving on over 600 projects already completed by the sector through the Green Building Council of South Africa (GBCSA) Green Star rating since 2009, covering approximately 9 million square meters (GBCSA, 2020).

As a positive development, because of ESG reporting requirements, companies will have their own green agendas and strategies, a step further beyond just the industry and sector level (Reynolds, 2021). It is projected that sustainability will become even more prominent in society as we see the rise of Environment Social and Governance (ESG) reporting, providing the Green Building sector with an opportunity to drive the narrative (Pendlelton, 2021).

The public sector has an increased opportunity to escalate its Green Building and resource efficiency projects through the approved South African Economic Reconstruction and Recovery Plan introduced to ensure economic growth and establish an equitable economy (ERRP, 2020).

This aligns with the opportunity presented by incorporating the DPWI resource efficiency programme into the country's Strategic Integrated Projects (SIPs) as stated in the DPWI's Integrated Renewable Energy and Resource Efficiency Programme (DPWI, 2021).

Table 36: Consideration of Green Building Policy in Recent Projects

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	No	32	61.5	61.5	61.5
	Yes	20	38.5	38.5	100.0
	Total	52	100.0	100.0	

The limited integration of green building considerations highlights that voluntary participation has not achieved systematic adoption. Research emphasizes strengthened mandates, incentives and demonstration projects help overcome biases favoring conventional construction (Kibert, 2016). Robust policy compliance monitoring, enforcement and disclosure enable the shift to sustainability (Maia *et al.*, 2011). South Africa can accelerate

green construction by embedding requirements through legislation, change management, procurement and ongoing assessment.

4.16. Awareness of Conventional Building Challenges

The table below show responses to the question of respondents being aware of major environmental challenges that contribute to climate change because of conventional design, construction, and operation of buildings. The overwhelming majority of the respondents, 96.2% (50), answered “Yes”, and only 3.8% (2) of the respondents answered “No”.

There is again a demonstration of great awareness regarding environmental challenges resulting from conventional building construction and systems thereto, given that an overwhelming 96.2% of respondents confirm that they are aware. There is, however, concern that this level of awareness is not supported by required action on the ground at the decision-making level towards increasing the number of Green Building projects, based on respondents who state that not every project considered Green Building Policy as per table 35.

This situation suggests that other variables could negatively affect the uptake on the number of projects to implement Green Building, other than awareness of climate change or Green Building principles.

Table 37: Awareness of Conventional Building Challenges

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	No	2	3.8	3.8	3.8
	Yes	50	96.2	96.2	100.0
	Total	52	100.0	100.0	

4.17. Green Building Policy Awareness in Sector

The table below show responses to the question, “Is there a general awareness of Green Building Policy within the sector?” The majority of the respondents, 61.5% (32), agreed. This was then followed by 15.4% (8) of those who were neutral. In addition, those who strongly agreed were 11.5% (6), whereas 7.7% (4) disagreed. The remainder, 3.8% (2) of the

respondents, strongly disagreed with the question.

This is positive given that the majority of respondents themselves confirm that according to themselves as sector stakeholders, there is awareness of the Green Building Policy through 61.5% who agree and 11.5% who strongly agree.

There is a challenge, however. 15.4% of respondents remained neutral and 7.7%, particularly because, as shown in the feedback in Table 35 above, the number of projects that do not have Green Building considerations is high. This is most likely linked to the views or experiences of those who disagree and those who are neutral, although their number is less than those who agree that there is awareness of the Green Building Policy in the sector.

Table 38: Green Building Policy Awareness in Sector

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	6	11.5	11.5	11.5
	Agree	32	61.5	61.5	73.1
	Neutral	8	15.4	15.4	88.5
	Disagree	4	7.7	7.7	96.2
	Strongly Disagree	2	3.8	3.8	100.0
	Total	52	100.0	100.0	

4.18. Occupant Productivity Benefits of Green Building

The table and figure below show the responses to the question of Green Building promoting a healthier, more productive environment for building occupants. The majority of the respondents, 53.8% (28), strongly agreed, and 46.2% (24) of the respondents agreed.

This question weighs respondents' user experience (UX) as occupants or users of green buildings and systems thereof. There is great feedback from respondents being aware or having experienced that Green Building provide a healthier and more productive environment for building occupants, with 53.8% strongly agreeing and 46.2% agreeing.

Given this level of awareness and experience amongst respondents regarding Green Building, including its nature as an enabler for increased productivity, there should be a drive towards uptake to ensure more projects incorporate Green Building. Given this exciting appreciation amongst sector stakeholders, Project Managers and decision-makers should be able to drive a campaign towards more uptake, identifying and addressing other variables negatively affecting the uptake on the number of projects implementing Green Building.

Beyond operational and policy buy-in, this level of awareness and benefit of Green Building provides an opportunity to galvanise support even from organised labour interested in the well-being of employees and healthy workspaces/buildings.

Table 39: Occupant Productivity Benefits of Green Building

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	28	53.8	53.8	53.8
	Agree	24	46.2	46.2	100.0
	Total	52	100.0	100.0	

The recognition of Green Building's contribution to healthier wellbeing benefits reflects measurable improvements found in literature, such as enhanced indoor air quality, lighting and thermal comfort (Thatcher & Milner, 2016). Studies attribute 15% better occupant satisfaction to strategies like low VOC materials and passive climate control (Abbaszadeh *et al.*, 2006). Productivity and health gains justify investments; however, research recommends comprehensive post-occupancy evaluations to quantify and improve outcomes (Darko & Chan, 2017).

4.19. Encouragement of Green Building Expertise in DPWI

The table and figure below illustrate the statement, *"The DPWI encourages staff members to obtain expertise in Green Building and sustainable development".* Most respondents, 46.2% (24), agreed with the statement. This was then followed by 26.9% (14) of those who were neutral. In addition, those who disagreed with the statement were 15.4% (8), and 11.5% (6) strongly agreed.

This question is also important as a measure of the perception of the sector and employees

regarding employer (DPWI) commitment to driving Green Building expertise and skills development. However, there is a healthy perception of 46.2% of respondents who agree and 11.5% who strongly agree that DPWI is encouraging staff members to obtain Green Building expertise. Nevertheless, there must be more work done by DPWI to provide leadership in encouraging staff and sector to obtain expertise, given that 26.9% are neutral, possibly because they are not aware, and 15.4% disagree.

The 15.4% who disagree and the 26.9% neutral may affect the uptake on projects should they believe that the DPWI as an employer does not have a serious follow through on its policies by not encouraging the development of expertise to implement the policy throughout the Department. This element is one of the empowerment measures, motivators, and enablers to drive policy implementation in more projects.

Table 40: Encouragement of Green Building Expertise in DPWI

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	6	11.5	11.5	11.5
	Agree	24	46.2	46.2	57.7
	Neutral	14	26.9	26.9	84.6
	Disagree	8	15.4	15.4	100.0
	Total	52	100.0	100.0	

The moderately positive view of DPWI's encouragement reflects literature emphasizing internal expertise development enables sustainability leadership (Robichaud & Anantatmula, 2011). However, research also stresses skills strategies must be systematic and appropriately resourced (Maia *et al.*, 2011). Tailored training, mentorship and recruitment programs help build critical green capabilities (IEA, 2020). Targets and transparent reporting provide accountability.

4.20. Green Building Knowledge in Recruitment

The table below illustrates the statement *"Our Branch/Entity/Department/Company has a deliberate policy to recruit new employees with Green Building experience for the built environment and infrastructure-related work".* Most respondents, 34.6% (18), disagreed with

the statement. This was then followed closely by 30.8% (16) of those who were neutral. In addition, those who agreed with the statement were 23.1% (12), and 3.8% (2) strongly agreed.

Similar to Table 39, this measures all other sector employers' commitment to promoting and acquiring Green Building expertise. The trend in the sector is even more worrying than the situation at DPWI, which according to respondents, is doing better than other employers in terms of perception of the promotion of expertise.

According to respondents, the industry and sector have not moved to promote the required expertise or recruit the same, thus also affecting the potential to create more Green Building jobs. Sector employers and project owners should join the DPWI in promoting Green Building and building-related expertise.

Table 41: Green Building Knowledge in Recruitment

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	2	3.8	3.8	3.8
	Agree	12	23.1	23.1	26.9
	Neutral	16	30.8	30.8	57.7
	Disagree	18	34.6	34.6	92.3
	Strongly Disagree	4	7.7	7.7	100.0
	Total	52	100.0	100.0	

The lack of dedicated recruitment reinforces studies showing that the sustainability trajectory requires institutional commitment (Kibert, 2016). Literature recommends skills assessments, training pathways and expertise-building incentives to systematically develop green capabilities (Sperling *et al.*, 2012). Strategic development of emerging competencies enables organizations to lead and capitalize on the transition to green construction (Robichaud & Anantatmula, 2011).

4.21. Variables/constructs measures of central tendency and dispersion

Table 42 below shows the variables/constructs measures of central tendency and dispersion. The construct of Green Building promotion of a healthier and more productive environment for building occupants has the highest mean of 4.54 with a standard deviation of 0.50, followed by green building practices with a mean of 4.18 and standard deviations of 0.61. These were followed by compliance with the DPWI Green Building policy (mean = 3.76; standard deviation = 0.60) and general awareness of Green Building policy with a mean of 3.69 and standard deviation of 0.92. The fifth-highest construct contributed to local economic development, with a mean of 3.55 and a standard deviation of 0.72. Lastly, the use of Green Building Technologies with a mean of 3.47 and standard deviation of 0.73, and the policy to recruit new employees with Green Building experience with a mean of 2.81 and standard deviation of 1.01.

Besides the need for environmental sustainability, other critical drivers for Green Building worth noting in South Africa are exceptionally linked to socio-economic challenges, including unemployment and the high carton footprint in the country (Borel-Saladin & Turok, 2013). The results above mean that Green Building promotion improves health and other productive components, thus addressing the research objective. The researcher believes that addressing climate change challenges through the built environment presents opportunities for the entire value chain of Green Building, including environmentally friendly, innovative, and indigenous materials. There is an opportunity for up-and-coming entrepreneurs in South Africa to claim the Green Building space, particularly through opportunities presented by localisation potential in the sector. As observed in countries such as Nigeria, regarding materials for the built environment in general, developing countries seem to be facing a problem with the supply of building materials, pushing up their costs (Oruwari, Jev & Owei, 2002).

Table 42: Variables/constructs measures of central tendency and dispersion

Variables/constructs	Mean	Std. Deviation	N
Green Building promotion of a healthier and more productive environment for building occupants	4.54	.50	52
Green Building Practices	4.18	.61	52
Compliance with the DPWI Green Building Policy	3.76	.60	52
General awareness of Green Building Policy	3.69	.92	52
Contribution to local economic development	3.55	.72	52
Use of Green Building Technologies	3.47	.73	52
Policy to recruit new employees with Green Building experience	2.81	1.01	52

4.22. Correlation Analysis

Table 43 below shows Spearman's rho correlation results for each of the seven variables/constructs. The Spearman's rho correlation was applied since the data was measured using an ordinal scale. The Spearman's coefficient of correlation for the variables can range between either a positive coefficient of correlation of +1 and a negative -1 (MacFarland & Yates, 2016). If Y tends to increase when X increases, the Spearman correlation coefficient is positive. If Y tends to decrease When X increases, The Spearman correlation coefficient is negative. Negative correlation coefficient would thus mean a value less than 0 and demonstrates an observable pattern.

4.22.1. Green Building Practices and Compliance with DPWI Green Building Policy

The results show that the Green Building Practices and Compliance to the DPWI Green Building Policy ($r=0.571$, $p<0.01$) have a significant positive correlation, implying

respondents consider the two very important. A positive correlation exists between Green Building Practices and the Use of Green Building Technologies ($r=0.606$, $p<0.01$). A significant positive correlation exists between using Green Building Technologies and compliance with the DPWI Green Building Policy ($r=0.622$, $p<0.01$).

The positive correlation between Green Building practices and GB Policy compliance is consistent with research showing rating tools and government mandates reinforce sustainability adoption (Peng *et al.*, 2015; Robichaud & Anantatmula, 2011). However, studies also emphasize comprehensive monitoring and disclosure to drive higher performance (Du Plessis *et al.*, 2022).

4.22.2. Green Building Practices and Use of Green Technologies

There is a positive relationship between using Green Building Technologies and contributing to local economic development ($r=0.461$, $p<0.01$). A positive relationship exists between Green Building Practices and Green Building promotion of a healthier & more productive environment ($r=0.464$, $p<0.01$). The results below show a positive correlation between the DPWI Green Building Policy compliance and the contribution to local economic development ($r=0.442$, $p<0.01$). There is a positive relationship between Green Building Practices and the contribution to local economic development ($r=0.413$, $p<0.01$).

Lastly, there is a negative relationship between the Green Building promotion of a healthier & productive environment and the policy to recruit new employees with Green Building experience ($r=-0.301$, $p<0.05$).

The negative relationship suggests that there is no correlation between Green Building promotion of healthier & productive environment and policy to recruit new employees and decision makers that have Green Building experience or understanding thereof. For the researcher this may suggest that there is no institutional implementation of Green Building in place such that it affects recruitment, or this may mean Green Building is deemed necessary only at operational level and not a required skill for new employees.

The positive correlation between Green Building practices and technology adoption reflects literature emphasising integrated design and project delivery to enable emerging solutions and innovations (Wu *et al.*, 2021). However, research also stresses benchmarking

investments against continual improvement goals through transparent reporting (Maia *et al.*, 2011).

Table 43: Constructs Correlation Matrix

	A	B	C	D	E	F	G
A	1						
B	**.606****	1					
C	**.571****	**.622****	1				
D	**.413****	**.461****	**.442****	1			
E	-.087	-.038	-.79	.76	1		
F	**.464****	.182	.161	.078	.112	1	
G	-.178	.212	.053	-.077	-.154	**-.301***	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

KEY:

A = Green Building Practices

B = Use of Green Building Technologies

C = Compliance with the DPWI Green Building Policy

D = Contribution to local economic development

E = General awareness of Green Building Policy

F = Green Building promotion of a healthier & more productive environment

G = Policy to recruit new employees with Green Building experience

4.23. Hypotheses testing and discussion

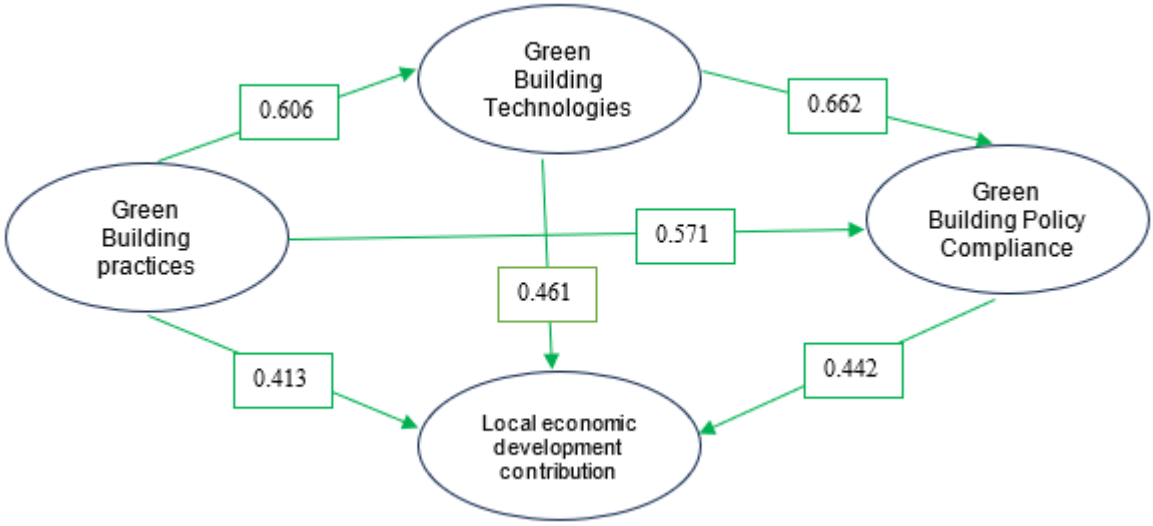

Figure 8: Hypotheses results

H1: Green Building practices have a significant positive effect on the use of green building technologies.

There is a significant positive relationship between Green Building practices and green building technologies ($r = 0.606$, $p < 0.01$).

The positive relationship supports literature showing that integrated Green Building design and delivery enable emerging solutions (Wu *et al.*, 2021). Studies also emphasise benchmarking technology adoption against continual improvement goals through transparent reporting (Maia *et al.*, 2011).

H2: Green Building practices have a significant positive effect on compliance with the green building policy.

A significant positive relationship exists between Green Building practices and compliance with the Green Building Policy ($r = 0.571$, $p < 0.01$).

The significant correlation reflects studies showing policy mandates incentivise sustainability across project lifecycles (Peng *et al.*, 2015). However, comprehensive monitoring and disclosure are critical to drive higher performance (Du Plessis *et al.*, 2022).

H3: Green Building practices have a significant positive effect on the contribution to the local economic development.

There is a positive relationship between Green Building practices and the contribution to the local economic development ($r = 0.413$, $p < 0.01$).

The positive relationship signals an opportunity and reinforces research emphasising planning, tracking and disclosing job creation, skills development and enterprise opportunities to maximize community benefits at socio-economic development level (Sperling *et al.*, 2012).

H4: Use of Green Building Technologies (GBT) have a positive effect on the Contribution to local economic development.
There is a positive relationship between using Green Building Technologies and the Contribution to local economic development ($r = 0.461$, $p < 0.01$).

This relationship highlights literature on strategic skills development, local content requirements or support to local innovation, and small business participation to optimize local impact (Willis *et al.*, 2018).

H5: Compliance with the DPWI Green Building Policy has an effect on contribution to local economic development.
A positive relationship exists between compliance with the DPWI Green Building Policy and the contribution to local economic development ($r = 0.442$, $p < 0.01$).

The correlation reflects research findings that integrated mandates, monitoring and reporting of sustainability's socio-economic outcomes enables realising the full potential (Maia *et al.*, 2011).

H6: Use of Green Building Technologies have a significant positive effect on compliance with the DPWI Green Building Policy.
A significant positive relationship exists between using Green Building Technologies and compliance with the DPWI Green Building Policy ($r = 0.622$, $p < 0.01$).

This significant relationship shows innovations often emerge through supportive frameworks and an enabling environment at policy and funding level, though studies recommend strengthened compliance structures (Cole & Valdebenito, 2013).

4.24 Conclusion

The results provide valuable insights into the implementation of Green Building practices, use of technologies, policy compliance, and contribution to local socio-economic development in South Africa. Overall, the results indicate a growing commitment to sustainability within DPWI, DPWI entities, and the wider Build Environment as a sector. However, gaps remain, working against the full realisation Green Building's potential benefits.

The survey revealed a strong awareness of climate challenges and broad support for Green Building principles. Significant experience also exists in implementing Green projects, though largely confined to pockets of excellence. This underscores the need to mainstream Green building through strengthened policy frameworks, incentives, skills development and ongoing benchmarking against transparent metrics. Targeted strategies can also enable wider participation in the green economy.

Whilst the DPWI is perceived as providing leadership to the sector through the Public Works Green Building Policy and related projects, the research identified opportunities to amplify advocacy, intergovernmental collaboration, skills development amongst employees, and project monitoring. Though voluntary certification has raised the profile of Green building, findings reinforce that participation remains limited without systematic integration across procurement processes, design standards and post-occupancy.

Realising local economic opportunities requires deliberate planning, tracking and disclosure of job creation, enterprise development and skills transfer. Mainstreaming these goals through inclusive implementation frameworks helps catalyse widespread adoption and impact. Ongoing engagement, capacity building and participatory approaches can also strengthen outcomes.

Overall, this research results do not only highlight Green Building's growing role, but also the significant potential to accelerate South Africa's sustainability transition through integrated policy mandates, transparent benchmarking and monitoring, targeted skills strategies and participatory models. Further research should explore funding opportunities to up-scale implementation, quantify benefits and engage marginalised groups to ensure just, inclusive outcomes in line with principles of Just Transitions.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

Upon concluding the study's outcomes, this chapter will provide recommendations based on the set objectives for this dissertation. The research study provides for potential research areas emanating from the study, which others can study further.

The purpose of this study was to assess the potential for Green Building to achieve key socio-economic imperatives, thus assessing the ability of the sector to contribute to the broader South African economy. This assessment is based on feedback from a diverse group of stakeholders in the sector, using stakeholder learned and lived experiences as project managers, project coordinators, senior managers, asset managers, facilities managers, users, property owners, property managers, researchers, engineers, and architects.

The journey traversed through this research has been to establish the potential for Green Building to increase Enterprise Development, job creation, and local innovation. Further, the aim was to raise awareness of built environment Indigenous Knowledge Systems as identified socio-economic development interventions. Findings presented by the researcher have shown elements of consistency with other international and local research on Green Building as a sector of the green economy.

In line with the United Nations Environment Sustainable Building Initiative findings, the built environment continues to present one of the highest potentials and opportunities to achieve the reduction of Greenhouse Gas emissions through the rollout of Green Building and related resource efficiency interventions, including offering a return on investment for investors (UNEP-SBI, 2014).

Based on existing literature and the findings of this study, the study affirms that the work on Green Building is linked to the green economic trajectory and, therefore, the United Nations Sustainable Development Goals. In this regard, concerning its findings on progress made

in the implementation of SDGs, the United Nations Department of Economic and Social Affairs (UN DESA) states that although several interventions have been made globally towards meeting set goals, it is a concern that goals such as *Affordable and Clean Energy* will not be met by 2030. This is despite several energy-efficiency and Renewable Energy interventions being made globally by different countries, including South Africa (UN DESA, 2020).

However, this slow progress is also partly due to the recent pandemic, which affected every sector and other economic factors affecting various countries post the pandemic (Musunda & Rakolote, 2022).

On the South African front, the outcomes and findings of this dissertation are consistent with the UN DESA findings. However, specific to Green Building, various stakeholders have implemented many Green Building projects in the South African built environment. Although this includes stakeholders such as the Department of Public Works and Infrastructure, there remains more to be done for Green Building projects to have a significant uptake. This is to enable the sector to contribute meaningfully to the creation of Green Jobs, Enterprise Development, local innovation and other socio-economic imperatives, as highlighted by 61.5% or 32 participants who responded to this research that Green Building Policy is not considered in their project specifications.

The findings of the research are consistent with literature review in Chapter 2. Particular reference in this regard is the area of green jobs creation, enterprise development, and innovation, directly contributing to socio-economic development.

Literature review covered postulation which suggested that through Green Building, sustainable Development and the resultant green economy should catalyse job creation and Enterprise Development. Maia and Giordano (2011:1) argue, "A greening economy should result in expansions of productive capacity and service delivery across a wide spectrum of economic sectors, although contractions may be experienced in others. Investment activity should progressively support this and result in meaningful employment creation.”

With regard to Enterprise Development, these research outcomes proceed to project what the literature postulates, that entrepreneurial studies in the field have defined enterprise or firm creation as resulting from the nexus of the individuals and an opportunity or potential in

the market they see (Shane & Venkataraman, 2000).

Liked to the South African specific energy challenges, and the need for interventionist projects, literature is affirms the outcome of research in relation to uptake on resource efficiency projects. Namely that for electricity consumers, such as Client Departments and industry, exposure to blackouts and rising annual energy and water tariff prices have triggered an awakening to alternative possibilities for energy supply. This reality, together with the expansion of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), is adopting sustainable solutions at a rate that the sector could have only dreamed of ten years ago (Brown, 2015).

Invariably, the management of innovation, people, and technology is a central motive force required to achieve market competitiveness and funding, towards achieving a macro green economy. As covered in in the Literature Review of this research, the design, commissioning and uptake on projects has potential to benefit from the TIPS Leadership Management Framework, described as an integrated, systems approach to the management of Technology, Innovation, People, System (TIPS) (Davinci, 2020). This element is discussed in this chapter.

This chapter concludes the findings of this study, including suggesting that whilst there is entrenched awareness of Green Building activities based on stakeholder feedback, some teams may still face challenges in implementing or managing Green Building projects. This is due to potential challenges such as attachment to the legacy business, capacity contractions, budget shortages, lack of skills, and lack of integrated project implementation.

As part of the recommendations, the study presents a Green Building project implementation framework, which addresses critical thematic areas of the study, particularly the identified socio-economic development imperatives, for stakeholders to consider in the implementation of projects. The framework will use high-level elements of the systems thinking approach and green project management, suggesting that an integrated approach is required for the mandatory uptake of Green Building to be realised for the sector's increased contribution to socio-economic development.

Given the foregoing and the study's outcome, the study postulates that there is indeed a vast potential for Green Building to increase Job Creation, Enterprise Development, Local

Innovation, and awareness of Indigenous Knowledge Systems, including implementation in the South African Built Environment.

5.2. Recommendations based on research objectives

As a positive development, this study confirms that there is much activity in implementing Green Building, although not at the sector's full potential. This is confirmed by an overwhelming 76.9% or 40 respondents to this research who confirmed that they do have experience working with a team implementing Green Building technologies, innovations, and resource efficiency, i.e., Renewable Energy, including water, energy, and waste efficiency.

Green Building projects are championed by various private sector stakeholders, including the Department of Public Works and Infrastructure, through the DPWI Green Building Policy, which highlights a commitment by the Government to provide leadership to the sector on Green Building (DPW Green Building Policy, 2018).

As already stated, these projects include the rollout of energy and water efficiency, integrated solid waste management, renewable energy, construction of new buildings and retrofitting of existing building. This is achieved using Alternative Building Technologies (ABTs), Green Building Technologies (GBTs), and sustainable Indigenous Knowledge Systems (IKS) applicable to the built environment, i.e., biodiversity and the ancient architecture of using rammed earth in the construction of certain buildings and facilities (DPWI, 2018).

The study recommends that whilst implementation has commenced on several projects, there are a few projects happening on the ground based on the current built environment scoping of projects. This is potentially due to the fact that other Green Building projects are still at a planning stage, and an integrated framework and reporting system has not been fully put into place to record certified and uncertified Green Building projects and resource efficiency projects. This postulated management framework would include measurement and verification, technical reporting, and socio-economic development data to close gaps in reporting on installed technologies as demonstrated in the stakeholders' responses above and provide consistent verified resource efficiency savings data, jobs created, and

enterprises developed.

One suggests that to address concerns and feedback received from stakeholders as per the questionnaire of this study, this integrated framework is required to manage and report on the Green Build project going forward, given the envisioned pipeline of Green Economy projects (Reynolds, 2021). As stated earlier in Chapter 4, South Africa continues to present opportunities for the required increased uptake of Green Building, improving from over 600 projects completed by the sector through the Green Building Council of South Africa since 2009 (GBCSA, 2020).

As stated in the interpretation of results earlier, sustainability will become even more prominent as we see the rise of ESG reporting, providing the Green Building sector with an opportunity to drive the narrative (Pendlelton, 2021).

The public sector has an opportunity to increase its Green Building and resource efficiency projects through the country's Economic Reconstruction and Recovery Plan (ERRP, 2020).

The plan provides various interventions, such as aggressive infrastructure investment, employment-orientated strategic localisation, reindustrialisation and export promotion energy security, and green economy interventions to forge a new economy in a new global reality (ERRP, 2020).

This is particularly beneficial for the Department of Public Works and Infrastructure and the Green Building Policy Programme, given that the DPWI Integrated Renewable Energy and Resource Efficiency Programme (iREREP) is already included in the country's *Strategic Integrated Projects* to introduce a pipeline of infrastructure projects (ISA, 2021).

As part of an integrated approach to resource efficiency in the built environment, this project preparation is mirrored by the increasing focus on water efficiency, solid waste management for recycling, and planned increased use of construction waste in new construction projects.

Moreover, the South African Government, through the Department of Mineral Resources and Energy (DMRE), has recently made it mandatory for property owners to know the energy consumption of their buildings, calling for a compulsory display of Energy Performance (EPCs) in buildings 1000m2 and above for the government and 2000m2 for

the private sector (EPC Regulations, 2021).

The rollout of Energy Performance Certificates requires an unprecedented collection, assessment, and submission of building energy consumption data by property owners to issue EPCs, providing an opportunity for a pipeline of energy efficiency projects and green jobs.

Key to this study is the potential for procurement of indigenous knowledge and skills applicable to Green Building, i.e., use of indigenous plants, arts from indigenous communities and use locally produced materials such as like rammed earth in certain Green Building construction projects, among others.

5.3.1. Impact of Public Works Green Building Policy on increasing Enterprise Development opportunities

Based on feedback from randomly selected sector stakeholders, this research has proven that there is indeed a positive impact of Green Building on Enterprise Development, given experiences in different projects. However, these results also clearly suggest that there is more to be done in the sector.

The identified subsets of Green Building and resource efficiency present vast socio-economic development opportunities, including Enterprise Development. As discussed earlier, these identified subset interventions include:

a. Energy and water efficiency;
b. Renewable Energy (embedded generation);
c. Solid Waste Management (Recycling);
d. Biodiversity;
e. Rammed earth construction; and
f. Use of Alternative Building Technologies/Green Building Technologies, including related eco-labelling of building materials.

The study covers key recommendations on each identified Green Building subset to increase Enterprise Development opportunities, using the study's proposed *Green Building Project Framework Hut* as a high-level framework to structure Green Building projects. As opposed to a conventional Project Management Framework, the proposed Green Building Project Framework Hut is more of a framework to structure projects, emphasizing four

fundamental vertical pillars of a project, holding together into place the four *horizontal binders* of a project.

5.3.1.1. The Green Building Project Framework Hut

The *Green Building Project Framework Hut* (GBPFH) is shaped as an African hut, its analogy being a man-made asset built to be sustainably embedded in the local environment.

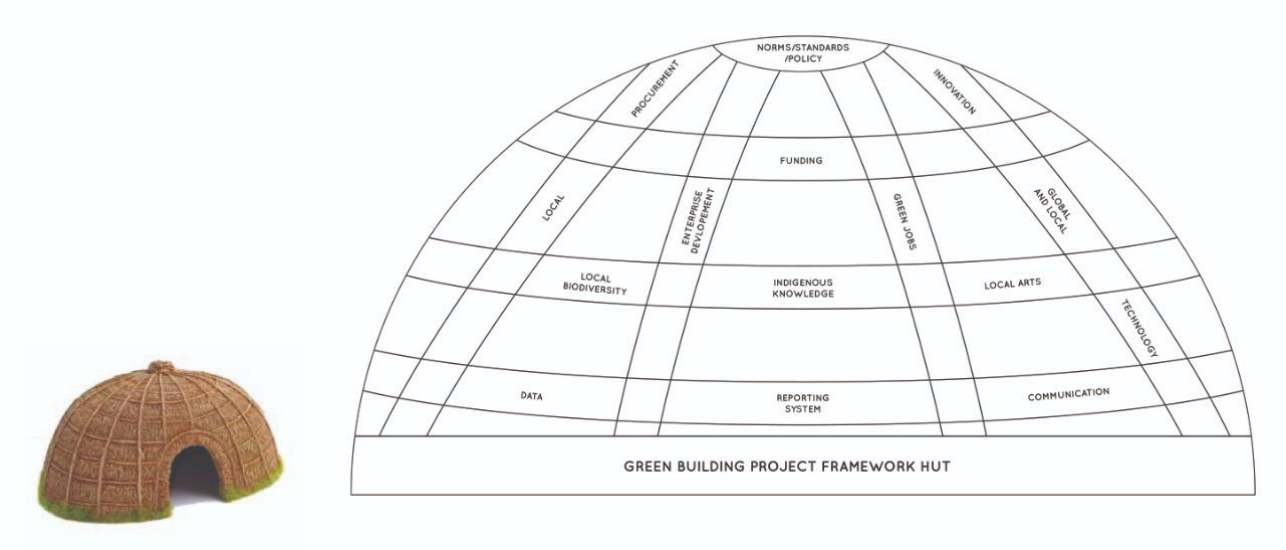

Figure 9: Green Building Project Framework Hut (Xulu Ka Dlamini, 2022).

The study postulates that given the outcomes of this research, for a Green Building and resource efficiency project to be viable and feasible in achieving a return on investment (RoI), it must achieve the required levels of innovation and use of technology. At the same time, it must be meaningful and responsive to the identified socio-economic development imperatives. Further, it has to be structured in the proposed Green Building Project Framework Hut, which encompasses the following:

5.3.1.1.1 *Vertical fundamental pillars* of a Green Building Project:

a. a Green Building project must primarily have levels of innovation and technologies to make the building actually function efficiently as a green building within its locality. Innovation and technology can be either local or international, focusing on performance, assessing and deploying local opportunities, i.e., local manufacturing/assembly. This is the first fundamental intervention;
b. a Green Building Project must create local green jobs, which can be quantified and reported on. This must include labour-intensive tasks in the value chain of

constructing and managing a Green Building and its subsets. This is a second fundamental;

c. a green project must create opportunities for local businesses through applicable legislation. These opportunities must be identifiable and reported on. An enterprise development framework, economic value, and skills development areas must be structured;
d. a green project must quantify and report on its local procurement in the whole value chain of the project. Local procurement encompasses both the procurement of products from South Africa, and procurement from local suppliers in a specific geographic region. Applicable legislation in this regard would be applicable.

5.3.1.1.2 *Horizontal binders* of a Green Building project:

a. applicable policies, standards, and applicable prescripts must be applied in all Green Building projects. At departmental level, prescripts must be set, where not available, on training and development, with clear targets. The sector must be the best advocate for its own prescripts and support the national trajectory towards a green economy;
b. every Green Building project must be based on a sustainable feasibility study, financial bankability, and have a quantifiable return on investment. This is to ensure ongoing buy-in by investors and credibility for the sector. For this, the sector must be a destination of choice for local and international green finance;
c. every Green Building project must pay tribute to and incorporate local aspirations and sustainable relationships with the environment and people. Accordingly, projects must have a strong feature of local indigenous knowledge, using innovation in its incorporation, and working with local indigenous people. These opportunities include biodiversity, involving food plants, rammed earth designs, use of local arts, culture and new/recycled materials, with a role for young people to inspire future generations;
d. given a recurring theme from respondents' responses regarding uncertainty or lack of knowledge on installed technologies and related resource efficiency derived, the research study suggests that audits, data collection and independent validation in resource efficiency and Green Building projects should be a backbone for accurate reporting on consumption savings, technology mobilisation, and greenhouse gas emissions reduction. This credible data and

reporting system is also necessary for consumption baseline determination, and for applications to participate in incentive schemes.

Linked to data collection and reporting is the element of communicating messages to stakeholders for purposes of advocacy and securing ongoing support. Every Green Building project should thus have clear communication during planning, implementation, and reporting to keep the client and stakeholders abreast of the project's green milestones.

5.4. Research Results & Recommendations through TIPS Lenses

The researcher notes that in keeping with the global trend, South Africa continues to positively experience an emergence in green economy technologies and innovations. To remain relevant and sustain riding the wave of emerging innovation and technologies, businesses require new ways of managing innovation and technology (White, Bruton, 2010.

As stated above, the TIPS Managerial Leadership Framework provides for a holistic approach to Management of Technology, Innovation, People, and Systems (DaVinci, 2019).

The outcome of this research provides for useful understanding for project managers and various stakeholders within DPWI and the sector to understand and appreciate the resource efficiency and Green Building, albeit at different levels of contribution and advancement. As a leadership management framework, the TIPS framework serves as an interpretations and leadership management tool for Management of Technology, Innovation, People, and Systems, highlighting areas of intervention required of project managers, specific to opportunities at different levels of the organisation and business value-chain.

For leaders, amongst these implementation issues is a fundamental need for new ways to communicate needed information (engagement), organise tasks (coordinate), lead advocacy, collaborate, and manage people (White, Bruton, 2010). The postulated Green Building Project Framework presents a model for implementation of successful resource Efficiency and Green Building projects, including interventions such as Renewable Energy and Green Hydrogen with technologies such as fuel cells.

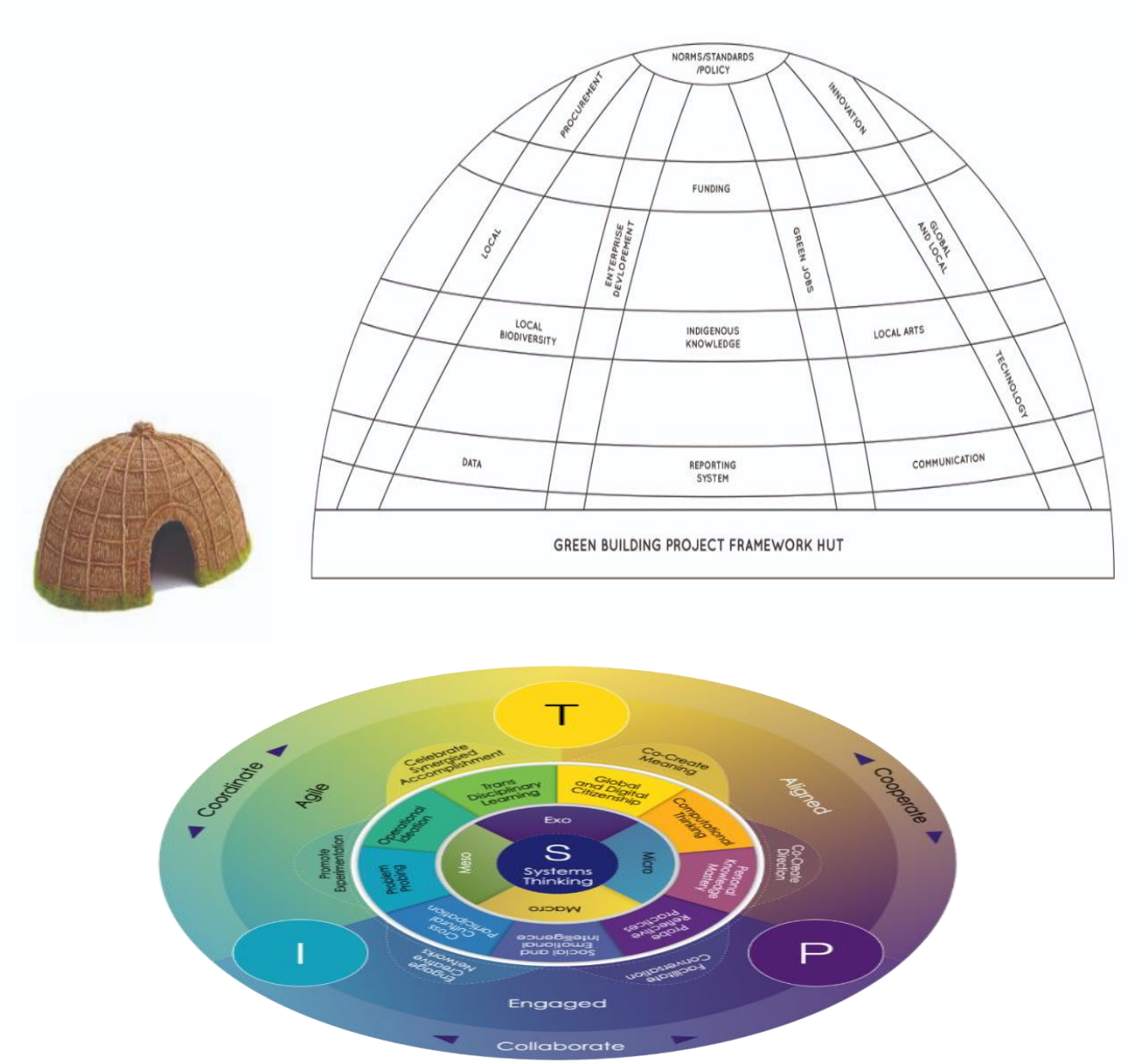

Figure 10: GBPFH through lenses of TIPS Leadership Managerial Framework

Application of the GBPFH through TIPS lenses as the foundation and ‘floor’ and ‘foundation’ of the hut would have the following narrative:

5.4.1. Micro and Meso Levels

At Micro level for Management of Technology and People, and Meso level for Management of Innovation and Management of Technology, respectively, within DPWI project managers need to:

a. Put in place prescripts and interventions aimed at skills development and **training** on Green Building and green economy interventions, as part of as part of **'personal knowledge mastery'** espoused in in TIPS. These include Water Efficiency, Energy Efficiency, waste management, **PV Green Card installer training**, including sustainable development master classes etc.
b. Engaging in **'computational thinking'** (CT) defined as **action-based thinking**, as a conceptual foundation required to **solve problems effectively and efficiently** involving detailed analysis, repeatable in different contexts (Shute, Sun, Asbell-Clark, 2017). Promoting **innovative thinking and participation**, allowing **problems to be broken to granular level** in order to establish understanding and **correct solutions.**
c. Probe reflective practices, classically defined as essentially a way of improving practice in professional practice, recognising the intuitive, the artistic, and the creative in professional practice (Fook, 2015). The researcher suggests that this **for DPWI is to promote the culture of innovation** and **utilise skills which professionals actually possess and those that can be nurtured,** such as reflective practice, in what professionals actually do in practice in project management, **recognising their creativity in practice on the implementation of the vertical and horizontal pillars of GBPFH**.
d. At **Meso level** this includes operational ideation to enhance innovation that drive projects, and ways of implementing projects to improve operational uptake on Green Building.
e. Within the Meso level, there is **problem probing involving key stakeholders** within DPWI and the sector.
f. At Meso level **cross cultural participation is applied**, within DPW this includes learnings and implementation of interventions in **Indigenous knowledge (IKS)** and Enterprise Development pillars of the GBPFH, including broader socio-economic development, enhancing market engagement in implementation of projects.
g. The Meso level requires **Promotion of experimentation through pilot projects** and partnerships with public entities, the private sector, and international partners.

The process at micro level includes Co-creating meaning, Co-creating direction, and facilitating conversations as espoused in TIPS framework (DaVinci, 2019), as part of a consultative and engaged process. The research study suggests the micro level would innately have more actions implemented by DPWI project managers, given the direct control of the micro level environment (Guckin, 2019).

5.4.2. Macro and Exo Levels

The macro environment is broad and larger, involving global, regional, national, and sector contexts and markets for products, services, or projects. The Exo level is also not in the direct control of DPWI project managers (Guckin, 2019).

As per findings of this research, the study recommends the following action points:

a. At Macro level, in the Management of People and Management of Innovation, amongst other interventions, practice **Social and Emotional** Intelligence in dealing with **sector stakeholders** and **international partners** (**diplomacy**), facilitating **peer-to-peer conversations and benchmarking**. This imperative is particularly useful in the benchmarking and procurement of **foreign technologies** (direct foreign investments) whilst promoting local innovation and manufacturing.

b. Engagement of creative networks operating in the green economy, such as research institutions, academic institutions, and innovation hubs. This further facilitates familiarity with and promotion of global prescripts to which South Africa is signatory to such as the global Sustainable Development Goals (SDGs), Africa's developmental growth agenda, and South Africa's legislations, policies, funding and trade instruments, and diagnostic tools such as the National Development Plan.

b. At Exo level, there is an opportunity to entrench **Global** and Digital **Citizenship** in DPWI project managers, to ensure systematic awareness of the multiple sub-systems of the green economy as a sector and within DPWI, such as **global accords which the organisation is signatory** to (DaVinci, 2022), in line with the aim of TIPS Managerial Leadership Framework of systematic awareness of multiple sub systems at play in a workplace (sector) (Anderson, 2019). This area and other areas of TIPS assists with addressing gaps discovered in research findings, including the gap of awareness. These include awareness of and deployment of new and developing technologies at macro and exco levels, such as Digital Twin (DT) applications for Intelligent Green Buildings (IGB), which have improved the business case for Intelligent Green Building and contributed to rapid industry growth as IGB gain interest amongst architects, engineers and owners (Yang, Lv, Wang, 2022).

c. For the Exo level, promote operational ideation in the design and implementation of projects, for innovative operational outcomes.
d. Celebrate major or minor synergised accomplishments, whenever new or improved ways of doing things is innovated, and whenever Green Building projects are launched.
e. In managing the Exo setting of TIPS, which the developing person is not part of, but is effected indirectly by the setting i.e. the national socio-economic programmes and regulations of South Africa (Anderson, 2019). DPWI leadership and managers need to embrace and practice transdisciplinary learning throughout the department to achieve being an 'agile' and 'aligned' organisation, given that the green economy is not borne out of one specific discipline, but as demonstrated in this research, is constituted by a plethora of sectors of the economy, positively impacting all sector of the economy (Musango, Brent, Bassi, 2014). The cost of transdisciplinary learning and training is to be funded by through the DPWI directly and through international partners as a measure of skills development, training, and learning in line with the TIPS Framework (DaVinci, 2022),

The research study concludes that the juxtaposition and implementation of the GBPFH as a framework, with the DaVinci TIPS Leadership Management Framework to improve on DPWI and sector challenges discovered through the findings of this research is a feasible, innovative, and necessary approach and intervention. The elements of TIPS address all vertical and horizontal pillars of GBPFH i.e. green jobs creation, technology mobilisation, enterprise development, skills development, and funding.

5.5. Effects of specific policy subsets, i.e., Renewable Energy, energy and water efficiency, integrated solid waste management, and Indigenous Knowledge Systems on contributing to increased job creation

Conclusions on this objective suggest that there is a recognisable contribution of Green Building to the creation of green jobs and skills development, as confirmed by the majority of respondents. There, however, remains a vast opportunity for more jobs to be created through Green Building and others.

Based on feedback from respondents to this study, skills development is a critical area to be attended to. This is based on feedback from a question/statement in the questionnaire that "*Our Branch/Entity/Department/Company has a deliberate policy to recruit new employees with Green Building experience for the built environment and infrastructure related work*". Although most of the respondents, 34.6% (18), disagreed with the statement, this was then followed closely by 30.8% (16) of those who were neutral, meaning the combination of those who disagree with the statement and those uncertain or neutral is a staggering 65.4%.

On several occasions, the International Labour Organisation (ILO) has addressed the vital link between the environment and employment through Green Jobs, arguing for better reflecting the social dimensions in the agenda for sustainable development. This link has gained momentum to ensure that there is indeed an employment and social dimension to climate change mitigation and adaptation actions (Van der Ree, 2019).

The creation of Green Jobs and skills development and/or reskilling remain critical requirement that is key to realising *Just Transitions* for an equitable Green Economy, which is essential to balance the reality in the sector as per feedback from respondents.

Similar to other sectors, for the built environment re-skilling and skills development are areas of emphasis in order to increase green jobs created by the sector, achievable through, amongst others, the implementation of Green Building training and skills transfer where new technology and projects are introduced in the identified Green Building subsets as mentioned earlier such as Energy and water efficiency, Solid Waste Management, Biodiversity, and Alternative Building Technologies/Green Building Technologies.

The research study suggests that to create green jobs, there should be more Green Building projects related to labour-intensive interventions such as rammed earth construction of selected facilities i.e. Police Stations, eco-labelling of building materials, energy efficiency i.e. rollout of Energy Performance Certificates (EPCs) as part of monitoring and compliance to Regulations, water efficiency, indoor Air Quality improvement post the recent pandemic in 2020 - 2022, and to an extent, installation of Renewable Energy technologies and related operations and maintenance (O&M) contracts.

In line with the research study's proposed *Green Building Project Framework Hut*, some projects must put the vertical fundamentals and horizontal binders in place as described above.

5.6 Extent of budget spent by government and private companies on Green Building projects and localisation content, specific to materials, components and smart technologies such as LED and OLED light bulbs, Internet of Energy, solar geysers, and innovative Alternative Building Technologies.

Although some projects implemented in the building sector have used new technologies to some extent, feedback from respondents on this objective strongly suggests that there is also still more to be done by the public and the private sector to commission more Green Building projects. This includes increasing expenditure on local procurement of innovative green materials and technologies.

Although there is established awareness of Green Building prescripts as per feedback from the respondents, the study strongly recommends that a lot more change management, reengineering of current business processes, education, and people management is still required in this regard in order to change people's mindsets, especially by decision makers commissioning projects and approving budgets. This is particularly important given the fact that "*Unwillingness to change and attachment to old technologies and legacy business*" scored higher than others according to respondents' feedback on factors affecting Green Building,

Given the slow pace of projects prepared and issued to the market for several reasons, as per respondents' feedback in this dissertation, the study recommends that view that more dedicated funding should support project preparation and development. This will assist Government Departments, Municipalities, State-owned Entities (SoEs), and the private sector to issue more bankable and market-ready projects to market, as an enabler for increased Enterprise Development and the creation of green jobs in Green Building, green infrastructure, and resource efficiency projects.

Such funding could be blended financing between government, local and international Development Finance Institutions (DFIs), and commercial banks. Furthermore, as a lead Department on labour and employment matters, which are central to the Green Economy

(Naik, 2021) and Just Transitions, the Department of Employment and Labour, Sector Education and Training Authorities (SETAs), working with the Department of Public Works and Infrastructure, should lead the establishment and implementation of an infrastructure sector focused *Green Jobs Project Preparation Fund*, as one of the key interventions to cover the funding element of the proposed *Green Building Project Framework Hut* herein. This will ensure that there is dedicated expertise, skills and funding to issue long-term viable, financially sound, and socially responsible Green Building and infrastructure projects to market, contributing to a sustainable Green Economy.

This suggests that with significant awareness, change management, and implementation in the built environment, Green Building has a significant potential to increase the built environment's economic activity, presenting a real opportunity to contribute to socio-economic imperatives. These include creating jobs, enterprise development, promoting indigenous knowledge, achieving equitable economic growth, and achieving development as envisioned in the South African Economic Recovery and Reconstruction Plan (ERRP, 2022).

The Government, through the Department of Public Works and Infrastructure, and the built environment as a sector, need to take significant and convenient steps towards improved collaboration to drive a sector-wide uptake on Green Building. Amongst other measures, existing utility budgets must be used smartly to achieve efficiency and improve project preparation funding to realise more market-ready projects.

The study indicates that this is achievable through a government and sector-wide implementation of the Public Works Green Building Policy, linked to local prescripts to support local innovation and businesses, supported by beneficial collaboration with international stakeholders.

5.7 Return on Investment of the Study

The researcher holds a view that Green Building interventions and its subsets present a wide range of Return on Investment (RoI) for the industry, the Department of Public Works & Infrastructure, professionals, and new entrants in a form of graduates from universities, as a career option.

This view is informed by key drivers of the sector, specifically that Green Building has proven to offer a high RoI with regard to emerging business opportunities, ethical investment, and conservation of resources (Agyekum, Goodier, Oppon. 2022).

The researcher identifies four (4) key Return on Investment areas achievable in the implementation of proposed Green Building interventions are as follows:

i. **Industry RoI**: In line with the TIPS Managerial Leadership Framework, the industry context is concerned with the macro and meso environments. The rapid demand for alternative and sustainable sources of energy in South Africa, and a need for resource efficiency, is driving industry innovations at various levels, including technology and funding models. This trend brings about a number of opportunities around socio-economic development potential, as covered in the findings of this research. Through the National Development Plan, Climate Change Mitigation and Adaptation Strategy, and the DPWI Green Building Policy, the Department is able to achieve set socio-economic development targets such as women and youth empowerment, and localisation, through enterprise development and graduate placement programmes aimed at skills development. This is a direct benefit of increased projects and uptake in the industry;

ii. **Societal RoI**: In terms of TIPS, this aspect is concerned with the meso and macro contexts. The creation of green jobs is a benefit that comes with improved resource efficiency and competitiveness in the supply of resource efficiency. This area also thus contributes to a positive contribution in meeting climate change mitigation actions in South Africa, whilst improving the country's international reporting on the United Nations Sustainable Development Goals;

iii. **Organisational RoI**: In terms of the TIPS framework this area is concerned with the micro environment. Supported by verifiable data, the DPWI stand to achieve significant cost savings for Government buildings with regard to annual spend on operational costs, related to the management of a vast property portfolio, including mitigating against annual increases on electricity and water tariffs.

iv. **Personal RoI:** This area is part of a micro environment. Other employees equally stand to achieve a RoI by acquiring and producing knowledge, and gain leadership development as global leaders, by participation in innovation, technology mobilisation, and funding of projects. Gaining international and local networks, forming part of an emerging global leadership in the sector.

5.8. Conclusion

This dissertation has been able to cover areas of research linked to its topic and set the objectives and aim of the study.

The findings made are meaningful feedback from respondents and have enabled the researcher to appreciate the reality of sustainability projects in the built environment as a sector, and their contribution to identified socio-economic imperatives, particularly the extent to which a sector policy, such as the Public Works Green Building Policy, has generated awareness of Green Building as a paradigm and industry. This includes the extent to which policy has been implemented through various projects, existing challenges and opportunities.

For other researchers, there is an opportunity to build further from this research, to study linked industries that have the potential to benefit from the emergence and copious diffusion of Green Building in South Africa. In this regard, it is recommended that there is a need to research further on the industrialisation and localisation supporting prescripts, which are focused on funding, as an enabler of sustainable Green Building related industries in South Africa.

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ANNEXURES

Annexure A: Ethical Clearance Certificate

Annexure B: Green Building Research Survey Questionnaire