SOUTH AFRICA's READINESS OF THE SMART BUILT ENVIRONMENT TOWARDS 2035

By

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ABSTRACT

It is imperative that society works together with government and industry to find solutions in solving the problem of the high utilisation of natural resources in the built environment. Natural resources are not infinite, and the increasing population are compounding the problem. The high level of unemployment in South Africa could be increased dramatically if the old skills in the industry become redundant due to new technology and there are not enough skills to apply to these technologies. This study set out to investigate the extent of the readiness of South Africa for the Smart built environment towards 2035 with an aim to provide valuable information for decision making to the government, policy makers, academic and training institutions and business leaders. South Africa boasts about the achievements of the four major municipalities namely, Cape Town, Johannesburg, Tshwane and eThekwini in terms of their commitment towards the aim for net zero carbon emissions of newly built buildings by 2050. The commitment for sustainable solutions in all sectors is echoed by the Minister of Environmental affairs, as part of the Paris agreement.

South Africa does not lack the ability to plan for eventualities. This is evident by the myriad of strategies and policies that can be found all over the government information sharing outlets. The South African government is failing in implementing these policies and strategies that have been around for more than a decade. A lack of execution, lack of transparency as well as a lack of accountability is a hindrance to South Africa's general growth path. The realisation of the preferred future rest on the acceptance, by all South Africans, that technological advancement is inevitable, and that a joint and inclusive effort should be made to prepare for such a future.

South Africa has the ability and appetite to change the future for the better. Two fundamental areas of improvement are to create a united South Africa where people are held accountable for their actions. The unisons should transcend across the various South African government departments but must also include industry, entrepreneurs and the public to create a future where technology is embraced, and innovation encouraged, instead of waiting for technology to dictate a specific future.

Keywords – Future studies, Smart built environment, Smart cities, 3D printing, robotics, internet of things, Green economy, scenarios, causal layered analysis.

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LIST OF ACRONYMS AND ABBREVIATIONS

AI	Artificial intelligence
ANC	African National Congress
BIM	Building Information Modelling
CAD	Computer Aided Drafting
CBE	Council for the Built Environment
CLA	Causal layered analysis
C40	C40 Cities Climate Leadership Group
DEA	Department of Environmental Affairs
DPW	Department of Public Works
GBFA	Green Building for Africa
GBCSA	Green Building Council of South Africa
ICT	Information and Communication Technologies
iNeSI	iKamva National e-Skills Institute
IoT	Internet of Things
IRP	Integrated Resource Plan
LSFB	Light steel frames buildings
LSM	Living Standard Measure
ML	Machine Learning
NDC	Nationally Determined Contribution
NDP	National Development Plan
NERSA	National Energy Regulator of South Africa
NFGBSA	National Framework for Green Building in South Africa
NHBRC	National Home Builders Registration Council
NRCS	National Regulator for Compulsory Specifications
PESTLE	Political, Economic, Sociological, Technological, Ecological, and Legal factors
RDP	Reconstruction and Development Programme
SABS	South African Bureau of Standards
SACQSP	South African Council for the Quantity Surveyors Profession
SADC	South African Development Community
SANS	South African National Standard
SAPOA	South African Property Owners Association
SEA	Sustainable Energy Africa

SME	Small and Medium Enterprises
3D	Three-dimensional
USA	United States of America

CHAPTER 1

INTRODUCTION, PROBLEM STATEMENT AND CONCEPTUAL FRAMEWORK

1.1 Introduction

The environmental degradation is significantly impacted by the built environment during construction, operation and deconstruction. These impacts are approximated at consuming 40% of the world's energy, 15% of the world's fresh water resources and produces 23 to 40% of the world's Greenhouse gas emissions (Gunnell, 2009).

The South African government provided more than 3 million housing units to the poor and low-income households between 1994 and 2015. The housing backlog is in access of 2.1 million units. South Africa's informal settlements are in access of 2225 (Jeffery, 2015). These developments exclude the expected expansion of the infrastructure in the middle to upper-class domestic areas as well as industrial areas. The increasing need for buildings that are generally built utilising conventional practices that are high uses of natural resources is unsustainable.

South Africa's built environment has been deliberately formulated around labour-intensive technologies. This is a South African government initiative that is aimed at decreasing unemployment. A masonry house, for example, could provide fifty percent more jobs than that of a precast house that utilises different technologies (cidb, 2005).

The benefits of comfort, safety, flexibility and energy saving that are derived from the adaptation of new technologies to the built environment will result in a great percentage of buildings becoming increasingly "Smarter" in the future (Khanda, Salikhov, Gusmanov, Mazzara, & Mavridis, 2017).

It is therefore fitting to investigate the extent of the readiness of South Africa for the future Smart built environment towards 2035.

1.2 Problem statement

This study attempts to investigate the extent of the readiness of South Africa for the Smart built environment towards 2035 with an aim to provide valuable information for decision making to the government, policy makers, academic and training institutions and business leaders. Construction is one of the largest consumers of water, energy and material resources and also has a negative impact on the environment due to its formidable pollution (Akadiri, Chinyio, & Olomolaiye, 2012). More than 800 billion tonnes of natural resources have been consumed between 1900 and 2010 (Schandl Heinz, 2017). Natural resources are not infinite, and this creates a dilemma, that if not preserved would affect humanity.

The benefits of comfort, safety, flexibility and energy saving that is derived from the adaptation of new technologies to the built environment will result in a great percentage of buildings becoming increasingly "Smarter" in the future (Khanda et al., 2017). South Africa could be left behind by not having the skills to apply to these new technologies while conventional skills and resources could become redundant before any efforts are made to accommodate these changes.

1.2.1 Importance of solving the problem

It is imperative that society works together with government and industry to find solutions in solving the problem of the high utilisation of natural resources in the built environment. Natural resources are not infinite, and the increasing population are compounding the problem. The high level of unemployment in South Africa could be increased dramatically if the old skills in the industry become redundant and there are not enough skills to apply to these technologies.

1.2.2 Potential causes of the problem

As a developing country, South Africa is faced with a difficult decision between job creation or economic factors and objectives that the country set in terms of the environment. The biggest influencing factor of these trade-offs is the high level of unemployment in the country that is in excess of 25% (South African Association for the Advancement of Science., Wise, & Lange, 2009).

There seems to be a lack of focus on exploring the possibilities in the Green economy, that could potentially increase the employment rate as well as reducing the impact on the

environment. South Africa could also be ignoring the technological advancement in the built environment to ensure that the industry remains labour intensive to achieve unemployment targets.

1.2.3 Proposed solution to the problem

It would be ideal if an international Smart built environment intervention could be established to address the impact of the buildings on the environment. World standards could assist in providing shared learnings and consistency (Horne & Hayles, 2008). The literature review revealed gaps in the previous studies in determining what the reasons are for people not to adapt the Smart and Green technologies (Buys, Chanel, Research, Barnett, & Bailey, 2004). Future research should focus on answering the ultimate question of how buildings could provide a positive environmental contribution. Buildings would, therefore, need to be placed in a social context, where its form and function endeavour to harmonise with the natural landscape (Gunnell, 2009). The studies that were reviewed concentrated more on Green buildings and not Smart buildings. There is a further gap in the studies to identify current new technologies and the efficiency impact on resources of “Smart buildings”.

This study would aim to answer the research gaps of the other studies that were reviewed and provide possible future research opportunities.

1.3 The management question

This study attempts to investigate the extent of the readiness of South Africa for the Smart built environment towards 2035 with an aim to provide valuable information for decision making to the government, policy makers, academic and training institutions and business leaders.

1.4 Research methodology

The research falls under futures studies. The research methodology will be a combination of Causal layered analysis (CLA), Creswell’s mix methods and the six pillars method of future research. Further research would determine the best suitable methods to address the research questions and to answer the primary objective of the research.

CLA focuses more on exploring the present and the past and creating alternative futures instead of predicting the future (Inayatullah, 2005). This methodology would assist with the research by creating possible futures scenarios to assist in the decision making by the government, policy makers, academic and training institutions and business leaders.

Scholar mixed methods study is a combination of quantitative and qualitative data collection and analysis. The study is popular in health sciences and social and behavioural sciences (Creswell, 2013). The study would be ideal to assist with the recommendations as it adds value by looking at the study from two perspectives.

Inayatullah (2008) describes the six pillars of futures studies as providing “a theory of futures thinking that is linked to methods and tools and developed through praxis.” The pillars are: “mapping, anticipation, timing, deepening, creating alternatives and transforming”. This method would be utilised throughout the study.

1.5 Purpose of the study

This study attempts to investigate the extent of the readiness of South Africa for the Smart built environment towards 2035 with an aim to provide valuable information for decision making to the government, policy makers, academic and training institutions and business leaders. Government could use the information to determine what jobs could be created in the industry and evaluate it against the current industry jobs. Policy makers could use the information in making decisions on current and future policies to encourage Smart built industry. Academic and training institutions would be playing a crucial role to ensure that the future training needs for the Smart built environment are realised.

1.6 Research questions

The following questions will be answered in an attempt to investigate the extent of the readiness of South Africa for the Smart built environment towards 2035.

- What are the global drivers for change?
- How does South Africa’s build environment compare to developed countries?
- How do Smart buildings incorporate into “Green” or “eco” buildings?
- What are the critical technologies that influence the global build industry at present?
- How is South Africa leveraging from these technologies?

- What are the innovative developments that challenge the industry going forward?
- What do these developments mean for South Africa and the various stakeholders?
- What are the future skills required for the Smart build environment and the effects of the jobs on the current industry?
- What recommendations can be offered to the government, policy-makers, training and academic institutions?

1.7 Primary research objective

The rest of the world is shifting towards the Smart built environment. South Africa is still focusing on the conventional ways of building to achieve its unemployment targets. This study attempts to investigate the extent of the readiness of South Africa for the Smart built environment towards 2035 with an aim to provide valuable information for decision making to the government, policy makers, academic and training institutions and business leaders.

1.8 Secondary research objective

In order to support and achieve the primary objective, the following secondary objectives are set.

- To establish the global drivers for change
- To compare South Africa's built environment to developed countries
- To establish how "Smart" buildings, incorporate into "Green" or "eco" buildings
- To determine what the critical technologies are that influence the global build industry at present.
- To investigate how South Africa is leveraging these technologies
- To determine what these developments mean for South Africa and the various stakeholders.
- To determine what the future skills requirements are for the Smart built environment and the effects of the jobs on the current industry.
- To establish recommendations that can be offered to the government, policy-makers, training and academic institutions.

1.9 Conceptual research framework

Figure 1.1.9.1 below depicts the conceptual research framework that would be employed in the study. The methodologies revered to in the framework will be defined in Chapter 2. Chapter 3 will be used to explore the drivers of change referred to in the framework. Chapter 4 will be aimed at the application of the six pillars approach to futures studies and Chapter 5 will be used for the outcomes and conclusion of the study.

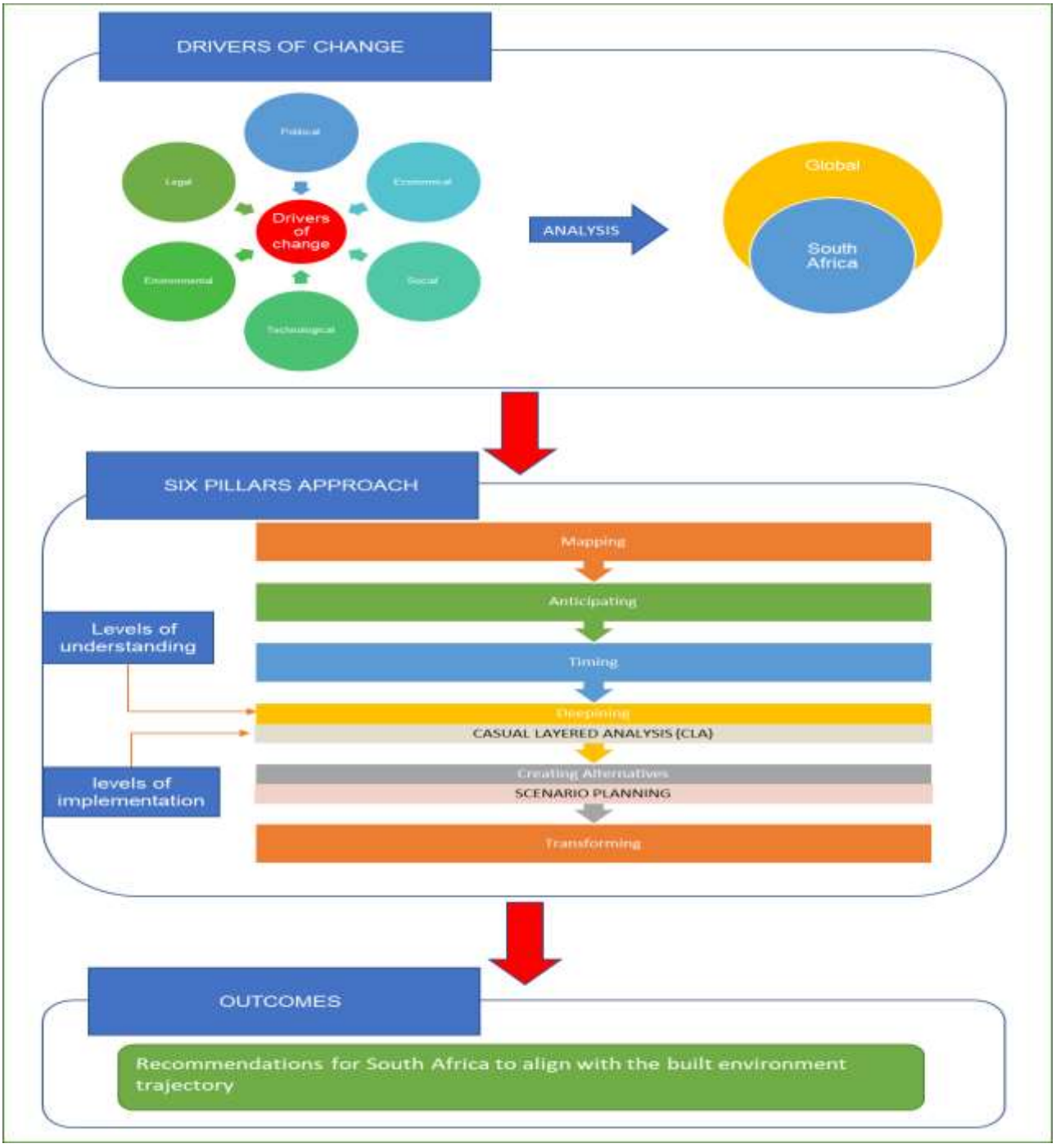

Figure 1.1.9.1: Conceptual research framework to be applied in the study

Source: Authors own construction

1.10 The outline of the study

Chapter 1 provides an introductory look into the study as well as presenting the problem statement, research questions and objectives and a summary of the methodology that would be applied in the research. The Chapter further presents the conceptual research framework that has been adopted to achieve the outcomes of the study.

Chapter 2 provides a comprehensive look into the research methodology that encompasses the conceptual framework to be employed in the study that is designed around the six pillars approach to futures studies.

Chapter 3 provides a comprehensive literature review that investigates the macro environment that brings about drivers of change in the built environment. A PESTLE (Political, Economic, Sociological, Technological, Ecological, and Legal factors) analyses will be used to support the literature review.

Chapter 4 will be an application of the six-pillar approach to future studies. Causal layered analysis will be incorporated to deepen the future, while scenario analysis will be utilised to create alternative futures.

Chapter 5 provides a reflection of the study and recommendations for South Africa. The problem statement, research questions and objectives are also addressed here. The Chapter will be concluded by providing future research opportunities that could be attempted.

CHAPTER 2
RESEARCH METHODOLOGY

2.1 Introduction

Chapter 1 deals with a summation of the research methodology that will be employed in the study. The scope of the study, as well as the research objectives, questions and contributions were also outlined in Chapter 1. The current chapter aims to elaborate on the research methodology that will be used to satisfy the research objectives.

2.2 Future studies

“Our future is unpredictable, but we are not powerless to confront it. The future can be anticipated, explored, and its course can be changed. This is what the field of Futures Studies deals with. People can engage in thinking about the future through different means, with different objectives, in order to reduce uncertainties and prepare for what might happen. Futures Studies allow us to navigate the past, the present and the future and inform us about the options, the choices we can make, and the actions we can take” (Bourgeois, 2014). Modern future study roots can be traced back to the 1950’s. The West initially employed future studies in their military industrial complex and the success of these studies enabled the government and private sectors to adopt these methodologies for their strategic benefit (Lang, 2000).

“I believe quite firmly that an inductive knowledge of a great number of things in the future is becoming a human possibility. I believe that the time is drawing near when it will be possible to suggest a systematic exploration of the future.” (Wells, 2008).

2.3 Research design

The research methodology will be a combination of Causal layered analysis (CLA), Creswell’s mix methods and the six pillars method of future research. CLA focuses more on exploring the present and the past and creating alternative futures instead of predicting the future (Inayatullah, 2005). This methodology would assist with the research by creating possible futures scenarios to assist in the decision making by the government, policy makers, academic and training institutions and business leaders.

Scholar mixed methods study is a combination of quantitative and qualitative data collection and analysis. The study is popular in health sciences and social and behavioural sciences (Creswell, 2013). The study would be ideal to assist with the recommendations as it adds value by looking at the study from two perspectives.

2.3.1 The Six Pillars of future studies

Inayatullah (2008) describes the six pillars of futures studies as providing "a theory of futures thinking that is linked to methods and tools and developed through praxis." The pillars are as follows:

2.3.1.1 Mapping

The first pillar consists of mapping the past, present and future in order to establish where we came from and where we are heading. A tool that would be utilised is the futures triangle maps as illustrated in Figure 2.3.1: The Future Triangle below. This tool maps today's views of the future through three dimensions namely: pull of the future; push of the present and weight of history.

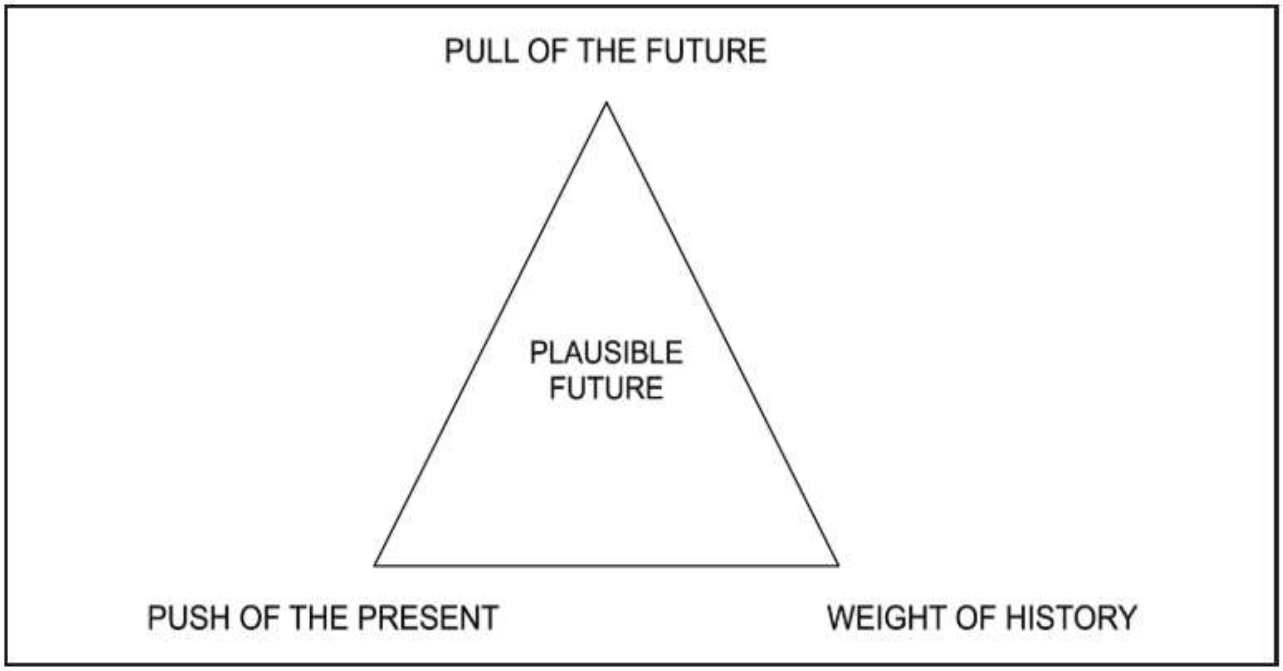

Figure 2.3.1: The Future Triangle

Source: Six pillars: future thinking for transforming (Inayatullah, 2008).

The image of the future pulls us forward but among the many images of the future, five or so are typical. These are Evolution and progress, Collapse, Gaia, Globalism, and Back to the future. (Inayatullah, 2008).

- **Evolution and progress:** A firm belief in rationality, with technological advancement that is pivoting around humanity;
- **Collapse:** Here it is believed that mankind reached and exceeded its limits and that fundamentalism, world inequity, tribalism, climate disasters a nuclear holocaust are deteriorating the future;
- **Gaia: "**the world is a garden, cultures are its flowers, we need social technologies to repair the damage we have caused to ourselves, to nature and to others, becoming more and more inclusive is what is important. Partnership between women and men, humans and nature and humans and technology are needed. This is challenging the very notion of ''man''." (Inayatullah, 2008);
- **Globalism:** Break free from traditionalism and embrace technology to break down borders;
- **Back to the future: "**we are past our prime; we need to return to simpler times, when hierarchy was clearer, when technology was less disruptive when the Empire was clear. Change is too overwhelming; we have lost our way and must return." (Inayatullah, 2008).

The pushes of the present consist of quantitative trends and drivers that impact the future (Inayatullah, 2008). The **weight of history** refers to the barriers that impact the change that we are hoping to achieve (Inayatullah, 2008). The interactions of these three forces, of the futures triangle, are analysed to ultimately result in the development of plausible futures (Inayatullah, 2008).

2.3.1.2 Anticipation

The main method of the second pillar is emerging issues analysis. S. Inayatullah (2008) give examples of some emerging issues disrupters such as:

- Will robots have legal rights soon?
- Will meditation be part of every school curriculum?
- Will we develop pharmacies in our bodies?
- Will the Smart toilet help us with early diagnostics?

- Will the slow cities movement redefine the 24/7 world?
- Will Smart objects create more fuel-efficient houses, communities and businesses?

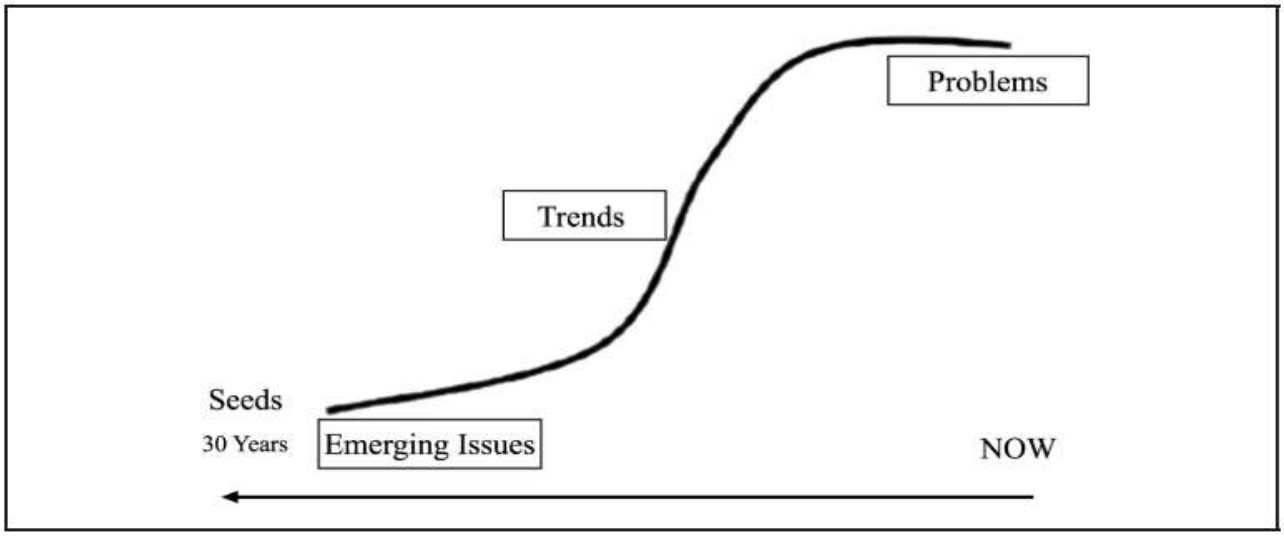

Figure 2.3.2: Emerging issues analysis

Source: Six pillars: future thinking for transforming (Inayatullah, 2008).

In a political context, solving emerging issues of tomorrow will not result in political reward for leaders by their voters. It will, however, enable cities and organisations to minimise harm and respond rapidly to emerging challenges (Inayatullah, 2008). Emerging issues analysis as referred to in Figure 2.3.2: Emerging issues analysis, focus on the determination of issues that would develop to an extent that it would require policy or a community response in the future (Lang, 2000).

The futures wheel works in conjunction with the emerging issues analysis and focuses on the development of the impact of an issue today on the longer-term future (Inayatullah, 2008). The futures wheel helps anticipate future issues, create the possibility of new products and move from seeing the world at a simple unconnected level to a complex connected level.

2.3.1.3 Timing

The third pillar, referred to as **timing the future** is the search for the grand patterns of history and the identification of each one of our models of change. Inayatullah (2010) highlights three fundamental levels of patterns that need to be wisely focused on in the timing the future pillar to better influence social reality. These levels are macro-, meso- and micro-patterns of change.

Inayatullah (2010) further describes these three levels as:

- **Macro historians** suggest that in order to understand the shape of time the following patterns are critical:
    - The future is linear, stage-like, good, improved and accomplished through hard work.
    - The future has its up and downs and considered cyclical. In this oscillation, it is critical to understand where one is to effectively strategize on when and how to act.
    - The future is a spiral and consisting of cyclical as well as linear and progress-based parts. To create a positive spiral, leadership needs to be courageous and have foresight abilities to challenge the beliefs of the past and assimilate it into a better future.
    - New futures are driven by a creative minority that acts as change agents towards a different future. Their innovative efforts are applied in social, political, spiritual, cultural or technological spheres.
    - There are pivot or key periods in human history when the actions of a minority can introduce a revolutionary change during these periods, where unorthodox approaches and behaviours need to be applied.
- **Meso-institutional level** refer to three contracting positions
    - Real change comes from those who reside in institutions. Changing the way, we see the world and this reflectiveness leads to a conscious change.
    - Real change is driven by institutional change and not consciousness. Societal change is brought about by changing the laws that govern society.
    - New technology brings about real change that revolutionises the way things are done and ultimately results in it becoming contingent to the way of life.
- **Meso-organisational level**
    - On this level the goal is not to transform the entire organisation but to find those individuals, normally making up 10 percent of the organisation, that can be classified as the champions of the change. There is normally a further 10 percent that is classified as the resistors that must be managed not to deter the quest for change. Approximately 40 percent of the organisation are classified as the early adaptors and need to be treated as important and supported by means of incentives. The remaining people only need their basic needs met.

2.3.1.4 Deepening the future

Causal layered analysis is a foundational method that is used to deepen and unpack the future (Inayatullah, 2010). CLA focuses more on exploring the present and the past and creating alternative futures instead of predicting the future (Inayatullah, 2005).

2.3.1.5 Creating alternatives

There are two fundamental methods in creating alternatives. Firstly, the structural-functional analysis of the organisation and finding alternatives for the same. The second being creating alternative futures by creating scenarios (Inayatullah, 2008b). With the aim to create alternatives, the scenarios creation tool would be utilised for this pillar. Hannah and Gassner (2007) define a scenario as a "description of a possible future situation, including the path of development leading to that situation. Scenarios are not intended to represent a full description of the future, but rather to highlight central elements of a possible future and to draw attention to the key factors that will drive future developments".

2.3.1.6 Transforming

In the final pillar, the future is narrowed down to the preferred future (Inayatullah, 2008a). Scenarios will be used in this process to determine the ideal futures for the South African built environment towards 2035. There are three decisive methods in the process of narrowing the future. The initial method is **visioning** which ultimately aligns the individual and collective goals and creates an image of what can be achieved. Visions can be developed via questioning; through scenarios that are an analytical approach and through creative visualization. **Backcasting** of the vision is then used to determine the events between the past and the future (today). Dissecting the events in a specific scenario, which is focused on what happened relating specific trends and events, gives a better insight into why today is what it is. The desired future is, therefore, more achievable due to the learnings of the past. The **transcend method** is used to resolving conflicts between visions by finding win-win solutions instead of compromise or withdrawal. The issues being disputed needs to be clearly expressed. Brainstorming can then be utilised to create alternatives or to integrate the visions. (Inayatullah, 2010).

This six-pillar conceptual framework will be used as the bases of the research design and study and CLA will be used to unpack and deepen the future of South Africa's Smart built environment towards 2035.

The ethical clearance and application for the study will be guided by the Nelson Mandela University ethical clearance process. "Research Integrity embodies a range of good research practice and conduct which can include intellectual honesty, accuracy, fairness, intellectual property, and protection of human and animal subjects involved in the conduct of research. The ethical principles upon which much research worldwide is conducted are shaped by '*The Belmont Report*' which ensures:

- **Respect for persons** (the research consent process ensures autonomy for individuals – 'informed' consent, confidentiality of data etc.)
- **Beneficence** (the intention to do no harm – to maximize possible benefits and minimize possible risks to people involved in research)
- **Justice** (fairness in distribution of research inclusion and exclusion)". (Kruger, 2014).

2.4 Causal layered analysis

CLA focuses more on exploring the present and the past and creating alternative futures instead of predicting the future (Inayatullah, 2005)."Causal layered analysis is based on the assumption that the way in which one frames a problem changes the policy solution and the actors responsible for creating transformation" (Inayatullah, 1998). Inayatullah (1998) identifies four layers within causal layered analysis. **Litany** is the first layer and refers to the official public description of an issue. This is normally covered in the news media. The general belief at this level is that the problem cannot be solved or that the problem needs to be resolved by the government. The **systemic level** is concerned with the analysis and interpretation of quantitative data that relates to social, economic, cultural, political and historical factors. The **worldview or discourse level** are concerned with a problem constituted by a frame of analyses. Astute assumptions are made in the quest to resolve the problems. The **myth or metaphor** level is the last level where the problem is constituted by a myth and provides an emotional level experience to the discourse being analysed.
Table 2.4.1 below expands on the theories and represents a summation of causal layered analysis by means of a systematic approach.

Table 2.4.1: A Systematic presentation of CLA

Level	Problem	Solution	Problem-solver	Source of information
Litany layer: Official public description of the issue	Problem seems unsolvable. Little personal responsibility	Short-term approaches	Government	Often appears as news. Television or newspaper
Systemic level Social science analysis	Short term historical factors uncovered	Collaboration between society and institutions	Government / monopolistic interest groups	Fringe/ peripheral journals/editorial pieces
Worldview layer Concerned with structure/discourse	Problem constituted by frame of analysis	consciousness transformation, in changing worldview, in rethinking politics of reality	Interaction of many variables	fringe/peripheral journals
Myth/metaphor analysis	Problem constituted by core or myth (unconscious structures of difference, basic binary patterns)	Uncover myth and imagine alternative metaphors	Collective	Work of artists and visions of mystics

Source: Derived from Causal layered analysis: poststructuralism as a method (Inayatullah, 1998).

Inayatullah (2005) describes some of the benefits of CLA as follows:

- CLA increased the productivity and range of scenarios;
- In a workshop setting, the insertion of an assortment of ways of perspective is included amongst the participants;
- The integration of non-textual and creative expression in the future process, resulted in CLA appealing to a wider audience;
- Harmonious and conflicting positions of participants are layered;

- CLA allows for deliberation beyond what is obvious or superficial;
- CLA brings about a variety of transformative actions;
- The alternative layers of analysis of CLA can result in formation of informed policy actions through this process;
- CLA reinstates the vertical in social analysis, that is, from postmodern relativism to global ethics.

2.5 Environmental scanning

Environmental scanning is a formal, systematic and focused on a specific interest. This is done to understand the nature and pace of changes in the specific environment that will contribute to a better understanding of the challenges and enable the development of future opportunities. In the process, the thoughts about strategic options are deepened and broadened. (Conway, 2009).

2.6 Scenario planning: creating alternatives

Godet and Roubelat (1996) define a scenario as: “A description of a future situation and the course of events which allows one to move forward from the original situation to the future situation”. OECD (2018) summarises key aspects of scenarios below. Scenarios:

- Creates possible futures, presented through carefully constructed snapshots of the future;
- Is utilised as a tool for shared vision development, creating focusing thought, and policy determination.
- Is employed as a tool to assist with deciding on actions in the present to shape the future. Scenario planning is therefore not utilised as a tool to predict the future but rather in anticipation of possible futures.

Figure 2.6.1: The identification of key uncertainties below illustrates the scenario planning concept where two uncertainties have been identified through an environmental analysis exercise related to the research objective. Contrasting outcomes of these two uncertainties are graphically outlined to create four different scenarios. Olsen (2016) elaborates on scenario planning by providing a recommendation of logical steps to be followed below:

- An unambiguous emphasis must be placed on the decision at hand. Linking scenarios to specific decisions ensures alignment with the specific planning needs from the onset and prevents the outcomes to be generalised.
- The key drivers of change must be identified that is related to the specific decision to be made. When dealing with uncertainties it would be ideal to phrase the uncertainties as questions for better clarification. Uncertainties that are key for the decisions to be made are classified as critical uncertainties.
- Identify and select two of the most important drivers of change.
- Develop the scenario outline. Creative names can be assigned to each scenario.
- Evaluate each scenario in terms of the decision to be made with regards to the implications of the scenarios.
- After summarizing the overall strategies, it would be ideal to determine strategies that could be effective over multiple scenarios.

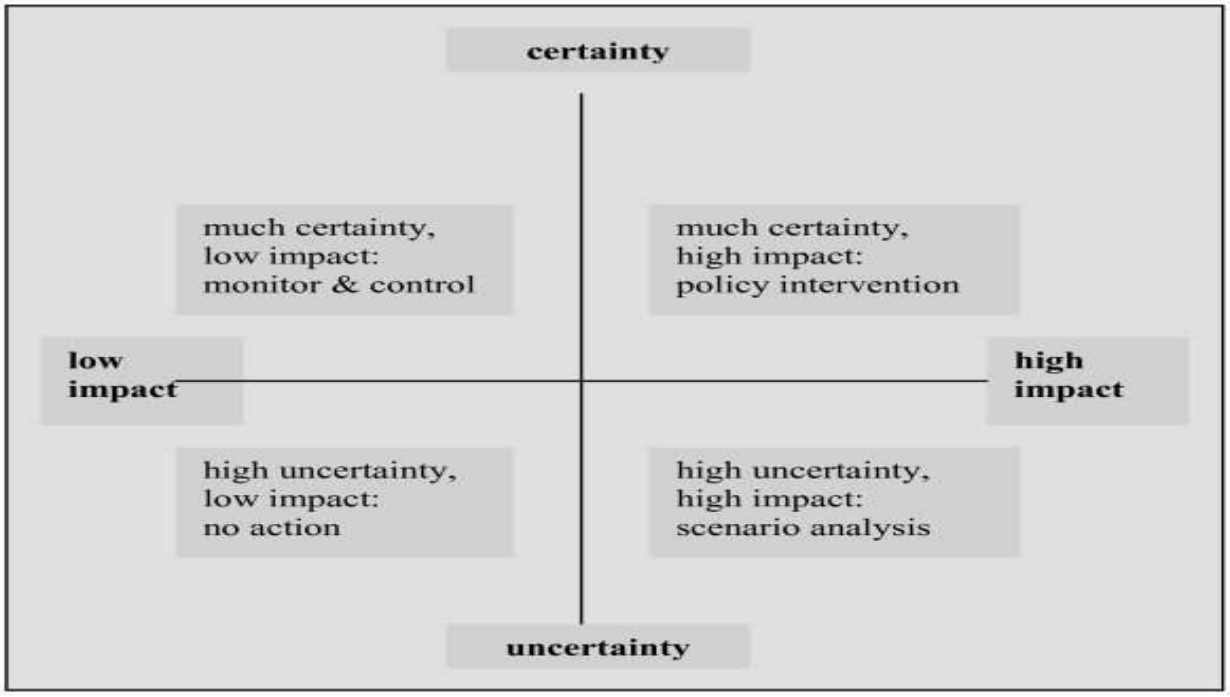

Figure 2.6.1: The identification of key uncertainties

Source: (Bierbooms, Bongers, and van Oers, 2011)

2.7 Conclusion

Chapter 2 presented the research methodology and design that would be adopted to effectively answer the research questions and objectives in line with determining the readiness of South Africa for the Smart built environment towards 2035. The following chapter would be focusing on conducting a comprehensive literature review to explore the drivers in the Smart built environment from a South African and global perspective.

CHAPTER 3
LITERATURE REVIEW

3.1 Introduction

The urban built environment is changing due to an increased demand in functionality demanded by the needs of overpopulated cities and is subjected to more rigorous building regulations and constrained resources (Buckman, Mayfield, and B.M. Beck, 2014). “Smart Buildings are buildings which integrate and account for intelligence, enterprise, control, and materials and construction as an entire building system, with adaptability, not reactivity, at its core, in order to meet the drivers for building progression: energy and efficiency, longevity, and comfort and satisfaction” (Buckman et al., 2014). Figure 3.1.1 below depicts the current and future capabilities of Smart Buildings. Smart buildings are heading towards predictability in line with occupant use. The more integrated buildings become with the addition of applications, sensors and devices, the further the building would progress on the Smart Building timescale (Buckman et al., 2014).

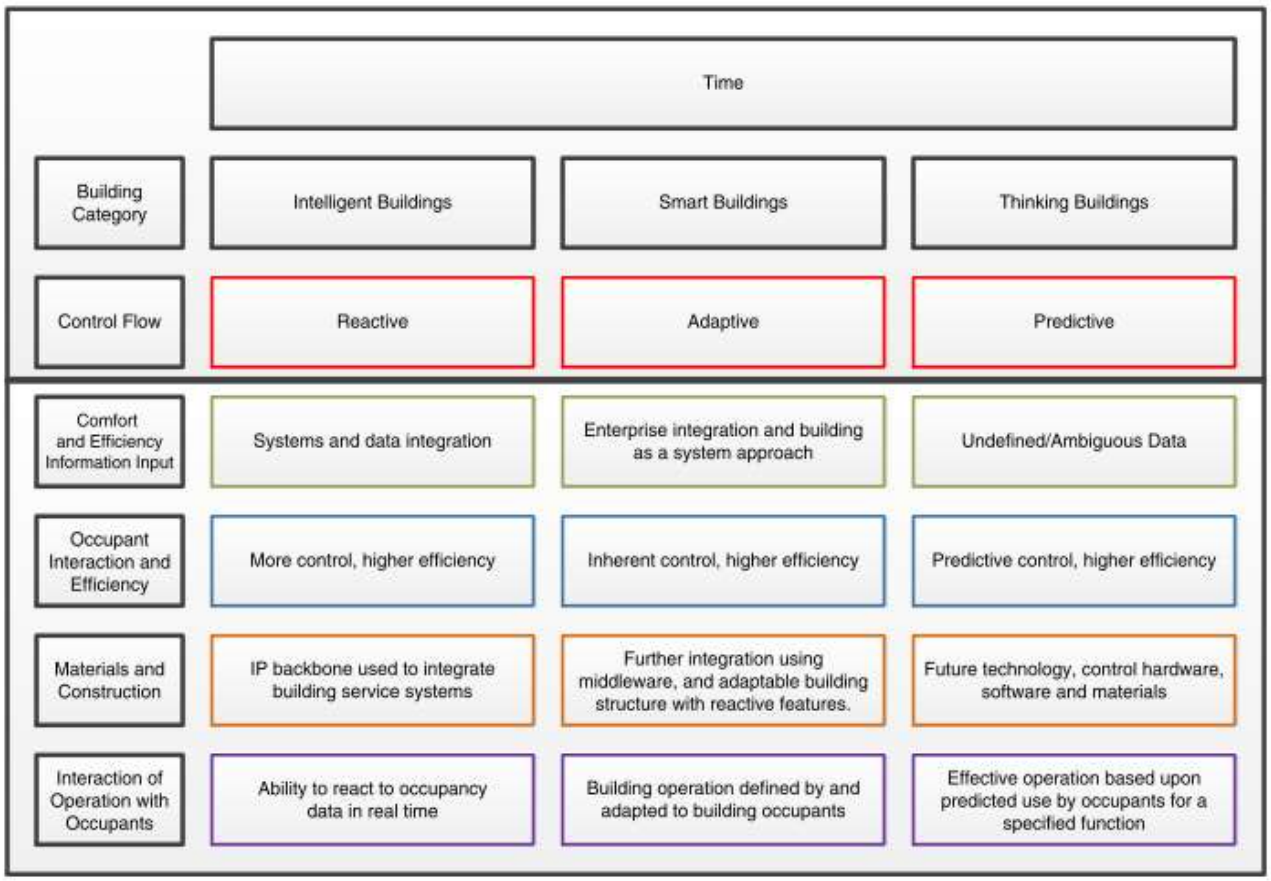

Figure 3.1.1: Upper and lower bounds of a Smart building
Source: What is a Smart Building? (Buckman et al., 2014)

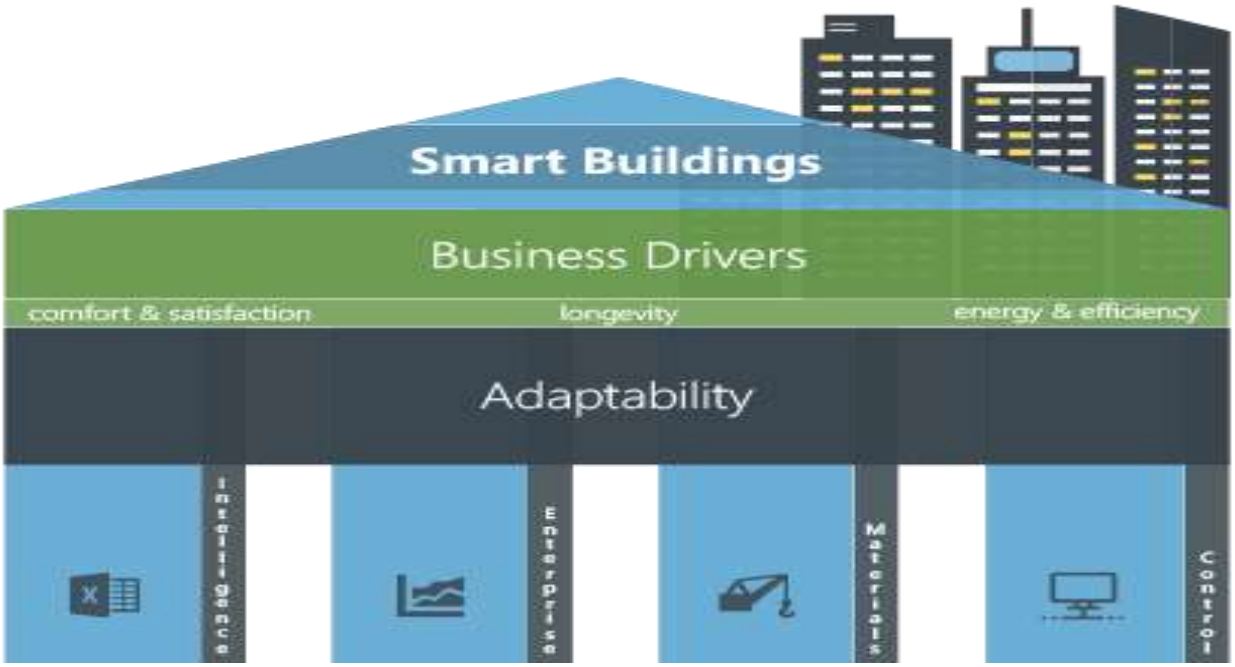

Figure 3.1.2: Smart Building Features

Source: What is a Smart Building? (Walton, 2017)

“Smart Buildings are buildings which integrate and account for intelligence, enterprise, control, and materials and construction as an entire building system, with adaptability, not reactivity, at the core, in order to meet the drivers for building progression: energy and efficiency, longevity, and comfort and satisfaction” (Buckman et al., 2014).

Walton (2017) illustrates the features of Smart buildings in Figure 3.1.2: Smart Building Features above and refers to four pillars that are the methods that meet the drivers for building progression. Adaptability, however, is at the core of defining Smart buildings. These pillars are Intelligence; enterprise; material and design and control. Smart system is created by utilising these pillars in the design and integration of adaptable buildings, to meet one or more of the drivers. Creating **adaptability** in buildings enables the provision for:

- Changes in the use of buildings and changes in occupants
- Varied perceptions of comfort at different times of the day or year
- Occupancy data characteristics that varies
- Changes in average annual weather conditions

Simultaneously ensuring that energy efficiency and occupant satisfaction is achieved or maintained. (Buckman et al., 2014).

Smart adaptability operates within three timescales as depicted in Figure 3.1.3: Adaptability over different timescales in a Smart building below. The successful operation of a Smart Building is dependent on the ability of the building to adapt based on the information at hand. This autonomy allows a building to distinguish between the designed requirements versus the actual information gathered and observed. The building can adapt to the disparity to ensure that if similar situations occur, that it would adapt to accommodate the differences and be similar to the design standards. Long-term adaptability is achieved largely by the building design: material used and the ability of the building intelligence and enterprise structure to be able to facilitate to long-term change. (Buckman et al., 2014)

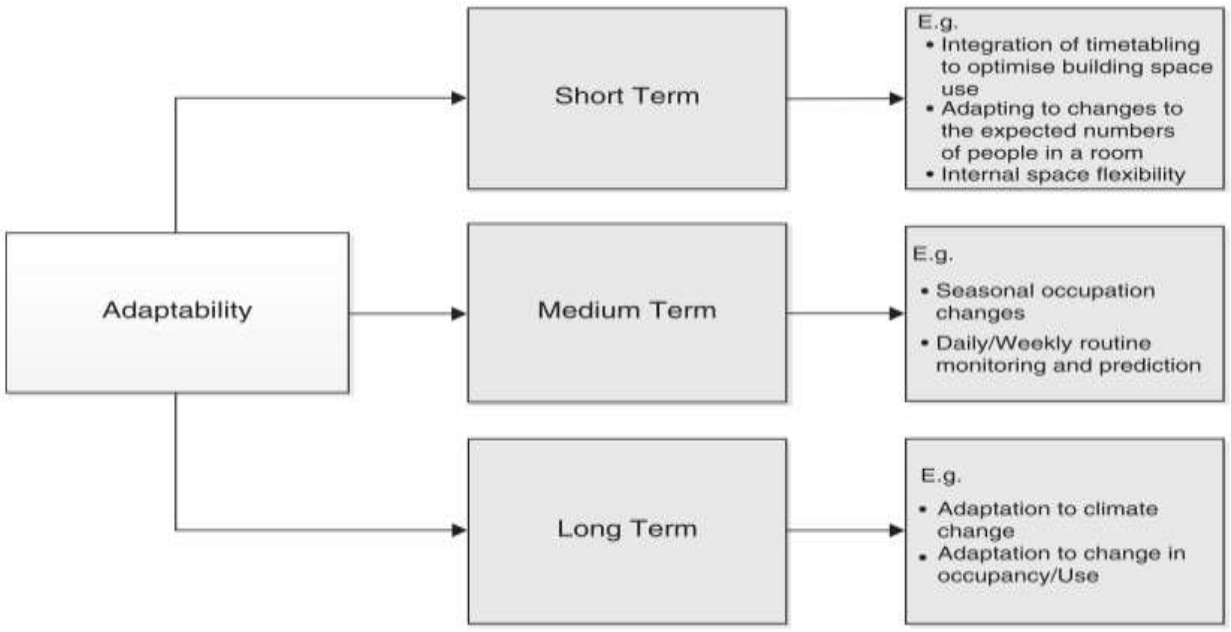

Figure 3.1.3: Adaptability over different timescales in a Smart building

Source: What is a Smart Building (Buckman et al., 2014)

3.2 Smart buildings vs Green buildings

“Integrating a building’s technology systems and constructing a sustainable or “Green” building have much in common. Green buildings are about resource efficiency, lifecycle effects and building performance. Smart buildings, whose core is integrated building technology systems, are about construction and operational efficiencies and enhanced management and occupant functions” (Sinopoli, 2007). Green and Smart buildings enjoy a symbiotic relationship where the one complements the other for enhanced benefits. Sinopoli (2007) argues that, for a building to yield high performance, it must be Green and Smart and further states that “Smart buildings make Green buildings Greener, and Green buildings make Smart buildings Smarter”.

Figure 3.2.1 depicts the commonality of Green and Smart Buildings. Similarity includes energy performance optimization, monitoring and controlling of systems, innovation in design and carbon dioxide monitoring, amongst others.

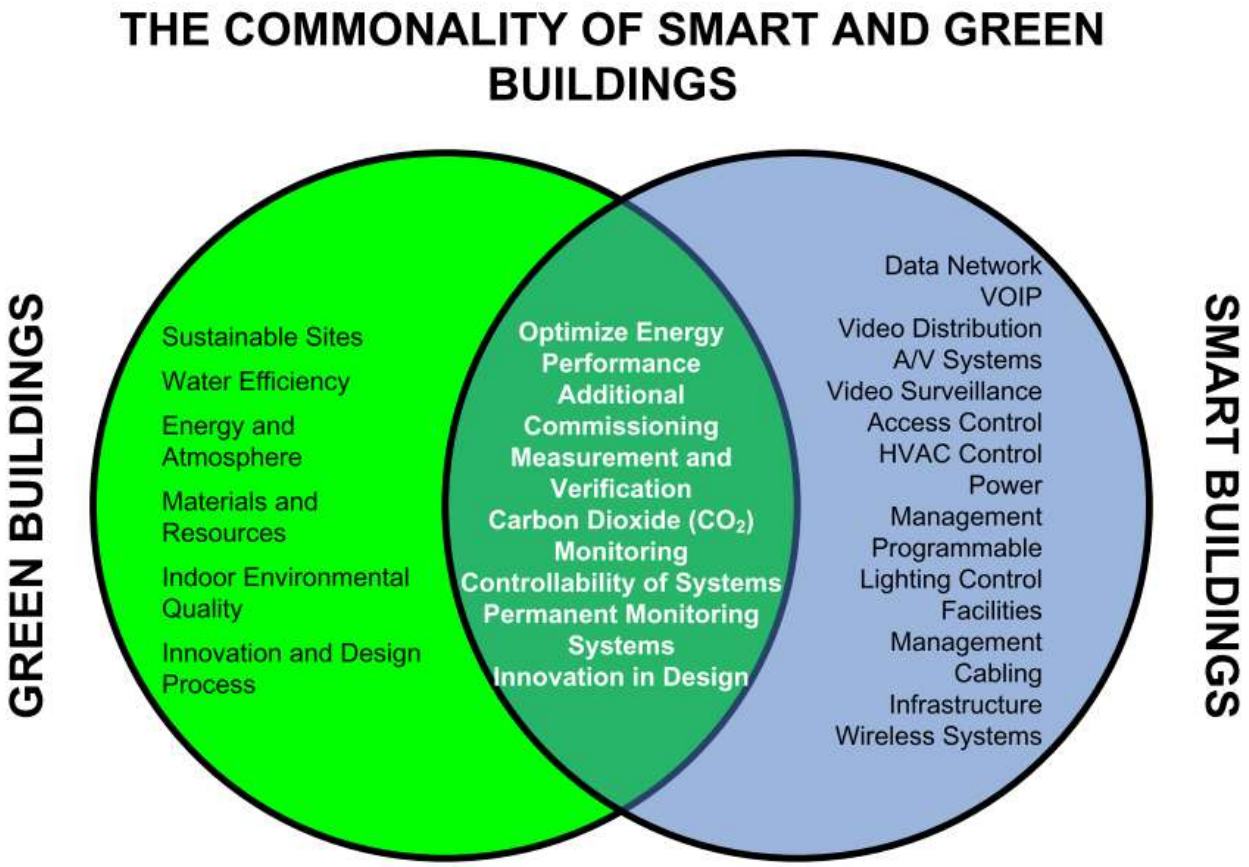

Figure 3.2.1: Commonality of Smart and Green buildings

Source: How Do Smart Buildings Make A Building Green? (Sinopoli, 2007)

3.3 Smart cities

3.3.1 What are Smart cities?

"A Smart city is a designation given to a city that incorporates information and communication technologies (ICT) to enhance the quality and performance of urban services such as energy, transportation and utilities in order to reduce resource consumption, wastage and overall costs. The overarching aim of a Smart city is to enhance the quality of living for its citizens through Smart technology" (Technopedia, n.d.). "The Smart city concept assumes the emergence of a new layer of urban data and advanced, interoperable, ICT's on top of the traditional physical elements in the built environment, opening up new possibilities for (re)design, operation and use of the built environment, and for interaction between citizens, or between government and citizens, what can lead to new

or better services and new business opportunities" (Borsboom-van Beurden, 2018). Borsboom-van Beurden (2018) highlights that a "wide-scale deployment of Smart city technologies could reduce CO2 emission by 7.8 gigatonnes, nearly 20% of global emission in that year" and in order to make Smart Cities a reality it would require for a collaboration between government, co-initiators and strategic allies that could include transport companies, landlords, housing associates, energy suppliers and other built environment stakeholders. Borsboom-van Beurden (2018) provides a comprehensive look at the stakeholders that need to contribute to the development of Smart cities, in Figure 3.3.1 below.

Figure 3.3.1: Overview of stakeholders in planning and implementation of Smart city solutions
Source: Window of Opportunity for Smart City Solutions in the Urban Fabric (Borsboom-van Beurden, 2018)

3.3.2 Smart buildings in the Smart cities' ambit

Smart buildings are a core element in the Smart cities ambit and could be utilised as an initial focus point in the development of such Smart cities. Focusing on a building level would afford a scalable approach to Smart cities development. Creating levels of Smart building certification systems would allow for the adoption of best practices that could further be extended in the creation of Smart cities. (Smeenk, 2018). Song (2018) echoes the belief of Smeenk and refers to modern buildings as a testbed that would provide technologies for incorporation into future cities.

“Smart building is a microcosm of a Smart city, and as we become a data-integrated, Smarter world, we need our building standards to keep pace. New standards will be required, and existing standards will need to be modified. Suppliers, solution providers, and integrators, as well as broadband, carrier and enterprise networks, and wireless evolution suppliers, must work together with industry associations to develop and advance a new platform to measure and monetize the Smart technology opportunities that define Smart cities – one building at a time” (Smeenk, 2018).

Figure 3.3.2: below depicts the level of connectivity brought about in Smart cities, the importance of the Internet of Things (IoT) and the areas that are affected by creating Smarter cities.

Figure 3.3.2: Internet of Things (IoT)

Source: (Skyworks, n.d.)

The days that Smart cities were a sci-fi prediction had lapsed and is a growing reality. Song (2018) highlights three focus areas of Smart cities as convenience, citizen engagement and safety. Atlanta in America pledged 250 million dollars for the improvement of connectivity and sensors to improve utility and traffic control.

3.4 The importance of the internet of things in Smart buildings

IoT plays a fundamental role in developing Smart buildings and Smart cities. Smart buildings and cities cannot be developed without a good IoT infrastructure that allows for real-time data and connectivity that is reliable and instantaneous. IoT is important to link the various sensors in Smart buildings to a central point that would be utilised for execution of preassigned tasks as well as the accumulation of information. This information gathered, also referred to “big data” could be utilised as a baseline for other buildings as well as optimising applications and setting standards. (Remo, 2017).

3.5 South Africa’s current IoT infrastructure and developments

3.5.1 Reliability of connectivity in South Africa

Connectivity in South Africa is improving but not at the pace to keep up with the rest of the world. MTN’s collaboration with Ericsson to trial 5G network technology is a positive sign for future accessibility to faster connectivity. South Africa is still vastly vulnerable in terms of connectivity with unconnected communities as a major concern. Service providers are expressing their commitment by investing heavily to connect such communities all over South Africa. (Writer, 2018).

3.5.2 Commitment of service providers in the IoT industry

Vodacom (n.d.) committed to IoT by instituting a dedicated IoT division. A key area of focus of this division is to collect and process valuable data to create automation of processes, improve asset efficiency and security by the integration of sensors and building systems.

3.5.3 Creating Smart villages and townships

The Limpopo division of the Public Sector ICT Forum has undertaken an ambitious initiative to take Smart concepts to villages and townships by following the Smart cities methodologies and concepts tailor-made for the need of these areas. The success of these trials will allow for the roll-out to the rest of South Africa, South African Development Community (SADC) and Brazil. A major concern that has been highlighted, is the need for solutions around the supply of medication by means of Smartphone connectivity that allows users to register and be serviced by means of Smart-driven machines. (Mzekandaba and Hinchcliffe, 2018).

3.6 Drivers of change

Horne and Hayles (2008) found that there is a lack of international benchmarking on housing sustainability performance and foresee a need to establish an international consensus regarding the assessment of performance of housing sustainability within the context of policy and regulatory development.

Buys, Chanel, Research, Barnett, and Bailey (2004) found that sustainable housing concepts deliver much more than economic savings and durability. It contributes to improved health and wellbeing. Buys et al., (2004) further highlighted the need to examine consumer resistance to environmental designs. Consumers prefer traditional styles due to the perception that environmental are less aesthetically pleasing, less safe and secure and less likely to provide a sound return on investment. There is, therefore, a shortcoming in the awareness of the consumers on the benefits of a Smart and sustainable home and that if this awareness is created and the correct choices are made, positive impact on the environment, as well as on the social and economic areas of life can be achieved.

Green buildings technologies are mainly focused on eco-efficiency and evidently reduces the negative impact on the environment. The design of Green buildings has a positive impact on human health while reducing the negative impacts on ecology and utilises less water and energy. These isolated positive impacts are not enough to ensure sustainability because Green buildings are not a common practice globally. Future research should focus on answering the ultimate question of how buildings could provide a positive environmental contribution. Buildings would, therefore, need to be placed in a social context, where its form and function endeavour to harmonise with the natural landscape (Gunnell, 2009).

As a developing country, South Africa is faced with difficult decisions between job creation or economic factors and objectives that the country set in terms of the environment. The biggest influencing factor of these trade-offs is the high level of unemployment in the country that is in excess of 25% (South African Association for the Advancement of Science. et al., 2009). The heavy reliance of the socioeconomic systems on natural resources makes South Africa vulnerable to global change. The trade that would be mostly affected by the new technologies in the construction industry has been identified as bricklaying.

To offset the effects of the shift in the building industry in terms of effected trades, cross skilling as well as upskilling initiative has been proposed ("The Impact of New Technologies on the Construction Industry," 2014). The skills gap in the built environment is increasing due to the need and application of new technologies and the requirement for architecture, design and engineering that are world class. The global construction industry has a growth forecast of 70% by 2025. In order to achieve this future growth, it would be vital to attract a more diverse workforce and expertise from outside the industry.

The new technologies would strengthen the industry due to the shift in design and operations. It is, however, crucial that there is a collaboration between industry; government and education and training institutions to ensure that sustainable solutions are found to ensure that there is a firm continuous talent pipeline ("The Built Environment Skills Gap," 2016).

The benefits of comfort, safety, flexibility and energy saving that is derived from the adaptation of new technologies to the built environment will result in a great percentage of buildings becoming increasingly "Smarter" in the future (Khanda et al., 2017). Smit et al., (2016) highlights that the built environment is shaped by political social and environment forces. The built environment also has a direct impact on health and as in the case of Khayelitsha in Cape Town, had a direct impact on non-communicable diseases. It is therefore imperative to extend the development of South Africa's built environment to the inclusivity of the needs of all walks of life.

Mitigation of and adaptation against climate change in South Africa is sporadic and lack the policy commitment and enforcement (du Plessis, Irurah, and Scholes, 2003). South Africa's attitude in this regard is evident of a lack of responsibility to mitigate the effects of climate change.

3.6.1 Political drivers

National Planning Commission South Africa (2015) defines the "The National Development Plan (NDP) as a long-term South African development plan, developed by the National Planning Commission in collaboration and consultation with South Africans from all walks of life". The plan outlines the intent of South Africa's focus on achieving key objectives by 2030.

“The Department of Environmental Affairs (DEA) is mandated to give effect to the right of citizens to an environment that is not harmful to their health or well-being and to have the environment protected for the benefit of present and future generations.

To this end, the department provides leadership in environmental management, conservation and protection towards sustainability for the benefit of South Africans and the global community” (South African Government, 2018). The DEA promotes social development and economic growth that is equitable, inclusive and sustainable through South Africa’s Green Economy strategy. The strategy consists of eight key pillars listed below:

- Green buildings and the built environment;
- Sustainable infrastructure and transport;
- Energy efficiency and clean energy;
- Water management;
- Conservation and management of Natural resources;
- Sustainable consumption and production;
- Sustainable waste management;
- Forestry and agriculture food production.

The DEA is implementing sustainable infrastructure and energy efficiency projects under the Green buildings and the built environment pillar. This initiative falls within the Green Cities Programme. (South African Government, 2018). Packirisamy (2018) highlights the lack of political accountability in the Zuma administration that fuelled corruption and mismanagement of state resources. During this time a considerable amount of state institutions faltered. Packirisamy (2018) emphasises the positive outcomes of the national conference held by the African National Congress (ANC) in late 2017. The conference brought about renewed hope by the change of leadership and due to the shift from party politics to the focus to resolve national issues. Although there has been a renewed shift in focus, the ANC remains under pressure to resolve the factionalism in the party. This could have an adverse effect on the party’s success in the national elections of 2019. The instability within the political environment has a direct impact on policy and mandate execution.

Adendorff and Collier (2015, p. 77) cites the disharmonious relations between the national, regional and local spheres of government as having a direct impact on accountability and creating tensions in these spheres. The inability to create constructive relations feeds the lack of coordination of responsibilities and power which leads to government mandates not being met and delivery of services in limbo.

The signing of the Paris agreement by the Minister of Environmental Affairs on the 22 April 2016 is indicative of South Africa's acknowledgement of, and commitment to address, the effects of climate change. This agreement is also legally binding and ensures that South Africa and the rest of the participants are held accountable. (A. Modise, 2016). The Minister Molewa said, "We need to adjust our ecological, social, and economic systems and change the way of doing business, so that we can transition to a lower carbon and climate resilient society, in a manner that also grows our economy, creates employment, and eradicates poverty," (A. Modise, 2016). These words are encouraging to note and affirmation that the government is aware of the broad change that South Africa needs to confront to have a greater impact on climate change.

3.6.2 Social drivers

South Africa is faced with a dilemma of providing basics such as housing, education, healthcare and employment in conditions where a high population growth rate is contending with economic development (Adendorff and Collier, 2015, p. 64). South Africa's population can be regarded as being young with an overwhelming child population of 15.04 million and a youth population of 14.04 million. The working class of ages 15 to 65 is projected to increase from current figures of 32.7 million to 39.04 million towards 2050. These current realities and future outlook creates further pressures on providing the basic requirements for the South African population. (Adendorff and Collier, 2015, p. 65). South Africa has been effected by the brain drain in Africa that saw in access of 20000 scarce skills leaving Africa since 1990 (Adendorff and Collier, 2015, p. 67).

One of the irrevocable and most influential forces in the world is considered to be urbanisation. South Africa's urban population is currently approximated at 13.83 million and is expected to increase by a further 13 million towards 2050. The high level of unemployment due to these influxes to cities are coupled with illegal and informal land occupation.

The urban environment will be compromised if management interventions are not instituted to ensure that the challenges of urbanisation is combated. The challenges bring opportunity to create specific focus for the enhancement of living conditions, increased energy efficiency and breaking the divide in urban development. South Africa is faced with a dilemma of providing adequate housing and coupled with it the basic services required for households. This will become of greater concern as the urban population grows. (Adendorff and Collier, 2015, p. 69).

Figure 3.6.1: Improvements in Living Standard Measure (LSM) between 2001 and 2010 in South Africa
Source: South African futures 2030 (J. Cilliers, 2014)

Figure 3.6.1 represent the improvement in the LSM 5 to 10 segment from presenting 48 percent of South Africa in 2001 to an increase of 69 percent of the population in 2010 (J. Cilliers, 2014).

Education and Innovation is paramount prerequisites for technological advancement. There is different public and political views on the 30 percent matric pass requirement that South Africa adopted. The Minister of Higher Education seems to be content with the allowable pass percentage for matriculants and argues that different people have different inclinations. Business leaders, education experts and teacher unions are criticising the quality of the matric certificate and argue that it does not equip matriculants to enter universities and the job market. (John, 2014). The pass percentage argument highlights the fast disparity in the views of government, business and the greater society. South Africa have not scored well in the IMD World Digital Competitiveness report of 2017.

Achieving a mere 47th out of 63 countries means that South Africa ranks in the bottom half and does not compare well in terms of digital competitiveness. Digital competitive comprises of three main factors namely: knowledge, technology and future readiness. (Khumalo, 2017).

3.6.3 Technological drivers

PCAS (2008) acknowledges technology as a key driver of change and is changing the way people work, the amount of times they travel to and from work, where they work, how relationships are formed and fostered as well as how goods are made or marketed.

Weber (2017) cites a transformation in the built environment that will bring about a change in the rules that currently apply in the real estate industry. This transformation can be contributed to the Internet of Things (IoT), robotics, Artificial intelligence (AI) and other technologies, which are also the major contributors in the formation of Smart cities, new business opportunities and automated processes. Automation is projected to contribute to the redundancy of 50 percent of current jobs by 2055. This significant change will have a definite impact on the working environment as well as the real estate assets and industry (Weber, 2017b). Figure 3.6.2 below highlights that 45 percent of activities in South Africa, can be automated by current technologies.

The convenience that the new technologies afford, could bring about a shift in the built environment due to a shift in requirements. Office space could be decentralised with people working from home. This convenience is afforded by the IoT development contribution. Infrastructure requirements that were predominantly dedicated to industrial areas would, therefore, be needed in residential areas. This would enhance connectivity and contribute to efficiency but also leave buildings and office space vacant. Technology would, therefore, effect the way homeowners, town planners, developers and other built environment contributors think about the future attractiveness, capabilities and adaptability of their current and future building designs. (Weber, 2017b).

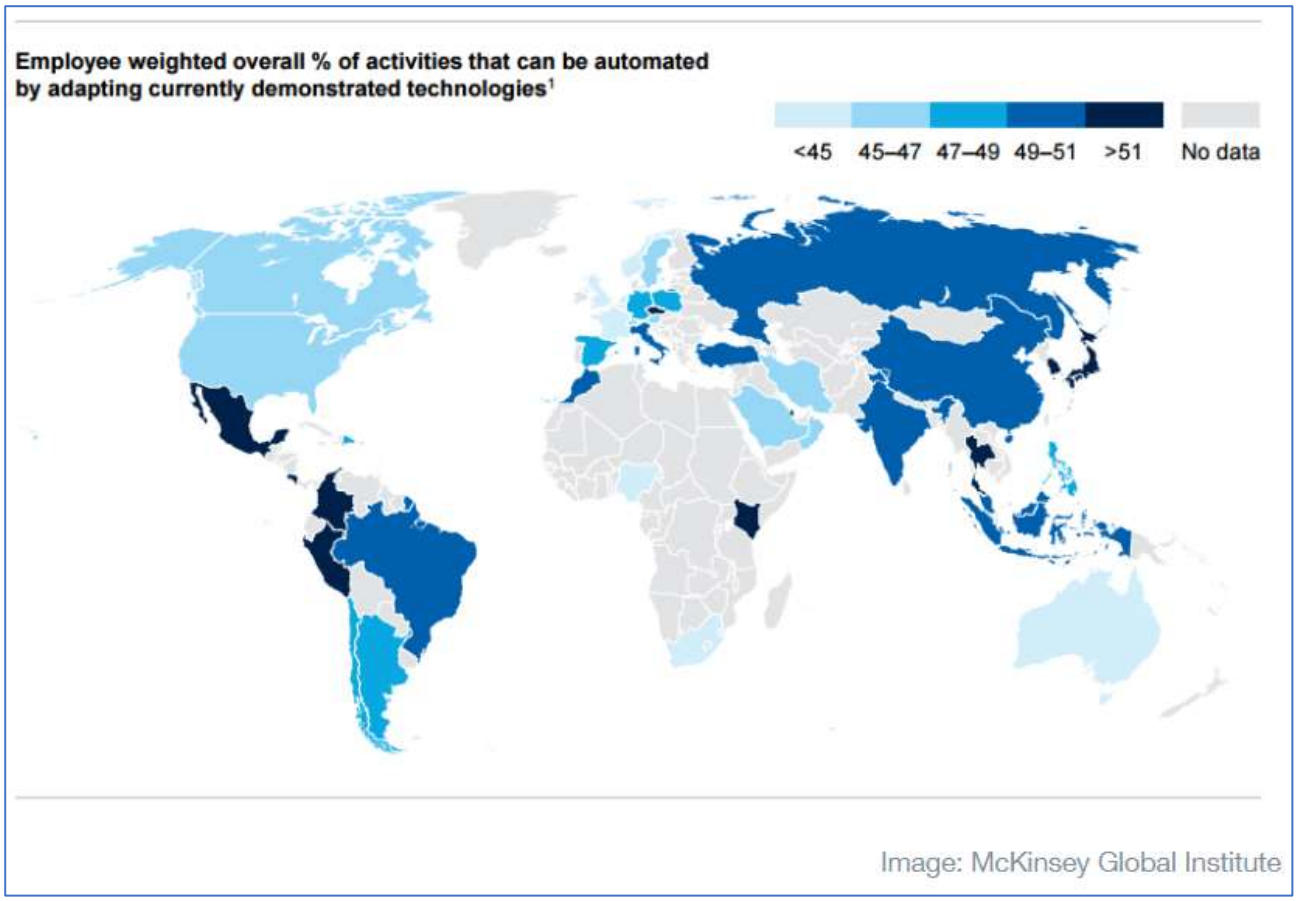

Figure 3.6.2: Employee weighted overall percentage of activities that can be automated by adapting currently demonstrate ed technologies.

Source: (Weber, 2017b)

3.6.3.1 Automation of Automation

There should not be complacency around technical jobs in the future. Jobs that require low or high skills could be replaced by artificial intelligence to an extent that artificial intelligence could be responsible for its own repair and enhancement (Weber, 2017a). Weber (2017a) further expresses the difficulty to automate and aspects that are generally neglected. These factors are:

- **Cost associated with the automation of jobs**. Where operational and capital cost of automation exceeds the cost of labour it is not cost-effective to implement such initiatives.
- A benefit of a reduction of **remuneration,** therefore a reduction in labour cost could be achieved with the availability of workers willing to work for less than current market labour costs.

- The trade-off between efficiency of automation versus **economies of scale** required to offset the investment.
- The **Entry costs** associated with the implementation of automation that cannot be afforded by Small and Medium Enterprises (SME) and other financially drained organisations forces these entities to use manual labour.
- Ethical and security threats could give rise to **regulation** development and enforcement to curb the control an uncertainty that AI could lead to.
- A lack of; awareness; knowledge; talent, clear strategy and unwillingness to invest are amongst the contributing factors that leads to **slow adaptation**.
- The lack of **Data** and the disparity between countries with regards to data availability and market transparency adversely effects the training of supervised machine learning (ML) models.

The global construction industry is predicted to be worth 12 trillion US dollars by 2020 and are still dominated by processes with high waste output. Technology that use to be optional in the past with regards to the construction industry, has become a necessity in recent years. Engineers, contractors and competitors needs to constantly adapt to these technologies in order to remain competitive. (Ferlaino, 2014).

3.6.3.2 Three-dimensional (3D) printing applications and integration with other technologies

3D technologies, drone technology as well as sophisticated integration of computer-aided drafting (CAD) technologies were used during the Crossrail project in London. Building information modelling (BIM) software were used to create a single information model by linking 1.7million CAD files. Drones were used to inspect and survey the construction. 3D printers were used to create parts for the construction while 3D laser scanning was used to track the progress versus the virtual model hence allowing to identify deviations and ensure prompt correction. (Castagnino, Rothballer, & Gerbert, 2016).

Figure 3.6.3: Large-scale 3D printer model

Source: 3D Printing: The future of construction (Jamie, 2018)

Figure 3.6.3 above illustrates the autonomous capability that can be achieved on large scale projects in the construction industry through 3D machines. Time-saving, the ability to complete complicated tasks like curves with ease, at a lower cost and a reduction of waste are some of the benefits of 3D machine that has been realised (Jamie, 2018).

A Chines company named Ma Yihe claimed to have constructed 10 houses in 24 hours by means of 3D printing, as depicted in Figure 3.6.4 below. The same company built their offices in modular form, also utilising 3D technology (Head, 2017).

Figure 3.6.4: 10 houses 3D printed in 24 hours

Source: 3D printers can build 10 houses in 24 hours (Miles, n.d.)

Head (2017) envisage that the constant introduction of new materials in the 3D technology sphere will enable 3D machines to construct complete buildings with services by 2020.

3.6.3.3 Automated machines laying bricks

Figure 3.6.5: Semi-automated mason construction robotics

Source: Mirror: Bricklaying robots (Curtis, 2017)

The bricklaying robot in Figure 3.6.5 has the capability to lay 3000 bricks daily. With up to six times more output than a human mason, the robot is a threat to masons and could revolutionise the construction industry. These robots have already replaced humans in the United States of America and the owners of the technology is targeting to enter the United Kingdom construction market with their technology. Fastbrick Robotics is an Australian company that is working on a prototype robotic bricklayer called Hadrian X for commercial use. (Curtis, 2017).

The Hadrian X would be an upgraded version of the Hadrian 105 that was launched in 2016. A key Feature of the Hadrian X is that it has the capability of placing 1000 bricks per hour compared to the 225 bricks per hour of the Hadrian 105. Fastbrick Robotics is aiming at making the technology available in Western Australia than the rest of Australia before it will make it available globally. (Hodgkins, 2016).

3.6.3.4 Light steel frames instead of brick and mortar

Light steel frames buildings (LSFB) has been successfully implemented in South Africa over the last decade, from being revolutionary to being widely accepted by customers by the efforts of a small amount of pioneering companies in the light steel frame technology (SA Builder, 2016). Figure 3.6.6 illustrates the ability of light steel frames to comply to the conventional or modern aesthetic requirements of the customers. Light steel frames concepts are synonymous with speed and quality of build, as well as cost effectiveness.

Engineering News (2015) echoes the sentiments of SA builder that LSFB's are widely accepted and became the first choice of numerous leading contractors. The Southern Africa Light Steel Frame Building Association (Sasfa) is concerned with the regulatory duties within the industry and is boasting about the growth of its membership that reached a membership of above 80 companies. The commitment of organisations such as KFC, McDonald's and Burger King to utilise LSFB's in the construction of the facilities is further contributing to the success of the industry and an acknowledgement of its sustainable benefits. The benefits of LSFB is cited as significantly reducing; wasted material; construction time; carbon footprint and transportation costs.

Figure 3.6.6: Before and after pictures of a residential light steel project
Source: South African Builder (SA Builder, 2016)

3.6.3.5 Smart sensors, IoT and connectivity

Maia (2018) highlights the dilemma of cost versus benefit of connectivity that Small and Medium Enterprises (SME) need to endure but also not understanding the real value that connectivity has in a digital transforming society. South Africa's average broadband speeds falls below the generally perceived average of 10Mbps for households. With an average speed of 6.38Mbps, South Africa is placed 72nd out of 200 countries and third in Africa, behind Kenya and Madagascar. Madagascar is placed 22nd globally and enjoys speeds of 24.87Mbps while Singapore has the world's fasted broadband speeds of 60.39Mbps (Moyo, 2018). South Africa will, therefore, need to improve in this regard to be recognised globally and to enjoy improved efficiency in data transfer that the faster speeds can yield. Smart sensors play a pivotal role in IoT and the fourth industrial revolution and will be comprehensively used in Smart buildings, transportation, utilities, agriculture, industry and other sectors. Connectivity is important for Smart sensors to enable the transfer of massive amounts of data throughout the built environment. (Roth, 2016).

3.6.3.6 Big Data

McArthur (2016) expresses the importance of Big Data in Smart cities by the equation Big Data + Built Environment = Smart City. Big Data applications is important for the collection, interpretation and analysis of information in the built environment that will allow for the development of predictive models and allowance for informed decisions by the identification of ideal courses of action.

3.6.3.7 Smart materials

“The application of Smart materials in the field of architecture mainly depends on the ability of these materials to change their shapes and characteristics based on passive form, under the influence of external stimuli such as humidity, temperature, solar radiation, light, air movement and pollution” (Saidam, Al-Obaidi, Hussein, and Ismail, 2017). Elif Süyük Makaklı (2017) expresses the need for architects and designers of future buildings to be aware of Smart material and their capabilities, to incorporate it into the to their designs. It is also important for all stakeholders in the built environment to collaborate in an attempt to have a full understanding of the nanotechnology for application in, and transformation of, the built environment.

3.6.4 Legal drivers

The Paris agreement is a legally binding agreement of global significance, that will keep South Africa and the rest if the world in check to deliver of climate change initiatives (A. Modise, 2016).

Sustainable Energy Africa (SEA) has been mandated to achieve building energy performance by constructing policies, regulations and by-laws that can be derived from the net zero carbon emissions program currently undertaken by Cape Town, eThekwini, Johannesburg and Tshwane (Cilliers and Euston-Brown, 2018). The program is under the abet of the C40 Cities Climate Leadership Group (C40) and supports South Africa’s intentions to achieve zero emission building standards by 2030 as set out in the National Development Plan. SEA further supports and leads the update of SANS 10400-XA (National Building Codes energy efficiency component) to achieve these initiatives.

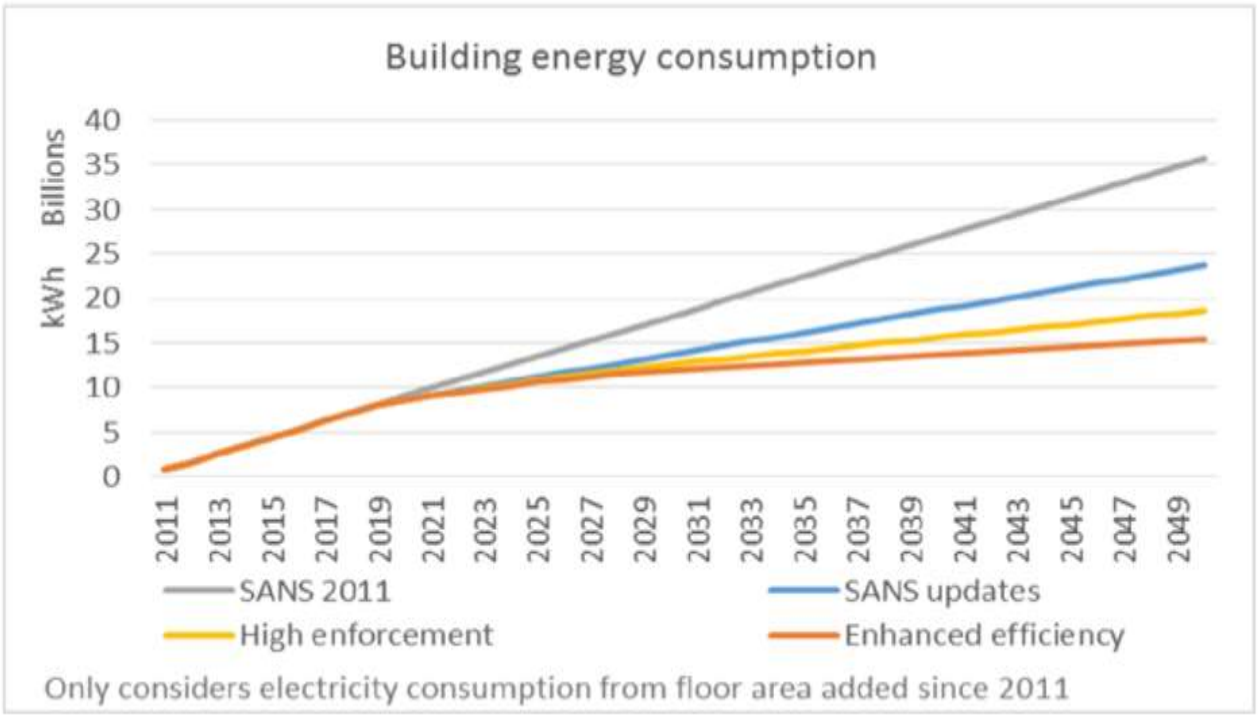

Figure 3.6.7: Building energy consumption projections within the Cape Town, eThekwini, Johannesburg and Tshwane metros

Source: (Cilliers and Euston-Brown, 2018)

Figure 3.6.7 above is indicative of the positive effects that an update to policies, regulations and standards would have as well as the impact that enforcement of such policies, regulations and standards would yield. Each city has a direct influence over the amount of energy that a building is designed to use. The building inspectorate, building plan approval process and other regulatory functions are key interjectory points that needs to be utilised for control of building energy usage (Cilliers and Euston-Brown, 2018).

The efforst in terms of compliance of the four cities in the SEA program is encouraging to note:

- Cape Town with its updated Resource Efficiency Criteria for Development guideline,
- City of Johannesburg with its simplified Built Environment Guideline,
- eThikweni working on incentives for Green initiatives with high resilience to climate impact, such as flooding, effecting Durban'
- The City of Tshwane with its initiative to ensure that all new city buildings have a Green Star certification rating of 5 stars and above coupled with the review of its Green Building By-law for more focused approach to a zero carbon target. (Cilliers and Euston-Brown, 2018).

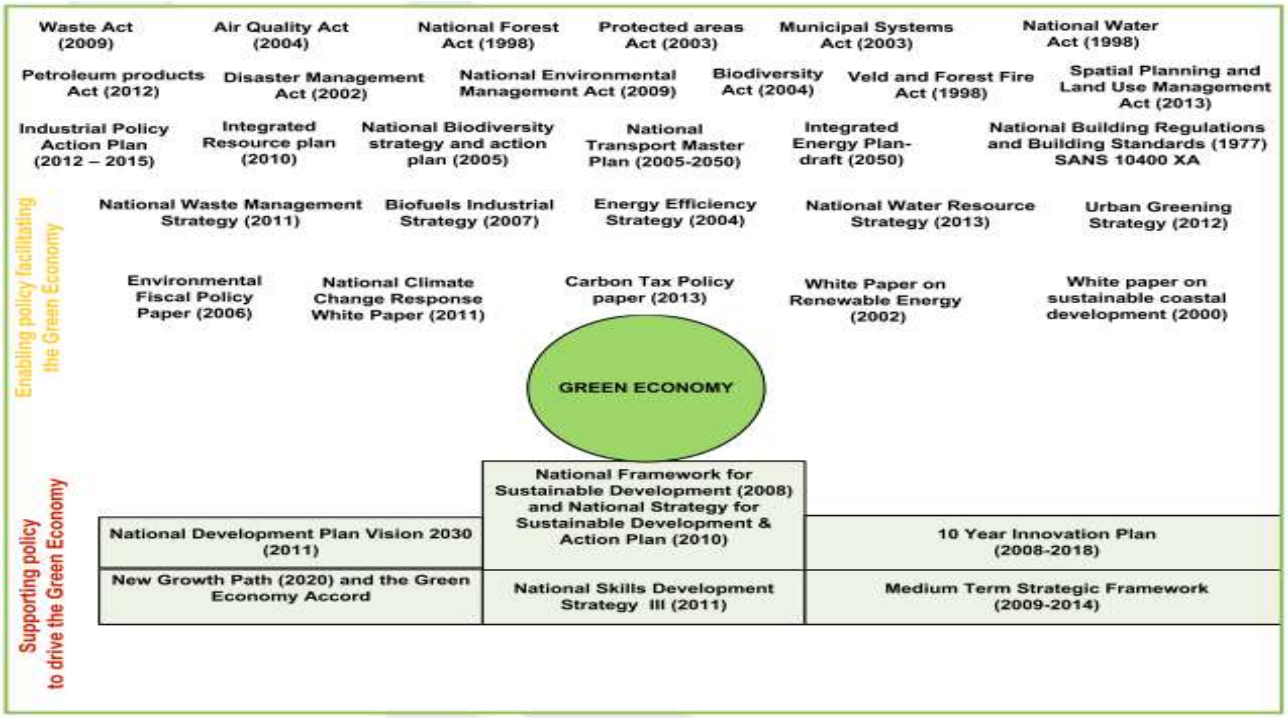

Figure 3.6.8: A summary of the policies and strategies that support and facilitate South Africa's transition to a Green economy

Source: Steering towards a GREEN ECONOMY Steering towards a Green Economy: A reference guide (Stafford et al., 2014)

Figure 3.6.8 above is a summary of the policies and strategies that support and facilitates South Africa's transition to a Green economy. The Green Economy has a notably extensive reach in the economy. Consisting of variety of influencers, the Green economy has the capability of greatly impacting the South African economy constructively. It is also notable and alarming that these policies and strategies have either been adopted more than a decade ago, or their target dates have lapsed. It is therefore questionable if these strategies and policies are real drivers of change that could lead to a Green Economy.

3.6.5 Economical drivers

The benefits of the Green building and energy efficient industry extends far beyond climate change goals. Energy security is crucial for South Africa's economic growth and is amongst the large-scale economic priorities that include, job-creation, resource conservation, long-term resilience and social factors such as quality of life (Cilliers and Euston-Brown, 2018). Cilliers and Euston-Brown (2018) further highlight the economic benefit of investing in energy saving because "a megawatt saved being far cheaper than a megawatt generated".

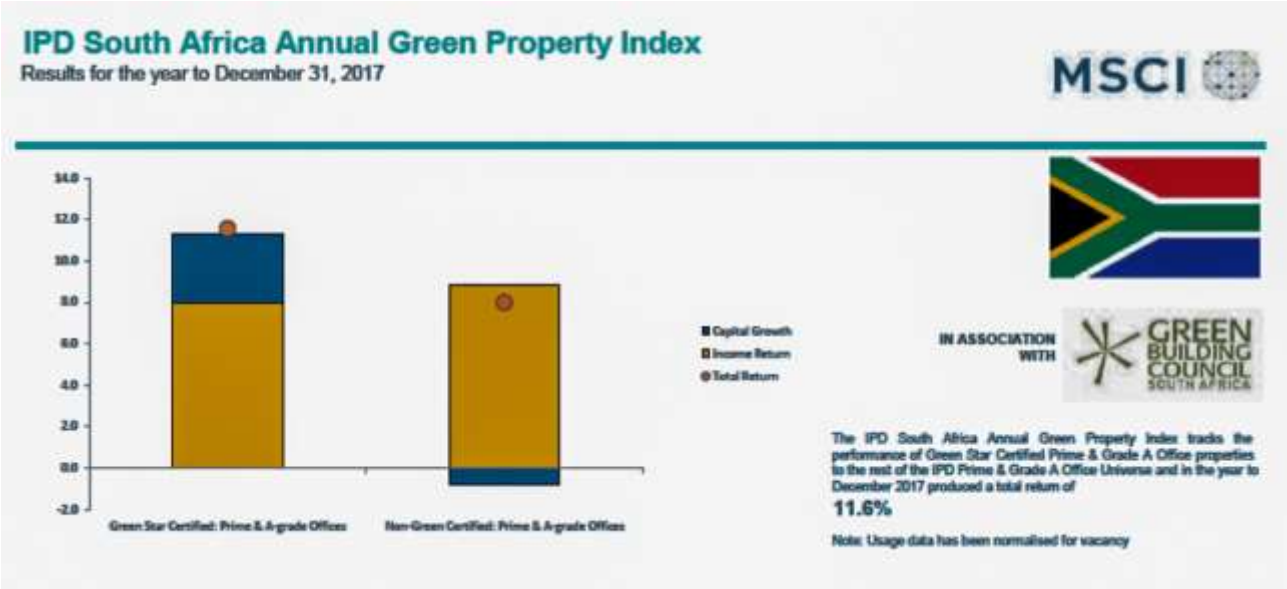

Figure 3.6.9: IPD South Africa Annual Green Property Index: Results for the year to December 31, 2017).

Source: (Cilliers and Euston-Brown, 2018)

Figure 3.6.9 illustrates the benefit that can be derived from certified Green buildings as opposed to buildings which are not. The pareto indicates an approximated 45 percent higher return from certified Green buildings, hence a viable option for individuals and investors.

3.6.5.1 The Green Economy

DEA (n.d.) defines the Green economy as a "system of economic activities related to the production, distribution and consumption of goods and services that result in improved human well-being over the long term, while not exposing future generations to significant environmental risks or ecological scarcities". There is a global drive for the inclusion of the Green Economy potential in national strategies and policies and the implementation of the same (Stafford et al., 2014). The Green Economy is generally poorly understood. "The Green economy is not an 'add-on' or an emerging sector, but an imperative and framework for all economic activity. It brings effect to the concept of sustainable development and requires coordinated action of government, the private sector, and civil society" (Stafford et al., 2014).

Table 3.6.1 below expresses the areas of potential in the Green economy and the benefits that can be derived from it. The potential will increase by urbanisation that is estimated at 62 percent currently and projected to reach 70 percent by 2030 and 80 percent by 2050 (Stafford et al., 2014).

Table 3.6.1: Green economy initiatives and benefits in the transport, water, energy, waste and agriculture focus areas

Green economy focus area	Key green economy Initiatives	Examples of green economy Benefits
Transport and Urban efficiency	- Integrated spatial planning to improve urban efficiency - Promote and enable green building design and green building materials and standards. - Promote and enable low carbon transportation	- Increased mobility and connectivity without the need for additional transport - Increased urban efficiency through the efficient use of resources such as water, energy and materials - Reduced traffic congestion, improved vehicle fuel efficiency and low carbon transport through switching to biofuels, shared use of vehicles, mass transit and non-motorised transport
Energy	- Promote and enable energy efficiency and demand side management - Increase the proportion of renewable energy in the national energy supply mix - Enhance the universal access to clean renewable energy services	- Provides consumers with information needed to reduce energy consumption and increase energy efficiency - Reduced demand for fossil fuel-based energy supply, reduction in emissions and the promotion of local innovation and economic development - Reduced inequalities related to clean, modern energy services with universal electricity grid availability and access to renewable energy sources
Waste	- Measures to improve supply chain efficiency and prevent the production of waste - Reduce the waste going to land-fill by increasing reuse and recycling - Invest in clean technology and value adding to waste	- Reduces costly waste treatment and unnecessary raw material demands by-promoting resource efficiency - Reduces costly waste and opens up green jobs and new opportunities in reuse and recycling - Reduced production of wastes and pollutants and improved waste management with new enterprise opportunities
Water	- Enhance the provision of water and sanitation services - Increase water-use efficiency and equitable distribution through appropriate incentives - Improve monitoring and reporting to ensure best practice and standards in water and wastewater management	- Universal and equitable access to water and sanitation services to improve human well-being - Improved water use efficiency to improve the management of water quality and quantity, and the fair and equitable allocation of water resources - Improved water resources management and best practice towards water security
Agricul-ture	- Develop sustainable agricultural systems where the dependency of agriculture on natural resources is recognised - Focus agricultural production to improve food security and livelihoods, and create resilient ecosystems - Develop and enable access to organic markets through the support of small-scale farmers and establishment of organic norms and standards	- Increased resource efficiency and investment in natural capital to maintain and enhance the provision of ecosystem goods and services - Agriculture is geared to improve food security and creating resilient ecosystems; thereby reducing poverty, improving livelihoods and creating green jobs. - New market opportunities for small scale farmers and SMMEs with increased rural socio-economic development and the localisation of the food value chain to deliver equitable benefits

Source: Steering towards a GREEN ECONOMY Steering towards a Green Economy: A reference guide (Stafford et al., 2014)

3.6.6 Environmental drivers

The effects of climate change on buildings is driving changes within the built environment to accommodate these effects such as keeping cool in warmer weather; dealing with more extreme wet weather and preventing or staying away from flood risk areas. Buildings must further aim for a low or zero carbon impact and reduced fossil fuel utilization (Roberts, 2008). Cilliers and Euston-Brown (2018) express that 36 percent of energy-related Greenhouse gas emissions, within the Cape Town, eThekwini, Johannesburg and Tshwane metros, are derived from commercial and residential buildings combined. Figure 3.6.10 illustrates the contribution of commercial and domestic properties, on energy-related Greenhouse gas emissions, within the Cape Town, eThekwini, Johannesburg and Tshwane metros. Residential buildings should, therefore, be acknowledged as a major contributor to Greenhouse gas emissions.

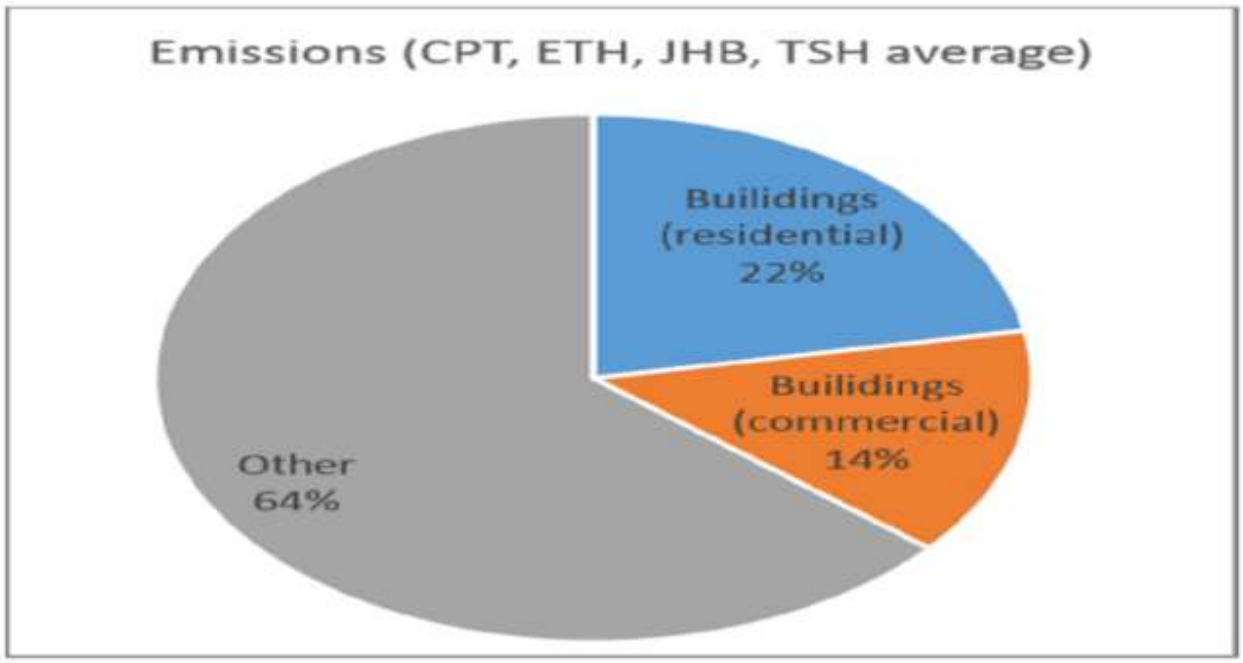

Figure 3.6.10: Energy-related Greenhouse gas emissions, within the Cape Town, eThekwini, Johannesburg and Tshwane metros

Source: (Cilliers and Euston-Brown, 2018)

South Africa has been fortunate to be endowed with natural resources and mineral deposits. The coal reserve abundance ensured South African's to enjoy relatively affordable electricity. The electricity generation is highly reliant on coal and therefore carbon intensive. This places South Africa as the 42nd largest producer of carbon emissions per capita. To counter the imminent global pressure to reduce these emissions, South Africa will need to deliver on its objectives in the National Development Plan towards 2030. Involving neighbouring countries could yield added benefit in the pursuit of environmental sustainability. (Adendorff and Collier, 2015, p. 115).

The environmental degradation is significantly impacted by the built environment during construction, operation and deconstruction. These impacts are approximated at consuming 40% of the world's energy, 15% of the worlds fresh water resources and produces 23 to 40% of the worlds Greenhouse gas emissions (Gunnell, 2009). The South African government provided more than 3 million housing units to the poor and low-income households between 1994 and 2015. The housing backlog is in excess of 2.1 million units. South Africa's informal settlements are in access of 2225 (Jeffery, 2015). These developments exclude the expected expansion of the infrastructure in the middle to upper-class domestic areas as well as industrial areas.

The increasing need for buildings that are generally built utilising conventional practices that are high uses of natural resources are unsustainable. Modise (2016) highlights South Africa's current drought conditions, that is seen to be the worst El Nino in decades. These conditions are compounded by the Pacific Ocean's rising sea temperatures that further raises temperatures and results in a reduction of rainfall all over the world. Global climate change aggravates these conditions further. The reduction of Greenhouse gas concentration in the atmosphere therefore needs urgent global attention.

Climate Action Tracker (2018) rates South Africa's Nationally Determined Contribution (NDC) target as highly insufficient as referred to in Figure 3.6.11 below. The Integrated Resource Plan (IRP) that has been adopted under South Africa's new President, Cyril Ramaphosa, is likely to achieve most of its 2030 targets but will require ambitious targets to meet its NDC. Climate Action Tracker (2018) recommends that South Africa extend its renewable energy expansion well beyond 2030, eliminating coal usage for energy, significantly reducing natural gas usage by 2050 and to explore opportunities in industry, transportation as well as buildings.

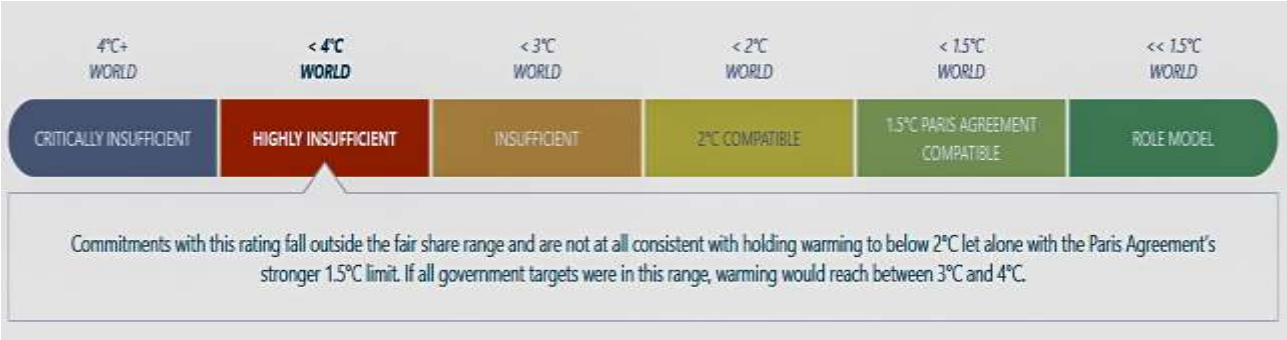

Figure 3.6.11: South Africa's climate change tracker

Source: Climate Action Tracker: South Africa (Climate Action Tracker, 2018)

3.7 Possible resistance to change

According to Borsboom-van Beurden (2018) the most common barriers to Smart cities are:

- high initial and operational costs of Smart city solutions,
- lack of financing and appropriate business models,
- siloed governments,
- lack of technical skills in staff,
- risk aversion by financial organisations,

- split incentives,
- inconsistent government policies,
- prohibitive legislative frameworks, for instance for precommercial procurement,
- lack of proven solutions and validated examples, and
- difficulties with engagement of local stakeholders.

3.8 Global innovation in the built environment: Successes

3.8.1 "The Edge": New office building for Deloitte Netherlands

Figure 3.8.1: EDGE: The new office building designed for Deloitte Netherlands
Source: Shaping the Future of Construction: Insights to redesign the industry (World Economic Forum, 2017, p. 25)

Deloitte Netherlands received the highest accolades for a Smart building when their new Amsterdam office depicted in Figure 3.8.1 above, referred to as The Edge, was considered as the most sustainable office building in the world. The project yielded a net negative result in terms of energy consumption. A conventional building's energy consumption is estimated at an average of 40.7 kWh/m2/year whereas The Edge boast an estimated negative energy usage of -0.3 kWh/m2/year. (World Economic Forum, 2017, p. 27).

The project brief was not just aimed at improved sustainability, but also to improve end-user interface experience and workforce integration. These improvements were realised by the integration of various aspects of the building. A single network connectivity to all technical aspects of the building allows for a holistic view of the building in real time. Connectivity includes but is not limited to the lighting and cooling systems, the robot that moves around the aisles after hours as security guard, the lift as well as towel dispensers and coffee machines. This integration resulted in increased resource efficiency. The collaboration between the developer, the customer and suppliers resulted in the project contributing to the realisation of 21 new innovations implemented for the first time in the world. The Philips' Ethernet-connected lighting initiative was one of such innovations that Phillips itself was sceptical to implement but its benefits were realised and is currently integrated as into other buildings. (World Economic Forum, 2017, p. 26).

The World Economic Forum (2017, p. 27) highlighted various impacts of the project. Some of these impacts are:

- New standards have been set for sustainability and flexible working by the project.
- Minimising the building running cost and environmental impact but simultaneously maximising the productivity of its occupants.
- Hot-desking was achieved through its building app and Smart data system that lead to an increase in the building's capacity, initially designed for the 1100 workspaces to service 1700 occupants to an achievement of servicing more than 2500 occupants.
- The excess power that the building generates allows employees to charge their electrical bicycles and electric cars at no charge.
- A multidisciplinary team made up of the client, the developer, contractor and architect, brought their different expertise together that pushed the boundaries in aspects of Big Data, app design and renewable energy.
- iBeacons and additional sensors currently on trial in some offices will allow for The Edge to be transformed to The Edge 2.0. This innovation will allow individual movement to be actively monitored and creating active usage heatmaps to model and analyse the actual behavioural patterns that could make RFID and normal time management systems redundant. This would further improve productivity and user fulfilment.

3.9 South Africa's built environment

The Green Building for Africa programme (GBFA) was launched in 1997 and the South African Property Owners Association (SAPOA) and the Council for Scientific and Industrial Research has been promoting Green building concepts ever since (GreenCape, 2014).

The Western Cape Government identified objectives to enable the Green Economy Strategic Framework within the province. The strategic principles indicates that the "Green economy" must, be business-led and opportunities focused; Works for the poor Advocates a people-centred approach and advocates an effort to lead by example (GreenCape, 2014). Political endorsement for the Green growth initiatives in the Western Cape was realised through the 2012 Green is Smart initiative that was launched by Premier of the province.

3.9.1 Built environment regulatory framework

The Department of Public Works (DPW) is the custodian of South Africa's building industry regulatory framework. The policy setting framework for the building industry in South Africa is supported by the National Regulator for Compulsory Specifications (NRCS). The NRCS has a National Building Regulation Division that is responsible for ensuring a uniform understanding and implementation if the National Building Regulations and Building Standards Act, Act 103 of 1997 (NBRBS Act). Provisions are made through the South African Bureau of Standards (SABS) to ensure that the technical aspects of the National Building Regulator are satisfied. The SABS are therefore tasked to develop technical standards that are in line with the national building regulations. South African National Standard (SANS)10400 is the specific standard that addresses the technical aspects of the national buildings regulations, with part X dealing with environmental sustainability and part XA dealing with energy use in buildings. (GreenCape, 2014).

GreenCape (2014) further highlights that although the South African Government adopted a National Framework for Green Building in South Africa (NFGBSA) as its official policy on Green buildings, it is not a legislative requirement. This could be a fundamental reason for the slow implementations of Green concepts in South Africa. In 2014 the Green Building Council of South Africa (GBCSA) certified 50 buildings of which 11 were in the Western Cape.

A further 40 alternative building technologies were approved by the National Home Builders Registration Council (NHBRC), of which 36 were from the Western Cape. Although small numbers it is indicative of the Western Cape's commitment to be a front-runner in the Greening of South African buildings.

3.9.2 Findings through industry events

The Vision 20/20 conference in 2013, that was hosted by the South African Council for the Quantity Surveyors Profession (SACQSP), contributed to key findings in the industry as stated below:

- No control of construction material in the building industry
    - This highlights a need and opportunity to introduce the waste market into the construction industry.
- Water efficient fixture and good water harvesting systems reduce cost and water harvesting significantly.
- Some government commitment is evident by the introduction of Green building ratings to newly built government buildings.
- There is a business case for the tenant and developer for long-term financial benefit and return on investment.

3.9.3 Zero-Carbon new buildings in South Africa

Cilliers and Euston-Brown (2018) highlight the commitment of four major cities in South Africa towards the aim for net zero carbon emissions by 2050, that is aimed at newly- built buildings. To achieve these commitments, Cape Town, Johannesburg, Tshwane and eThekwini are implementing innovative programmes and policies.

3.9.4 The States empty buildings

According to Gqirana (2016), the South African government owns more than 2000 buildings that are standing vacant all over the country. The rates and tax bill, as well as water and electricity for the vacant buildings, amounts to approximately R60 million.

These empty buildings create an opportunity for the South African government to elevate the pressure on the Reconstruction and Development Programme (RDP) housing projects by converting these buildings to low-cost residential areas that comply with Green and Smart specifications.

3.10 Conclusion

Chapter 3 provides a comprehensive look into the drivers of change in the built environment. A comprehensive PESTLE analysis provided insight into drivers in the macro environment relating to the built environment. The following chapter will utilise the drivers that was identified in the application of the six pillars approach to future studies. The aim of Chapter 4 is to create alternative futures for the Smart built environment in South Africa towards 2035.

CHAPTER 4

APPLICATION OF THE SIX PILLAR APPROACH TO FUTURE STUDIES

4.1 Introduction

Chapter 3 was aimed at a comprehensive review of literature pertaining to the Smart built environment and the driving forces that are steering change in the industry. A PESTLE analysis was used to expand on the driving forces and key technological driving forces were identified. Chapter 4 aims to apply Futures studies methodologies from a South African perspective on the Smart built environment. Adendorff and Collier (2015, p. 45) argues that the future only exists in our imagination and that one cannot just plan for one future but needs to plan for various futures. Inayatullah (2008) describes the six pillars of futures studies as providing "a theory of futures thinking that is linked to methods and tools and developed through praxis." The pillars are mapping, anticipation, timing, deepening, creating alternatives and transforming and will be deployed in this chapter to resolve the research objective.

4.2 Mapping the future

Inayatullah (2008a) refers to mapping the future as the first pillar of future studies. In this pillar, the past present and future are mapped to have a better understanding of where we come from and the trajectory of where we are heading.

4.2.1 Countdown to human free construction

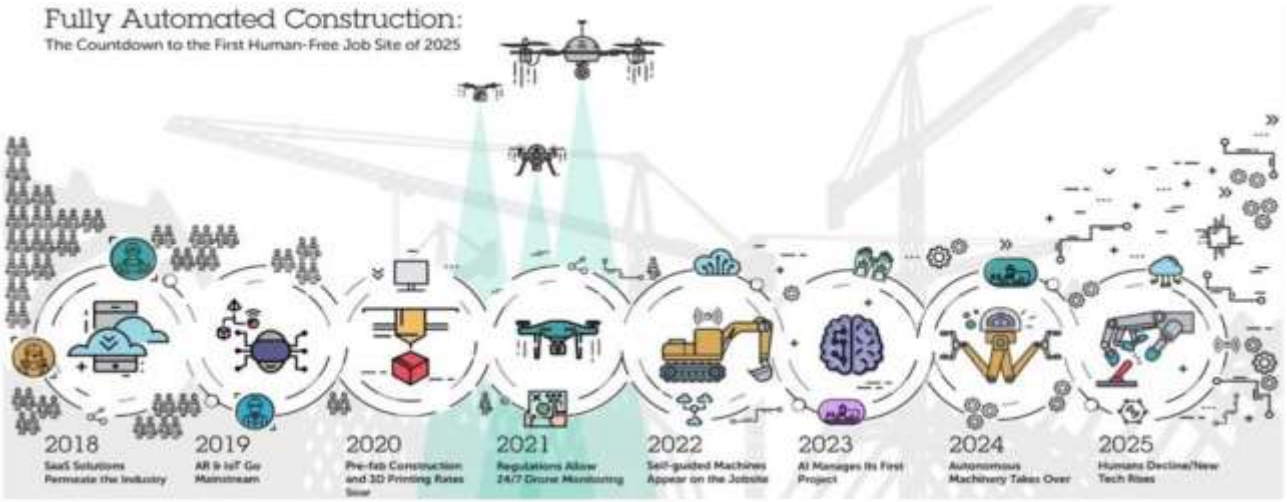

Figure 4.2.1: The Future of Automation in construction

Source: (Hertzman, 2018)

Hertzman (2018) cited the accelerated development of software technology and sensors as the key drivers behind the exponential development of autonomous machines. The uses of such machines, such as contractors needs to ensure that they develop their workforce to be able to utilise such machines in their offerings. The timeline in Figure 4.2.1 is indicating a significant decline in manual labour from 2019 in conjunction with an alarming increase of autonomous machines. Hertzman (2018) argues that an autonomous construction industry is inevitable and should not be ignored as if it is only applicable to the distant future. It would be difficult for the construction industry to argue against the utilisation of new technologies that would save cost and simultaneously improve speed and quality. Hertzman (2018) further raises alarm that contractors and effected parties should react now before it is too late for them to have an influence or voice in the matter.

4.2.2 The timeline and trajectory of sustainable architecture

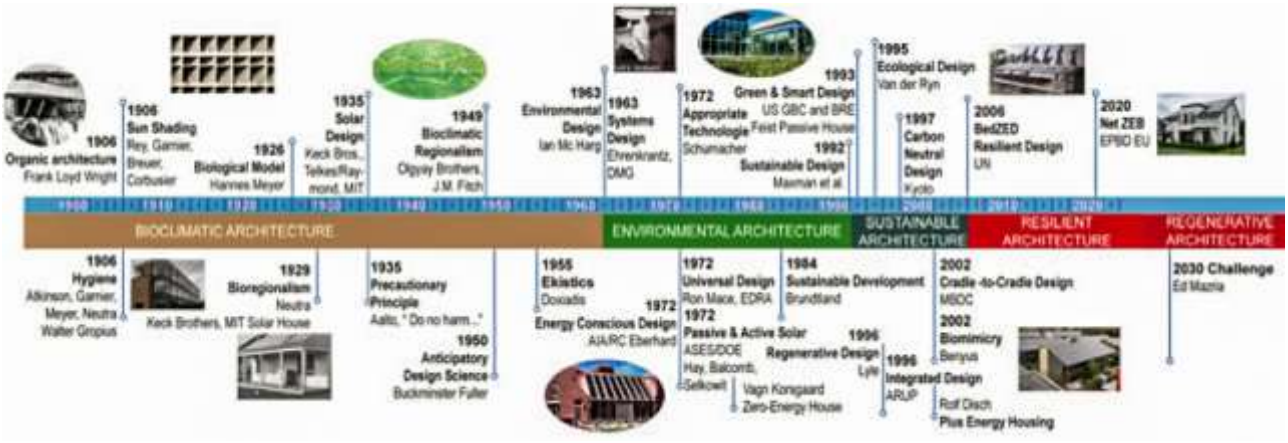

Figure 4.2.2: Timeline: Modern history of sustainable architecture

Source: Regenerative and Positive Impact Architecture: Learning from Case Studies (Attia, 2018)

Paradigm	Years	Influencer	Paradigm
Bioclimatic architecture	1908–1968	Olgyay, Wright, Neutra	Discovery
Environmental architecture	1969–1972	Ian McHarg	Harmony
Energy conscious architecture	1973–1983	AIA, Balcomb, ASES, PLEA	Energy efficiency
Sustainable architecture	1984–1993	Brundtland, IEA, Feist	Resource efficiency
Green architecture	1993–2006	USGBC, Van der Ryn	Neutrality
Carbon neutral architecture	2006–2015	UN IPCC, Mazria	Resilience
Regenerative architecture	2016–Future	Lyle, Braungart, Benyus	Recovery

Figure 4.2.3: Change sustainability paradigms that influenced architecture of the last century

Source: Regenerative and Positive Impact Architecture: Learning from Case Studies (Attia, 2018)

Figure 4.2.2 and Figure 4.2.3 above illustrates the paradigm shift of architecture over the last 120 years. According to Attia (2018), the architectural domain is entering a different paradigm that is referred to as Regenerative Architecture. This paradigm refers to positive impact creation through buildings that are environmentally effective and sustainable. It is also an improvement on the previous paradigm named Carbon Neutral Architecture that focus on energy neutral architecture or zero energy targets. What use to be a niche offering transcended into a global driver.

4.2.3 Global trends that are changing the built environment

According to Bateson (2017), trends over the next 10 years will be focusing on increasing productivity and enhancing human life. Bateson (2017) further highlights five megatrends that will shape the built environment. These megatrends are:

- **IoT**: IoT has been increasing at a rate of 20% annually and are projected to increase further as the manufacturing cost decreases as well as the increase in device functionality. The internet of things will enable and improve the networked built environment and the connectivity will improve with the enhanced integration of personal devices, controls, sensors, switches and the like.
- **The rise of intelligent buildings**: Enabled by IoT, building controls advanced from basic controls of heating, cooling and lighting to the integrated building management systems that become autonomous to an extent that it can predict individual needs and respond accordingly.
- **Sustainable design and construction processes:** Contractors are aiming to reclaim between 95 and 100 percent of construction waste. The drive to reduce waste and increase efficiency will intensify the need for contractors, property developers and manufacturers to support and implement sustainable design and construction processes and will lead to a focus on the circular economy. To enable the designers and clients to explore the concepts, extensive use will be made of immersive technologies and virtual reality applications.
- **Built environment resilience:** The effects of climate change in terms of temperature change, extreme weather, flooding and other effect are calling for resilience in the built environment. The assurance of electrical supply redundancy will be a focus point and designers will need to incorporate backup strategies into their designs.

- **Health and wellbeing in buildings:** is a megatrend that would force employers and landlords to adapt their buildings in order to retain or attract occupants. “Good facilities in comfortable surroundings, with good light and ventilation, increase happiness and improve productivity”(Bateson, 2017).

“These megatrends are driven by a combination of technological, environmental and social change. Property professionals, and the property supply chain, will need to make sure that people’s needs are at the centre of change” (Bateson, 2017). Kolczak (2017) provides a similar perspective on the trends that would affect the future of our cities and refers to his 5 megatrends as:

- **Building for people:** Urban planning shifted from planning for cars to planning for people. Renewal efforts are defined by inclusivity and innovation.
- **Health and wellness:** An emerging area of research is the impact that building design has on health and wellness in the workplace as well as hospital and schools. This is driven by the fact that individuals spend close to 90 percent of their time indoors.
- **Going Green:** Creative ways needs to be adopted to embed nature into urban settings.
- **Planning for climate change:** San Francisco initiated their resilience effort in 2014 by creating a resilience officer function. 84 global countries have since followed suit to implement similar functions.
- **The Net-zero Standard:** 200 commercial buildings in the United States of America (USA) gained Net-zero energy ratings in 2016. Oregan state in the USA is requiring all new homes to be “zero-energy ready” and allowing for solar panel installations by 2023. The Google Project Sunroof is an innovative initiative where homeowners from The United States of America and Germany can see what their potential solar potential is by providing their street address. To achieve a zero-waste rating, an achievement of 90 percent saving of waste to landfill must be realised. This is achieved by compositing, recycling, reduction, reuse and prevention.

Jewell (2017) provides a different perspective on the future of the built environment. According to Jewell (2017), the built environment has been sluggish in embracing the environmental, cultural, technological and demographic shift.

The built environment has been doing business as usual while other industries radically reshaped the way they do things and what they offered. This complacency in the built environment is under threat by the major shifts in technology, the way people work that is changing and what people are expecting from their buildings.

Jewell (2017) identified four drivers that, according to Aurecon Buildings of the Future leader Peter Greaves, could radically change the built environment over the next 30 years. These drivers are:

- **People**

  The value proposition of buildings is pivoting around people and buildings of the future will be able to "self-tune" to the requirements of its occupants. "Advancements in monitoring and security, building management system apps, information screens, WiFi, automated elevators, lighting and air conditioning will mean that services are adjusted before the worker even steps out of the building of the future elevator" (Jewell, 2017).
- **Flexible design**

  The rapid technological transformation will require buildings to be designed with keeping flexibility in mind. This brings about an opportunity for off-site or modular construction. 3D printing will revolutionise the design concepts that would be achieved through its flexibility and ability to handle complexity. To stay relevant, stakeholders in the built environment will need to embrace new methodologies, materials and technologies.
- **Complex technology with ease of use**

  The technologies will increase in sophistication but conversely improve user interface to an extent that users will almost not be aware of its existence. Buildings will be regarded as Smart devices that can receive and transmit data for autonomous facilities management. Buildings of the future will, therefore, be able to "learn, anticipate, adapt and enhance: without the users being aware of it" (Jewell, 2017).
- **Measuring bottom-line benefits**

  According to Jewell (2017), the dilemma of calculating the value derived versus the cost of Smart buildings are calling for enhanced ways of measuring the cost-value equation by creating a specific measuring standard. In order to calculate the return of investment, Aurecon suggests the inclusion of measuring "their achievement of occupant wellness, connection to local community, energy being delivered to the right

place at the right time, as well as the integration of appropriate technology and new materials" in the specific measuring standard (Jewell, 2017). There needs to be a realisation and acceptance that the world is changing, and these changes call for robust discussion that include government and economic leaders that should be initiated by innovative leaders and engineers. From a work environment perspective, human resources management should engage building professionals and innovative executives to collaborate in exploring initiatives that would yield benefits for organisations and individuals in this regard and draft a specific measuring standard accordingly.

Futures triangle in Figure 4.2.4 below, is a tool that maps today's views of the future through three dimensions namely: pull of the future; push of the present and weight of history. Based on the literature review and CLA, the futures triangle can be constructed below.

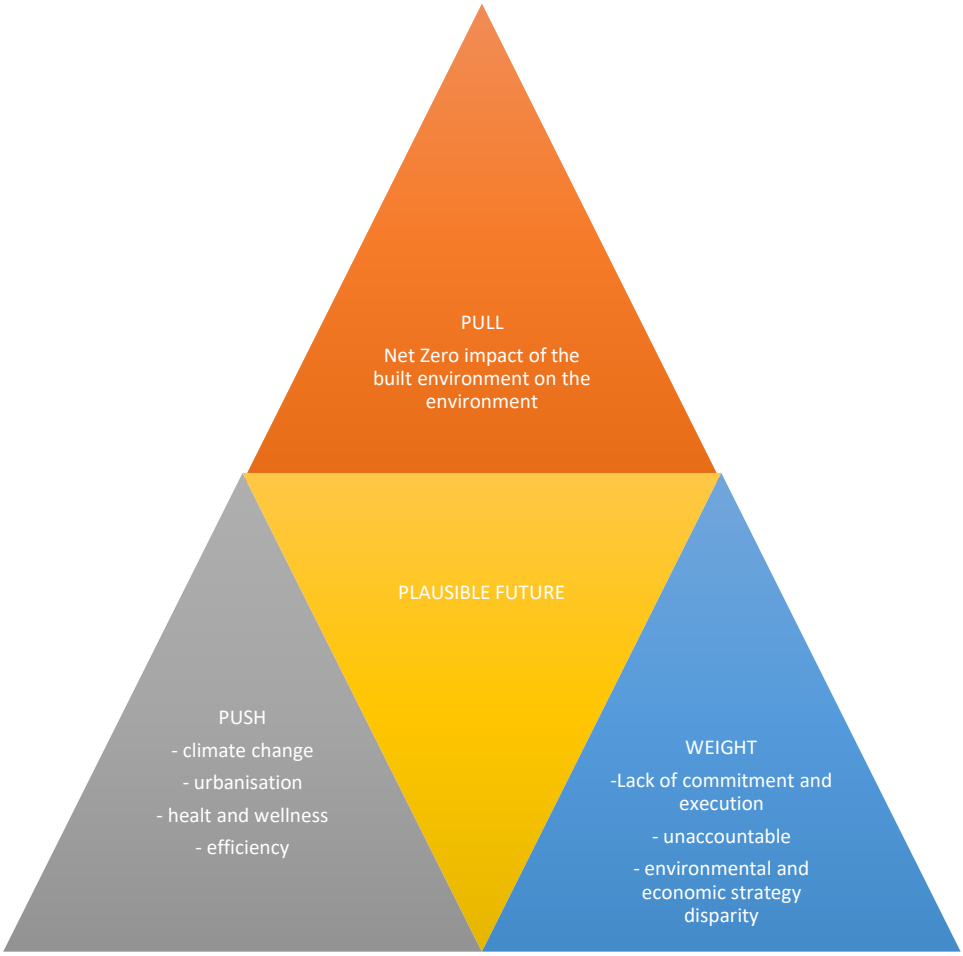

Figure 4.2.4: The Futures Triangle

Source: Adapted from Six pillars: futures thinking for transforming(Inayatullah, 2008a)

4.3 Anticipating the future

As alluded to in Chapter 2, Anticipating the future is the second pillar in the futures studies framework. The analysis of the emerging issues as described in the first pillar is conducted in this pillar. Issues are identified here before it becomes cumbersome, while also looking for new opportunities and possibilities.

The following questions can be:

- Is South Africa's economic initiative in creating labour intensive jobs through infrastructure projects impacting on the future of the built environment?
- Is South Africa's policy effectively implemented in the build environment?
- Is South Africa's RDP built environment countering the policies in the built environment?
- Is South Africa's ICT sector ready to handle the change in the Smart built environment?
- What are the factors that affect South Africa's slow response to the Green economy and Smart environment?

4.4 Timing the future

Timing the future is the third Pillar in the futures framework and identifies each one of the models of change by searching for grand patterns of history.

4.5 Deepening the future

As referred to in Chapter 2, Causal layered analysis is a foundational method that is used to deepen and unpack the future (Inayatullah, 2010). CLA focuses more on exploring the present and the past and creating alternative futures instead of predicting the future (Inayatullah, 2005). As part of the CLA process, the author identified four areas of deepening and highlighted a question under each area to be explored. These areas and questions are formalised below.

4.5.1 Uncertainty if South Africa understands the full potential of incorporating Smart and Green concepts in the built environment or if there is an agenda behind the slow progress of Green technology.

The research highlights the uncertainty, if South Africa understands the full potential of incorporating Smart and Green concepts in the built environment or if there is an agenda behind the slow progress of Green technology. Table 4.5.1 outlines the CLA structure of this question.

Table 4.5.1: CLA: Understanding South Africa's readiness for the Smart Built environment in terms of government support

Level	Concern
Litany layer:	Uncertainty if South Africa understands the full potential of incorporating Smart and Green concepts in the built environment or if there is an agenda behind the slow progress of Green technology.
Systemic level Social science analysis	Eskom holds the monopoly for power generation in South Africa. There is a disparity in the drive for Smart and Green solutions on the different levels of government. South Africa has a fast amount of policy and legislative framework to enable Smart and Green initiatives
Worldview layer structure/discourse	The Green economy should be a collaboration between multiple stakeholders that include government, industry, consumers and innovators. The Green economy has potential that is not being explored by the South African government. Automation in the built environment increases efficiency and quality while reduces cost.
Myth/metaphor analysis	Government holds the key to innovation and can dictate the pace

Source: Authors own construction

4.5.2 Understanding South Africa's readiness for the Smart Built environment in terms of skill, knowledge and infrastructure

The research highlighted an uncertainty if South Africa's has the necessary skills, knowledge and infrastructure for the Green Economy and Smart built environment potential and trajectory.

Table 4.5.2: Understanding South Africa's readiness for the Smart Built environment in terms of skill, knowledge and infrastructure

Level	Concern
Litany layer:	Uncertainty if South Africa's has the necessary skills, knowledge and infrastructure for the Green Economy and Smart built environment potential and trajectory.
Systemic level Social science analysis	South Africa lacks behind the world trajectory. The education system is not creating enough entry-level candidates in ICT and for the built environment in general. The policies and regulations pertaining to the development of skills and infrastructure for the built environment is paramount for this industry but not enforced. Manual labour to increase employment vs technology.
Worldview layer structure/discourse	Policies are in place but drafted in isolation. Government unaccountability business as usual. Inclusivity and transparency need to be adopted.
Myth/metaphor analysis	Keeping the built environment labour intensive would protect the industry from transformation and create jobs

Source: Authors own construction

Table 4.5.1 and Table 4.5.2 above represent the emerging map that is part of the CLA exercise and highlights some of the questions pertaining to the Smart built environment, Green economy and the built environment that the research has brought about.

4.5.3 The **Litany** level

The **Litany** level emphasises the built environment as viewed today. The research had an in-depth look into drivers that are affecting the built environment from a global and South African perspective. Technological drivers have been boldly highlighted as a global driver for change in the built environment. The Smart Build environment is built on the foundation of two fundamental aspects being ICT coupled with IoT and Green technologies. Apart from Technology, the built environment and especially the Smart built environment are also directly impacted by political, environmental, economic, legal and social drivers.

South Africa's infrastructure development is driven by government spent and highly reliant on manual labour to boost employment and is synonymous with the strategies of the South African Government to reduce poverty (South African Association for the Advancement of Science. et al., 2009). These strategies are counterintuitive to enhancing skills levels in South Africa and is also hampering technological transform of the industry.

D. Modise (2018) confirms the sustainable potential impact of Greening buildings. With a close to 20% of the worlds water usage and 40% of the world's electricity usage, the built environment deserves much more attention than it is getting in terms of sustainability. The research highlights the **uncertainty, if South Africa understands the full potential of incorporating Smart and Green concepts in the built environment or if there is an agenda behind the slow progress of Green technology.** The first aspect to contend with is to understand if the South African government has real intentions of adopting Green technologies and if there has been a reduction in demand from consumers. In order to explore this, the South African power generation and regulatory framework will be looked at.

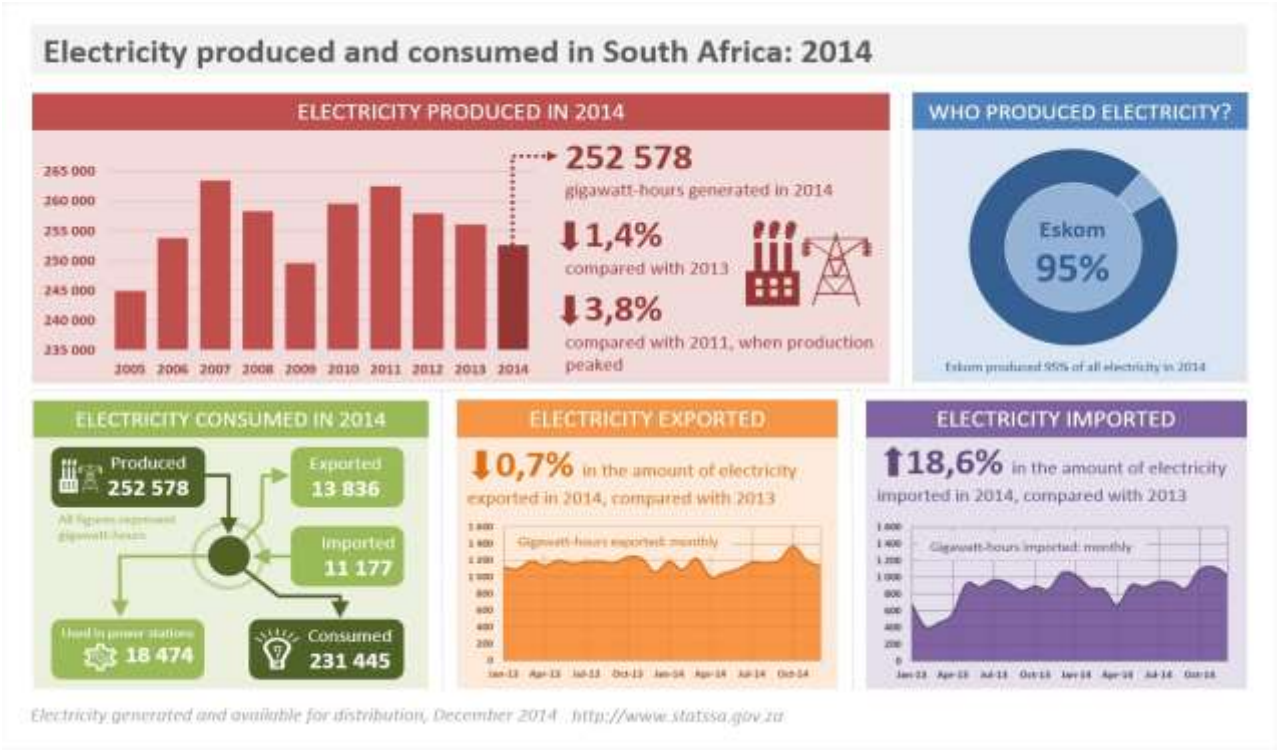

Figure 4.5.1: Electricity produced and consumed in South Africa 2014

Source: Who is South Africa buying electricity from? (Powertime, 2015)

Figure 4.5.1 depicts the extent of power production and consumption in South Africa over a ten-year period. It can clearly be noted that Eskom has the monopoly when it comes to power production in South Africa by contributing to 95% of the total power produced. It can also be noted that power production has seen a decline in recent years.

The National Energy Regulator of South Africa (NERSA) is predominantly responsible for the consideration and issuing of licenses for the operation, transmission, distribution, import as well as export of electricity. Pricing and tariffs are also regulated through NERSA who is further responsible for the issuing of rules to implement the national government's electricity framework, the integrated resource plan and the National Regulatory Act. (NERSA, 2015).

TABLE 4: MEDIUM TERM SYSTEM OUTLOOK FORECASTS (ESKOM MTSAO OCT 2017
Capacity (MW) and Capacity Margins (%) at Annual Peak

Year	National Annual Peak Demand Forecast *	Eskom Installed Capacity incl new build	Import Capacity Firm	Total Eskom Installed Capacity plus Imports	Eskom Purchases non-renewable ***	Renewable Energy capacity	Other Non-Eskom existing capacity	Total Firm Capacity Incl Imports & other & 25% capacity	Demand Response	EE & DSM	Reserve Margin (Excl RE & Other Purchases)	Reserve Margin (Incl Imports, RE & Other Purchases)
	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	%	%
2018	38884	46368	1500	47868		3800	4658	53476	900	110	23.10	37.53
2019	39766	47088	1500	48588		4458	4373	54076	900	130	22.18	35.98
2020	40176	48691	1500	50191		5088	4233	55696	900	130	24.93	38.63
2021	41811	48480	1500	49980		6305	4233	55789	900	130	19.54	33.43
2022	42747	49178	1500	50678		6305	4233	56487	900	130	18.55	32.14

Figure 4.5.2: Medium-term capacity outlook

Source: NERSA, System adequacy outlook (NERSA, 2018)

Figure 4.5.2 illustrates that Eskom will remain the preferred supplier of electricity to South Africa with a marginal increase of renewable energy supplies. This could largely be contributed to the fact that Eskom would lose revenue if individuals are generating their own electricity requirements. Watson (2017) affirms this notion by highlighting the Department of Energy's intent to draft legislation that would force consumers to register their solar generation installations with NERSA. Watson (2017) further comments that the surplus that has been created by the reduction in demand over recent years and the fact that electricity sales is a major income for municipalities is key reasons for governments intervention in consumer off-grid energy generation. STATS SA (2017) presents the degree of income that electricity is contributing to municipalities. It is alarming to note that according to STATS SA (2017), "South Africa's 257 municipalities earned just over a quarter of their total income (R22,5 billion) from selling power in the first quarter of 2017.

With R15,7 billion spent to purchase the electricity from Eskom, municipalities were left with an R7 billion surplus, precious additional money that can be used to fund other municipal activities". What makes matters worse is that municipality income dependency on electricity varies from 27 percent to 97 percent in the case of Greater Kokstad municipality.

The Minister of Energy is driving the commitment to achieve the target of producing 17 800MW renewable energy by 2030 in terms of the Integrated Resources Plan. This equates to close to a third of Eskom's current generation. (IPP Small Projects, 2018) The introduction of independent power producers is a positive contribution to sustainability and would reduce the monopoly that Eskom is currently enjoying. There is a notable inconsistency in the sustainable offerings that municipalities are offering the poor in terms of free off-grid energy supply. According to STATS SA (2018) "The Free Basic Alternative Energy Policy instructs municipalities to select suitable off-grid energy sources, and to provide access to these indigent households". Paraffin, fire gel and candles are the main energy sources that rural areas are focusing on in terms of free off-grid energy. It is encouraging to note that close to 113200 poor households received free solar off-grid energy. What is still concerning is that 86500 poor households rely on free paraffin as off-grid supply, 13700 poor households receive free candles and 19600 poor households receive fire gel as off-grid supply (STATS SA, 2018).

The escalating price of electricity is making the switch to solar and renewable solutions more affordable for consumers (Pearson, 2017). Pearson (2017) further cites Tony Clarke, managing director of Rawson Property Group as highlighting that eco-friendly concepts, as well as solar and PV solutions, are gaining traction. This pushback can also be seen in the demand reduction from Eskom that is indicative that consumers are sourcing alternative solutions and may have also become more conscious of energy usage.

There has been a significant global improvement in the recognition by consumers of the benefits associated with Green initiatives (Petrullo et al., 2017). The improvement for consumer demand, between 2012 and 2015, increased globally from 35 percent to 40 percent. During the same period, it is also noted that Green initiatives triggered by environmental regulations, increase from 23 percent to 35 percent.

The signing of the Paris agreement by the Minister of Environmental Affairs on the 22 April 2016 is indicative of South Africa's acknowledgement of, and commitment to address, the effects of climate change. This agreement is also legally binding and ensures that South Africa and the rest of the participants are held accountable. (A. Modise, 2016). There is substantial evidence in the literature review that indicates that the South African government and South African consumers are well aware of the benefits of Green and Smart initiatives. South African municipalities will need to become less reliant on electricity as an income to enable improved support for Green and Smart initiatives on all levels of government.

The second concern is the **uncertainty if South Africa has the necessary skills, knowledge and infrastructure for the Green Economy and Smart built environment potential and trajectory.** Hertzman (2018) cited the accelerated development of software technology and sensors as the key drivers behind the exponential development of autonomous machines. The users of such machines, such as contractors needs to ensure that they develop their workforce to be able to utilise such machines in their offerings. According to Attia (2018), the architectural domain is entering a different paradigm that is referred to as Regenerative Architecture. This paradigm refers to positive impact creation through buildings that are environmentally effective and sustainable. It is also an improvement on the previous paradigm named Carbon Neutral Architecture that focuses on energy neutral architecture or zero energy targets. What used to be a niche offering transcended into a global driver.

According to Bateson (2017), trends over the next 10 years will be focusing on increasing productivity and enhancing human life. Bateson (2017) further highlights five megatrends that will shape the built environment. These megatrends are IoT, sustainable design and construction processes, the rise of intelligent buildings, built environment resilience as well as health and wellbeing in the built environment. "These megatrends are driven by a combination of technological, environmental and social change. Property professionals, and the property supply chain, will need to make sure that people's needs are at the centre of change"(Bateson, 2017).

As alluded to in the literature review, technology that use to be optional in the past with regards to the construction industry has become a necessity in recent years. Engineers, contractors and competitors need to constantly adapt to these technologies in order to remain competitive. (Ferlaino, 2014).

“Dr Mao Amis, founder and CEO of the African Centre, says: South Africa is at a crossroads, where it needs to either fully embrace a Green economy trajectory - or continue to grapple with the triple challenge of poverty, inequality and environmental degradation” (Amis, Montmasson-Clair, Lugogo, & Benson, 2018).

The South African built environment is one of the sectors that remained unreformed and conventional. The lack of providing a continuous pipeline of skills coupled with the degrading levels of primary, secondary and tertiary education is severely effecting the quality of entry-level skills in general and especially relating to the built environment (Odendaal, 2017). Odendaal (2017) cites a skill pipeline as important for enabling transformation in the built environment. The Council for the Built Environment (CBE) is focusing on the skills pipeline for the sector and is highlighting the need for a backward focus on the school basic education to enhance entry-level candidates.

It is encouraging to note that the Information and Communication Technologies (ICT) panel recognises that the fact that ICT can play a fundamental role in facilitating the objectives of the NDP. The iKamva National e-Skills Institute (iNeSI) will be focusing on developing programs with a specific focus on ICT innovations such as IoT, Big Data and cloud computing the next six years. (The DTPS, 2016)

A development in this area will enable South Africa to be better equipped for the Smart built environment from a skills and knowledge perspective. South Africa’s average broadband speeds falls below the generally perceived average of 10Mbps for households (Moyo, 2018). This will be a major stumbling block for South Africa’s transformation of the Smart built environment. The commitment and successes of South Africa’s four largest cities namely Cape Town, Johannesburg, Tshwane and eThekwini in terms of creating Smart cities is an acknowledgement that South Africa has the ability and appetite to create Smart cities (Z. Cilliers and Euston-Brown, 2018).

4.5.4 The **Systemic** level

The **Systemic** level deals with regulation and policies that enable a conducive environment for transformation and growth of the Smart built environment. As alluded to in the literature review, South Africa does not have a shortage of plans, policies and regulations to drive the

Smart and Green built environment. A key shortcoming is the lack of accountability as well as valuable indicators to show progress or highlight areas requiring development.

The Green Economy strategies and policies as referred to by Stafford et al. (2014) In the literature review, has been around for more than a decade but did not contribute to a significant change in the Green Economy or the holistic economy. The question then arises if policies and strategies are not met, what is the recourse or who is held accountable? Corruption has become synonymous to South Africa and to a certain extent, part of the way things is done. A key enabler for any government sectors to effectively apply improvement and regulative strategies is funding. “The Auditor-General has cited non-compliance with laws and regulations, lack of internal controls, supply chain management transgressions, unauthorised, irregular, fruitless and wasteful expenditure and corruption as some of the key failures of government entities” (GSB.UCT, 2017).

GreenCape (2014) further highlights that although the South African Government adopted a National Framework for Green Building in South Africa as its official policy on Green buildings, it is not a legislative requirement. This could be a fundamental reason for the slow implementations of Green concepts in South Africa.

4.5.5 The Worldview level

Adendorff and Collier (2015, p. 77) cites the disharmonious relations between the national, regional and local spheres of government as having a direct impact on accountability and creating tensions in these spheres. The inability to create constructive relations feeds the lack of coordination of responsibilities and power which leads to government mandates not being met and delivery of services in limbo. South Africa lacks the ability to hold government accountable.

The latest cabinet reshuffle by President Cyril Ramaphosa is bringing about a positive change, by the merger of postal services, Communication and Telecommunication. This change would create a unified approach in these sectors, with regards to policy creation and delivery in the fourth industrial revolution (Mvumvu, 2018). Built environment and infrastructure projects are strategic avenues for government to create jobs and not necessarily prioritising transformation of the sector.

Technological enhancement is generally seen as a way to enhance efficiency and quality that enables economical enhancement but are in conflict with the objectives to create jobs.

4.5.6 The Myth/ Metaphor level

There is a perception that the buck stops with the government and that government determine the technological trajectory of a country. There is also a general uncomfortable association with technology and the destruction of labour. South Africa's built environment has been deliberately formulated around labour-intensive technologies. This is a South African government initiative that is aimed at decreasing unemployment. A masonry house, for example, could provide fifty percent more jobs than that of a precast house that utilises different technologies (cidb, 2005). These beliefs create tunnel vision and do not allow for the exploration into new technologies that would assist with the housing backlog to the poor. Chinese companies introduced 3D technologies successfully, that enables solutions for the poor and lower end markets. If new technologies are explored, more South Africans will be able to live dignified lives in houses instead of shacks.

4.6 Creating alternatives

There are two fundamental methods in creating alternatives. Firstly, the structural-functional analysis of the organisation and finding alternatives for the same. The second being creating alternative futures by creating scenarios (Inayatullah, 2008b). Scenario planning will be utilised in the study to create possible futures for the South African Smart built environment towards 2035.

4.6.1 Scenario planning

Godet and Roubelat (1996b) define a scenario as "a description of a future situation and the course of events which allows one to move forward from the original situation to the future situation".

4.6.1.1 Environmental Analysis

Table 4.4.6.1 below, represents a summary of the PESTLE analysis that was conducted as part of the literature review in Chapter 3.

Table 4.4.6.1: represents a summary of the PESTLE analysis that was conducted as part of the literature review in chapter 3.

External environment	South Africa	Industry
Economic	• Sluggish economic growth and Economic instability • Demand for low-cost housing increases with population increase • Green economy investment and exploration	• Economic instability will result in decreased spending or consumers looking for alternatives. • The demand for low-cost housing could change the built environment by exploring new cost-effective solutions • Green economy investment: could create new skills, generate income and combat the effects of the built environment on climate change
Political	• National development plan • Mismanagement of state-owned enterprises • Uncertain political future • Corruption • Strategies of government departments clashing e.g. energy and environmental • Global political pressure to comply with climate change objectives (Paris agreement) • Green economy strategy	• NPD - Drives the agenda for sustainability in the built environment • Decreased spending on infrastructure • Cost for built environment diverted for own use – slowing down infrastructure projects • Delay or prevent sustainable projects to be implemented • Drives the Green economy and innovation in the built environment • Impact is severe if unstable politic influence interferes with business strategy

		• Greatest employment and enables innovation in the built environment
Technology	• IoT • Robotics • Artificial intelligence • 3D printing • Automated brick laying machines • New building concepts and materials e.g. light steel frames • Big data information systems • Smart material • Smart sensors	• IoT is a key enabler of the Smart built environment – improves efficiency, creates jobs • Robotics - Increases quality, delivery, efficiency • Enables autonomy • 3D Improves flexibility, efficiency, delivery • Increased delivery, efficient material use • Big Data - Enables autonomy by create trends and analysis • Improves energy efficiency of buildings • Enables buildings to be "Smart"
Social	• Increasing population • High unemployment • Losing scares skills to emigration – brain drain • Increasing middle class • Urbanisation	• Increase housing requirements • Increased RDP housing • Making the industry labour intensive and uncompetitive • Modern building requirements with increased futures • Urban housing requirements increase
Legal	• Paris agreement • Green regulative requirements	• Increased innovation in the built environment • Enforcing Green concepts in buildings
Environment	• Environmental sensitivity awareness	• Increased awareness and innovation in the built environment

	• Reduction of waste and reduced impact on the environment.	

Source: Author's own construction

4.6.1.2 South African Industry Scenario (Smart and Green built environment)

In Figure 4.6.1 below, the drivers and uncertainties in the Smart built environment is mapped on two axes to establish those that represent a high uncertainty and high impact on the Smart built environment. The two critical uncertainties that has been identified is the political (governance) uncertainty and the technological uncertainty.

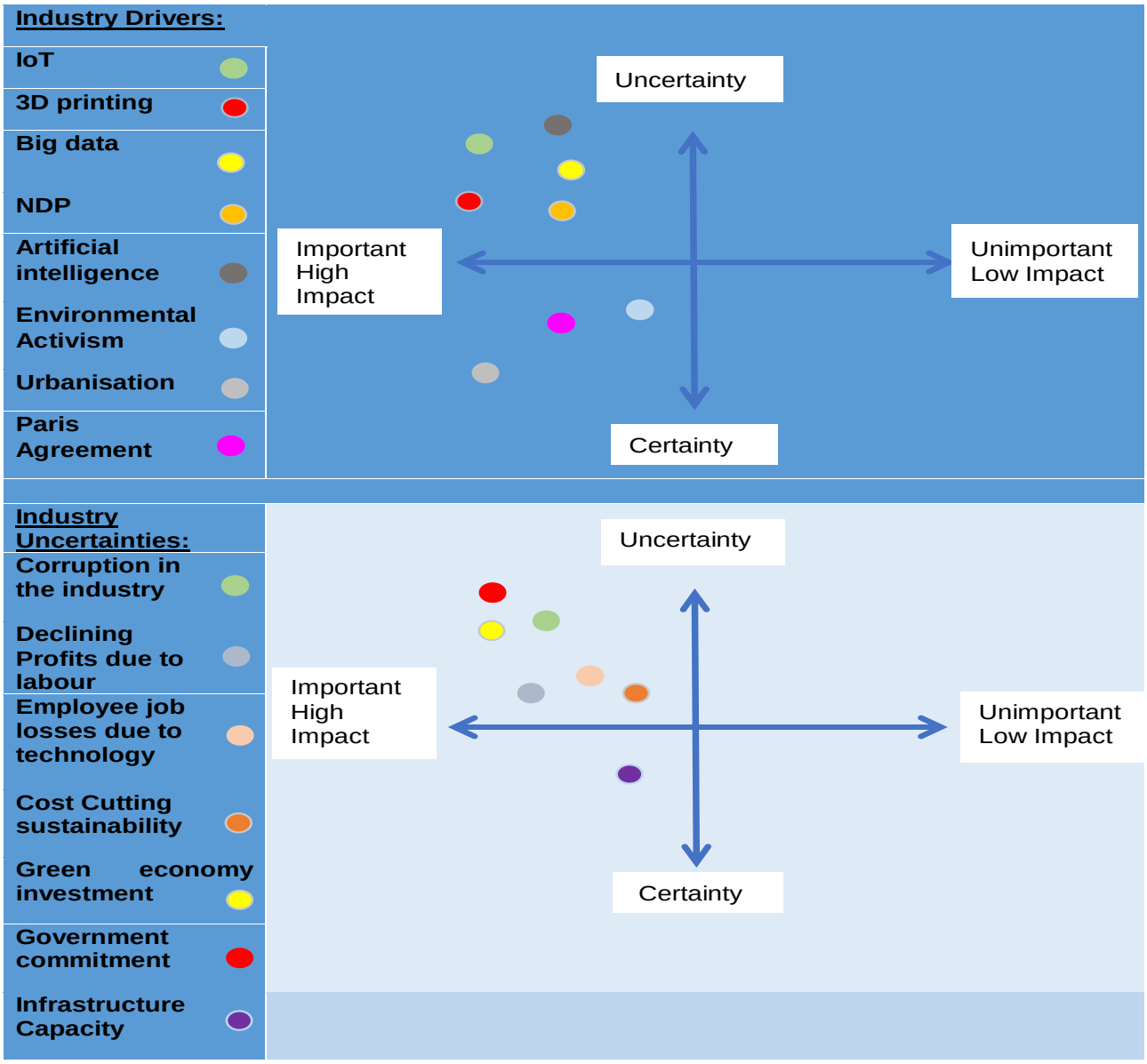

Figure 4.6.1: 2 X 2 matrix applied to built environment drivers and uncertainties

Source: Authors own construction

4.6.1.3 Scenarios

Figure 4.6.2 below, represents four scenarios that are constructed by following the 2 X 2 scenario matrix. The matrix was constructed by applying the two critical uncertainties to the matrix in order to create alternative futures for the South African Smart built environment towards 2035. The two critical uncertainties, that has been highlighted by the industry drivers and uncertainties, is political (governance) uncertainty and technological uncertainty. These uncertainties were applied by opposing views over two axes. **"Accountable inclusive governance"** represent the political uncertainty where the government includes all stakeholders, for example, industry, institutes, citizens and professionals to work together in resolving issues. **"Arrogant governance"** represents the political uncertainty where the government is afforded free reign, does not listen to South Africa's and are not held accountable for any wrongdoing. **"Embrace technology"** is when technology is accepted to contribute to society and innovation is encouraged. "**Technological ignorance"** represents the uncertainty where technology is shunned while there are clear drivers for technology. The four possible futures are named, "Smart future"; "Cast Away"; "Terminator" and "Status quo".

Figure 4.6.2: 2 X 2 Scenario matrix of Political (Governance) vs Technology

Source: Authors own interpretation of the 2 X 2 matrix

Table 4.6.2 below, summarizes the four scenarios constructed in Figure 4.6.2: 2 X 2 Scenario matrix of Political (Governance) vs Technology above.

Table 4.6.2: Summary of four future scenarios for the Smart built environment towards 2035

Scenario		Key Features and assumptions
1	Smart future	This future depicts the preferred future for the South African Smart built environment towards 2035. It is realised by a collaboration between government, industry, society and institutions who embraces technology. In this scenario, technology is used to contribute to the needs of the occupants of buildings, by the application, of predictive technologies, for efficiency of resources and occupants.
2	Cast Away	This future scenario represents the staling of technological implementation that leads to South Africa being left behind and become irrelevant in the global market. The government is advocating a state where technology is not required.
3	Terminator	In this future scenario, technology advancement is ignored to an extend that technology surpasses human intellect and dictates the norm. The government is not playing an active role in providing direction and control although advances in technology is rapidly dictating the ways things are done.
4	Status quo	This future is a resemblance of the current state where there is no coherence in decisions that are made in the South African built environment with regards to technology. A prime example is the ignorance of government not to listen to professionals regarding the trains that was to tall for the long-distance lines in South Africa (Myburg, 2015).

Source: Authors own construction

4.7 Transforming

South Africa made positive progress towards sustainability. The unification of the postal, communication and telecommunication ministries, is conducive to develop the ICT and IoT requirements for the Smart built environment. In order to reach the preferred future, questions will need to be asked about the decisions that needs to be made now. Some of these questions are:

- What needs to be done now in terms of infrastructure to achieve the preferred future goals?
- Who should be involved in structuring the pathway to the preferred future and what roles should be played by the participants?
- What decisions need to be made to ensure that the effects of technological advancement can be mitigated?

The realisation of the preferred future rest on the acceptance, by all South Africans, that technological advancement is inevitable, and that a joint and inclusive effort should be made to prepare for such a future. South Africa has the ability and appetite to change the future for the better. Two fundamental areas of improvement are to create a united South Africa where people are held accountable for their actions. The unions should transcend across the various South African government departments but must also include industry, entrepreneurs and the public to create a future where technology is embraced, and innovation encouraged, instead of waiting for technology to dictate a specific future.

4.8 Conclusion

Chapter 4 aimed at presenting scenarios of possible futures towards 2035. The Smart built environment is not unknown in South Africa but has not received the desired attention to enable a growth trajectory in line with the key global countries. There are various hindrances that is negatively affecting South Africa to become a leader in innovation. This chapter highlights the importance of the acceptance, by all South Africans, that technological advancement is inevitable, and that a joint and inclusive effort should be made to prepare for such a future. The following chapter will be focusing on reflecting on the study, providing recommendations, addressing the research problem statement and provide future research opportunities.

CHAPTER 5

RECOMMENDATION AND CONCLUSION

5.1 Introduction

The previous chapters focused on studying South Africa's readiness of the Smart Built environment towards 2035. Chapter 4 focused on the application of the six pillars approach of future studies and specific application of causal layered analysis to deepen the future. Scenario planning was further applied to create alternatives. This chapter will be dedicated to addressing the problem statement as well as the research questions and objectives. Further attempts would be to make recommendations that could be utilised by government, policy makers, academic and training institutions and business leaders. The chapter will be concluded by looking at future research opportunities.

5.2 Reflections

The environmental degradation is significantly impacted by the built environment during construction, operation and deconstruction. These impacts is approximated at consuming 40% of the world's energy, 15% of the worlds fresh water resources and produces 23 to 40% of the worlds Greenhouse gas emissions (Gunnell, 2009).

South Africa boasts about the achievements of the four major municipalities namely, Cape Town, Johannesburg, Tshwane and eThekwini in terms of their commitment towards the aim for net zero carbon emissions of newly built buildings by 2050. The commitment for sustainable solutions in all sectors is echoed by the Minister of Environmental Affairs, as part of the Paris agreement. South Africa does not lack the ability to plan for eventualities. This is evident by the myriad of strategies and policies that can be found all over the government information sharing outlets. The South African government is failing in implementing these policies and strategies that have been around for more than a decade. A lack of execution, lack of transparency as well as a lack of accountability is a hindrance to South Africa's general growth path. A unified approach, within government, as well as the inclusivity of industry and innovators, is crucial to successfully combat the effects on climate change.

“The Auditor-General has cited non-compliance with laws and regulations, lack of internal controls, supply chain management transgressions, unauthorised, irregular, fruitless and wasteful expenditure and corruption as some of the key failures of government entities” (GSB.UCT, 2017). A key finding of the study is that there needs to be a realisation that technological change is inevitable and that there needs to be a unified approach to tackle the challenges and look for solutions, before it is too late and South Africans must then accept the fate of the impact of technology and being left behind while the world is following the trajectory.

5.3 Strategic issues

A comprehensive literature review in conjunction with the application of the six pillars approach to future studies highlighted the need for strategic intervention into the South African built environment. Strategic concerns that were highlighted is amongst others:

- How to create a unison approach to enable the preferred future for the South African built environment towards 2035.
- How to cultivate innovation and education as an enabler for economic development in South Africa.
- How to develop Green and Smart technologies, in South Africa, to enhance the RDP built environment, to increase delivery of houses and reduce the effects that the built environment has on climate change.
- How to create indicators that would provide insight on the holistic effect of implemented projects in the South African Green and Smart built environment.
- How South Africa can benefit from the Green economy.

5.4 Recommendations

The following recommendations are presented of the backdrop of the drivers of change, causal layered analysis findings and the scenarios that has been presented in the study.

5.4.1 To cultivate innovation and education in South Africa, to enable innovative growth in the Smart built environment.

As alluded to in the literature review, Maths and Science is imperative in technological advancement. South Africa should therefore seriously reconsider the matric pass

requirements and improve the education standards at all levels of education. Education must be seen as an enabler for economic growth and not regarded as an expense. South Korea made a remarkable turnaround from being a labour-intensive economy to be a leader in innovation and technological advancement.

South Africa will need to move into the digital age by equipping teachers, at all levels of education, with the tools and skills to educate learners by means of technology. “The steep increase in the use of digital devices and the Internet with increasing levels of education shows that education matters in the uptake of digital technologies. This has huge implications for the role of education systems in equipping individuals with the skills they need to benefit from new technology” (OECD, 2016, p. 9).

5.4.2 Creating indicators that provides for a holistic view on the successes and failures of initiatives in the Green and Smart built environments in South Africa.

To provide transparency and present the actual benefits of the Green and Smart initiatives in South Africa, it would be ideal for the government to collaborate with industry, suppliers and consumers, to create indicators for initiatives that transcends the normal cost or purely economic impacts of such initiatives.

5.4.3 Improving the delivery of RDP housing while improving the impact on the environment in South Africa.

The South African government provided more than 3 million housing units to the poor and low-income households between 1994 and 2015. The housing backlog is in excess of 2.1 million units. South Africa’s informal settlements are in excess of 2225 (Jeffery, 2015). With an increasing population, South Africa will forever chase its tail in order to satisfy the housing needs of the unemployed. It is, therefore, fitting for South Africa to be open to new technology in the RDP built environment with an emphasis on improved delivery and net-zero impact on the environment.

The literature review provided remarkable evidence of the utilisation of 3D and other technologies in China, America and other countries, that can provide an improved delivery and reduce the environmental impact of the built environment. There is also an opportunity to collaborate with industry, universities and society, to develop Smart technologies for lower

entry-level housing to enable transparency and valuable insight and controls of such projects.

5.4.4 Improved municipal offerings in South Africa, that affect job creation, improve skills and combat the depletion of natural resources.

There is an opportunity to create municipal solutions that can be actioned by entrepreneurs and innovators, in collaboration with the South African government, education institutions and society. The provision of water and electricity to housing is part of the basic requirements in South Africa. If the basic offerings are extended to water tanks and basic solar systems, long-term benefit could be derived that would make the South African citizens less reliant on the government. Sustainability and efficient use of resources can be encouraged by introducing greywater systems as a basic requirement for households. This could also be enforced by regulative requirements for any household.

5.5 Addressing the problem statement and contribution and relevance of the study

The problem statement was addressed by undertaking a comprehensive literature review in chapter 3 followed by the application of the six pillars approach in chapter 4. On this backdrop, recommendations were formulated.

Answering the research questions:

I. What are the global drivers for change?

The literature review in Chapter 3, successfully highlighted the drivers for change in the Smart built environment, by adopting a PESTLE analysis of the macro environment.

II. How does South Africa's build environment compare to developed countries?

As alluded to in the literature review, South Africa has the ability and appetite to successfully implement Smart and Green solutions. Further evidence is provided by the initiatives of the four major municipalities in South Africa namely; Cape Town, Johannesburg, Tshwane and eThekwini who has committed to reach net-zero carbon emissions, aimed at new buildings by 2055.

III. How does Smart buildings incorporate into “Green” or “eco” buildings?

Smart buildings fall within the eco and Green ambit by providing solutions of efficient use of resources. Answers to this question was successfully pursued in the literature review in Chapter 3.

IV. What are the critical technologies that influence the global build industry at present?

The literature review in Chapter 3, highlighted 3D printing, robotics, IoT, broadband and big data interpretation systems as amongst the critical technologies that are changing the global built industry.

V. How is South Africa leveraging from these technologies?

The literature review in Chapter 3 provided some insight into new technologies that are currently deployed in the South African built environment. Chapter 3 and 4 provides some insight as to why there might be slow progress in the South African built environment, with regards to technological advancement.

VI. What are the innovative developments that challenge the industry going forward?

Chapter 3 and 4 highlights the shift to new buildings concepts that adopted new materials and technologies and the incorporation of IoT to enhance the occupant experience in the built environment.

VII. What do these developments mean for South Africa and the various stakeholders?

A key factor that has been highlighted in the literature review in chapter 3 and the application of CLA in chapter 4, is that technological advancement is inevitable and needs to be faced through a collaboration of the South African government, industry, innovators and society in general.

VIII. What are the future skills required for the Smart build environment and the effects of the jobs on the current industry?

The skills issue was explored in chapter 3 and 4 and further emphasised in the recommendations in chapter 5.

IX. What recommendations can be offered to the government, policy-makers, training and academic institutions?

Recommendations are addressed in chapter 5 and opportunities for further research are also highlighted. It can thus be concluded that the research objectives of the research were met.

5.6 Strength and weaknesses of the research

The literature review provided an in-depth look into Global successes and innovations in the built environment. The research provided a link between a technologically stagnant built environment, a slow-growing Green economy and the government's strategic intentions to protect ESKOM and keep the built environment labour intensive. Although the literature review was comprehensive, it did not expose the impact of the RDP housing on the built environment and opportunities that could be explored in this environment. The research would also have benefited more from an in-depth study on the offset of Green economy opportunities vs job losses associated with technological advancement.

5.7 Conclusion and future research opportunities

The study was conducted on the premise that the built environment is a major contributor to the depletion of natural resources globally and that the global built environment is adopting new technologies that is revolutionising the industry.

South Africa is a developing country and with the increase in the population as well as unemployment, South Africa’s need to support the citizens with housing is increasing. The preceding chapters embodied the aim of the study by providing the methodology of the study; a comprehensive literature review; followed by the application of the six pillars approach to future studies. Chapter 5 provided recommendations that could be utilised by government, policy makers, academic and training institutions and business leaders.

The Smart built environment research scope is infinite and there is a myriad of questions that still need to be answered. It would be ideal if future research could expand on the role that Smart buildings play in the Smart built environment. It would also be fitting to research

the establishment of Smart and Green buildings that would suit the different LSM levels but have a great sustainable impact.

Although some of the research opportunities has been mentioned as recommendations to decision makers, future research could provide a better understanding and solutions to these recommendations. Future research could provide possible solutions to leverage South Africa's manufacturing industry capability to create modular home solutions that can be applied locally as well as create export opportunities. Future researches could focus on the risks associated with Smart buildings and possibilities of elevating these risks. South Africa has the possibility of introducing Smart and Green technologies as part of its municipal offerings as a standard offering, part of the RDP programs. This is a further possibility of future research that could research the need and feasibility of such initiatives.

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CHAPTER 1: INTRODUCTION, PROBLEM STATEMENT AND CONCEPTUAL FRAMEWORK

1.1 Introduction

SOUTH AFRICA's READINESS OF THE SMART BUILT ENVIRONMENT TOWARDS 2035

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NAME: CLINTON KEITH HOLMES

STUDENT NUMBER: 206043510

QUALIFICATION: MBA

TITLE OF PROJECT:

SOUTH AFRICA'S READINESS OF THE SMART BUILT ENVIRONMENT TOWARDS 2035

DECLARATION:

In accordance with Rule G5.6.3, I hereby declare that the above-mentioned treatise/ dissertation/ thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

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I, (surname and initials of supervisor) C. Adendorff

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(student number) 20609 3510

a candidate for the degree of MASTERS IN BUSINESS ADMINISTRATION

with a treatise/dissertation/thesis entitled (full title of treatise/dissertation/thesis):

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considered the following ethics criteria *(please tick the appropriate block):*

	YES	NO
1. Is there any risk of harm, embarrassment of offence, however slight or temporary, to the participant, third parties or to the communities at large?		X
2. Is the study based on a research population defined as 'vulnerable' in terms of age, physical characteristics and/or disease status?		X
2.1 Are subjects/participants/respondents of your study:		
(a) Children under the age of 18?		X
(b) NMMU staff?		X
(c) NMMU students?		X
(d) The elderly/persons over the age of 60?		X
(e) A sample from an institution (e.g. hospital/school)?		X

(f) Handicapped (e.g. mentally or physically)?		
3. Does the data that will be collected require consent of an institutional authority for this study? (An institutional authority refers to an organisation that is established by government to protect vulnerable people)		X
3.1 Are you intending to access participant data from an existing, stored repository (e.g. school, institutional or university records)?		X
4. Will the participant's privacy, anonymity or confidentiality be compromised?		X
4.1 Are you administering a questionnaire/survey that:		X
(a) Collects sensitive/identifiable data from participants?		X
(b) Does not guarantee the anonymity of the participant?		X
(c) Does not guarantee the confidentiality of the participant and the data?		X
(d) Will offer an incentive to respondents to participate, i.e. a lucky draw or any other prize?		X
(e) Will create doubt whether sample control measures are in place?		X
(f) Will be distributed electronically via email (and requesting an email response)? Note: • If your questionnaire **DOES NOT** request respondents' identification, is distributed electronically and you request respondents to return it *manually* (print out and deliver/mail); **AND** respondent anonymity can be guaranteed, your answer will be NO. • If your questionnaire **DOES NOT** request respondents' identification, is *distributed via an email link and works through a web response system (e.g. the university survey system);* ***AND*** respondent anonymity can be guaranteed, your answer will be NO.		

Please note that if ANY of the questions above have been answered in the affirmative (YES) the student will need to complete the full ethics clearance form (REC-H application) and submit it with the relevant documentation to the Faculty REC-H (Ethics) representative.

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SUPERVISOR(S)	18 April 2018 **DATE**
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STUDENT(S)	09.04.2018 **DATE**

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PERMISSION TO SUBMIT A TREATISE/DISSERTATION/THESIS FOR EXAMINATION

NAME: CLINTON HOLMES

STUDENT NUMBER: 206043510 candidate for the

DEGREE: MBA in the

FACULTY: BUSINESS AND ECONOMIC SCIENCE **SCHOOL/DEPARTMENT:** NMU BUSINESS SCHOOL

has today submitted his/her treatise/dissertation/thesis for examination.

1. Has this treatise/dissertation/thesis been submitted with your knowledge and support?

YES ✓	NO

(Please tick the appropriate response clearly)

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A. Permission Granted for submission for examination	✓
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C. Submission against advice of Supervisor	

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(Please tick the appropriate response clearly)

1

If YES, has clearance been obtained from the relevant Ethics Committee?

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(Please tick the appropriate response clearly) If YES, *kindly provide ethics clearance reference number)*

Name of supervisor: Prof Chris Adendorff

Signature:

Date: 04.12.2018

Name of Co-supervisor: _____

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