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# The usefulness of planning support systems (PSS) to foster future spatial planning post-1994: a case of city of Ekurhuleni and Johannesburg

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# THE USEFULNESS OF PLANNING SUPPORT SYSTEMS (PSS) TO FOSTER FUTURE SPATIAL PLANNING POST-1994: A CASE OF CITY OF EKURHULENI AND JOHANNESBURG

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A research report **s**ubmitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in partial fulfilment/fulfilment of the requirements for the degree of Master of the Built Environment (Housing).

*21 December 2022*

**DECLARATION**

I Baleseng Tlholohelo Mokoena declare that this Research Report is my own, unaided work.

It is being submitted for the degree of Master of the Built Environment (Housing) at the University of the Witwatersrand, Johannesburg.

It has not been submitted before for any degree or examination at any other University.



(Signature of candidate)

21 day of December 20 22 in Johannesburg

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Abstract

South Africa has had  a history of apartheid planning which segregated space and people according to race. Therefore, since democracy began, policies have been created which have sought new ways of planning through integrated and sustainable development, by placing people, especially the poor, in well-located areas.

The responsibility placed on policy makers and urban planners post 1994, is however cumbersome and requires a lot of decision making often at all levels. As a result of this, there has been an upsurge in the recent use of technology to create smart cities. This research therefore seeks to explore the usefulness of Planning Support Systems to foster future spatial planning in South Africa by making use of empirical research methods. The results indicate that the biggest challenges in Local Government are a lack of finances, lack of capacity, lack of skill and lastly political will to implement newer and smarter ways of urban planning.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| AHP | Analytical Hierarchy Process |
| CoE | City of Ekurhuleni |
| CoJ | City of Johannesburg |
| CUPUM | Computers in Urban Planning and Urban Management |
| DA | Disseminated Area |
| DEMATEL | Decision Making Trial and Evaluation Laboratory |
| DMTI | Digital Multi Track Interface |
| DSM | Decision Support Model |
| EBDM | Evidence Based Decision Making |
| ELECTRE | Elimination and Choice Expression Reality |
| ESDP | European Spatial Development Perspective |
| EU | European Union |
| GAHP | Group Analytical Hierarchy process |
| GIS | Geographic Information Systems |
| GIScience | Geographic Information Science |

| | |
|---|---|
| GIS-MCDA | Geographic Information Science and Multi-Criteria Decision Analysis |
| LED | Local Economic Development |
| MCDA | Multi Criteria Decision Analysis |
| NDP | National Development Plan |
| PSS | Planning Support Systems |
| RPDM | Recognition Primed Decision Making Theory |
| SAFAD | Swedish Agency for Administrative Development |
| SDP | Site Development Plans |
| SPLUMA | Spatial Planning and Land Use Management Act |
| SULPi | Smart Urban Land & Property Index |
| WLC | weighted linear combination |
| WLC | Weighted Linear Combination |
| WLLI | Well-Located Land Index |
| WSM | Weighted Sum Model |

*This approach to the colonial world, its ordering and its geographical lay-out will allow us to mark out the lines on which a decolonized society will be reorganized*

*(Fanon, 1961; 29)*

CHAPTER 1: INTRODUCTION

## 1.1 Introduction

The use of the Planning Support Systems (PSS) term has been in existence since the 1980s (Pelzer, et al, 2014). It has been developed by researchers to assist Urban and Regional Planners in executing increasingly intricate duties of developing and managing neighbourhoods, cities and regions (te Brömmelstroet, 2010; Geertman et al., 2017). Such Planning Support Systems are defined as a unit of computer-based instruments (te Brömmelstroet, 2013). Such development of Planning Support Systems has made it easier for urban practitioners to analyse data as they are collected and to confront decision making tasks with more efficiency and flexibility (Geertman, and Stillwell, 2004; Pelzer, 2014). This means that Evidence Based Decisions can be made (Faludi and Waterhout, 2006). According to Geertman (2008; 217) cited in Pelzer et al. (2014), Planning Support Systems can also be defined as an incorporation of a group of components collectively supporting unique parts of professional planning tasks, based on geo-information technology instruments.

PSS has consequently assisted urban planners to engage in more Evidence Based Decision Making (EBDM) and scientific judgments (Faludi and Waterhout, 2006). This is based on the collection and use of valid and reliable data to allow for more knowledgeable judgments or decision making (Faludi and Waterhout, 2006; Barton & Harphan, 2010). EBDM is also described by scholars as applying more objective rather than subjective decision making (Faludi and Waterhout, 2006; Barton & Harphan, 2010; der Heide, 2006; Krizek, Forsyth, and Slotterback, 2009).

Additionally, Evidence-Based Planning (EBP) means simply being able to provide scientific evidence to solve a problem so that solutions may be found (Barton & Harphan, 2010). This type of planning avoids the process of deciding mere opinions and poor judgment through collecting and analysing data about a problem (Barton & Harphan, 2010). For example, Barton and Harphan (2010) also state that policymaking has become more reliant on evidence-based

planning to allow for more informed and quality decision making. Following this method of planning instils a lot more confidence in both the practitioners and the public. Often it also provides more professional political decision making and increases public trust among the citizens (Barton & Harphan, 2010). Evidence-Based Planning from a political perspective also has the advantage of increasing service delivery by providing, amongst other things, accurate, reliable and up to date information (Barton and Harpham, 2010).

As cities are moving towards being smart, they are increasingly informed by evidence-based planning. Furthermore, with all the information that currently exists about cities, Planning Support Systems are foreseen to become even more successful. Additionally, large quantities of information Planning Support Systems will channel information to be of use for decision making.

Methods like the Multi Criteria Decision Analysis[1] (MCDA) can assist urban practitioners find the best suitable land for housing development or the best land uses for specific activities in the City (Mokoena, Musakwa and Moyo, 2017). The Multi-Criteria Decision Method (MCDM) makes use of numerical techniques to assist in choosing between a discrete set of alternative choices (Triantaphyllou, 2000; Velasquez and Hester, 2013).Furthermore, the Weighted Sum Model (WSM[2]) is the most widely used technique for best decision making practice. The Analytical Hierarchy Process (AHP) is also one of the methods used in Multi Criteria Decision Analysis (MCDA) (Fong and Choi, 2000; Velasquez and Hester, 2013). It was developed by Thomas L. Saaty (1980) and still remains well known (Fong and Choi, 2000; Velasquez and Hester, 2013). This method is designed to quantify relative weights on a ratio scale of a given set of criteria (Akarte et al., 2001). What differentiates the AHP from other methods is that during the decision making process it provides a comprehensive structure for combining instinctive, irrational and rational values. It also checks consistency in the decision making process (Akarte et al., 2001).

[1] Also known as Multi Criteria Decision Method (MCDM)

[2] The Weighted Sum Model (WSM) can be described as the adding together of criterion values for every alternative and applying the individual criterion weights (Mulliner, Malys and Maliene, 2016).

In any decision making technique that requires numerical analysis of alternatives, there are three steps that are taken (Velasquez and Hester, 2013). The first is to determine the relevant alternatives and criteria; the second is to assign a numerical measure to the relative impact of alternatives on the criteria as well as the importance of the criteria (Velasquez and Hester, 2013). The third step is to determine a ranking of each alternative by processing their numerical values (Velasquez and Hester, 2013). The Weighted Sum Model (WSM) is the most frequently used method for single dimensional problems (Velasquez and Hester, 2013; Handoko et al., 2017). Alternatively, the Decision Support Model (DSM) uses methods such as the Preference Selection Index[3] and ELECTRE[4] to operationalise the decision making process (Handoko et al., 2017)[5].

In South Africa, since 1994, when a democratic government was established, the planning of neighbourhoods, cities, and regions shifted to focus on redressing past spatial injustices Spatial inequality in South Africa was developed in such a way that low income persons lived far from economic activity which meant that black people travelled longer distances to work

---

[3] The Preference Selection Index (PSI), according to Attri and Grover (2015), was developed to solve Multi-Criteria Decision Making (MCDM) problems and was first developed by Maniya and Bhatt (2010). The purpose of this method is not to assign a relative importance between attributes or to compute weights of the attributes involved in decision making, but to resolve conflict by deciding on the relative importance of selected attributes (Akyüz, 2015; Sawant, Mohite and Patil, 2011; Attri and Grover, 2015).

[4] The Elimination Et Choix Tradusant la Realité [Elimination and Choice Expression Reality] (ELECTRE) method is a Multi-Criteria decision analysis that first originated in Europe in the mid-1960s. It was developed by consultants led by Bernard Roy who were invited to work on multiple criteria and real world problems of new activities, after encountering problem the Weighted Sum technique. The ELECTRE was used to solve three main decision problems choosing, sorting and ranking. According to Agrebi, Abed and Omri, (2017), the advantage of using this method is to incorporate the decision maker's preference into the decision making process, and additionally, it considers both quantitative and qualitative criteria (Akyüz, 2015; Sawant et al. 2011; Attri and Grover, 2015).

[5] The following expression is used to calculate best alternatives.

> If there are *m* alternatives and *n* criteria then, the best alternative is that one that satisfies (in the maximization case), the following communication is made (Velasquez and Hester, 2013; 6)
>
> $A^*_{WSM-score} = max_i \sum_{j=1}^{n} a_{ij} w_{j'}$ for i=1,2,3, …, *m*. (2-1)

Where: $A^*_{WSM-score}$ is the WSM score of the best alternative, *n* is the number of decision criteria, $a_{ij}$ is the value of the *i=th* alternative in terms of the *j=th* criteria, and $W_j$ is the weight of importance of the *j=th* criterion (Velasquez and Hester, 2013; 6; Handoko et al, 2017;6).

opportunities (Harrison, et al., 2008). This promoted urban sprawl which has proven to be unsustainable from an environmental, economic and social perspective, because of the amount of land used for various activities in a city (Squires, 2002; Hasse and Lathrop, 2003). Urban sprawl is attributed to urban growth and low density development (Hasee and Lathrop, 2003). However, the per capita consumption of land in an urban sprawl model is an inefficient way of designing and managing cities (Hasse, and Lathrop, 2003). One of the reasons is that more energy sources such fossil fuels are used to transport people from one place to another; the second reason is that cities use more financial resources to render various services over a large foot print (Hasee and Lathrop, 2003; Van Metre, Mahler and Furlong, 2000; Brueckner, Mills, and Kremer, 2001). Additionally it is often seen that more agricultural land is encroached upon and more environmental resources are compromised such as wetlands (Hasee and Lathrop, 2003; Van Metre et al., 2000; Brueckner, Mills, and Kremer, 2001; Carruthers, and Ulfarsson, 2003).

Furthermore, the apartheid model unsustainably grouped people according to race and placed the poor on the periphery, which caused segregated spaces that created social injustice (Beall, Crankshaw and Parnell, 2014). As Fanon (1961) rightly depicts,

> "The colonial world is a world divided into compartments… Yet, if we examine closely this system of compartments, we will at least be able to reveal the lines of force it implies. This approach to the colonial world, its ordering and its geographical lay-out will allow us to mark out the lines on which a decolonized society will be reorganised" (Fanon, 1961; 29).

Unfortunately, this unstainable form of planning exists even today, and even though apartheid may be over, the design of the apartheid city still remains (Mignolo, 2007; 2012; Ndlovu-Gatsheni, 2013; Maldonado-Torres, 2007; Dubow, 2014; Harrison, Todes & Watson, 2008). This would mean that the spatial quality of some spaces is still unequal and does not allow low income persons to fully experience a better quality of life (Møller, 1998; Harrison, Todes & Watson, 2008). In order to resolve some of these issues, several policy documents and legislation were developed over the years such as the National Development Plan (NDP) 2030 and the Spatial Planning and Land Use Management Act (SPLUMA) No.16 of 2013. From a Local Government perspective, planning instruments such as the Land Use Scheme are applied to govern land use in South Africa. Both the Cities of Ekurhuleni and Johannesburg have new Land Use Schemes that they have incorporated and no longer use the old Town Planning

Ordinance of 1986. Further to that, instruments such as the Municipal Spatial Development Framework are used to guide development from a regional perspective.

## 1.2 Problem Statement

The spatial form of South Africa has significantly been distorted because of the historical agenda of segregating communities according to race. The forced removal of Black communities to reconFigure the space using legislature such as the Group Areas Act of 1950 and different pass laws were used to perpetuate apartheid planning (Mokoena, Musakwa and Moyo, 2017). This thereby created zones of 'beings' and zones of 'non beings' as Fanon (1961) correctly described. He further fully illustrates that,

> The zone where the natives live is not complimentary to the zone inhabited by the settlers. The zones are opposed, but not in the service of a higher unity. Obedient to the rules of pure Aristotelian logic, they both follow the principles of reciprocal exclusivity. No conciliation is possible, for the two terms, one is superfluous (Fanon, 1961; 30).

Consequently, the need to reverse this spatial form as described above, has driven the current agenda for planners and policymakers post-1994. Having said that, it is also acknowledged by Afifi et al. (2013) that strategic and spatial planning is one of the most complex tasks for public organisations. Planners often have to deal with issues at various spatial and temporal levels, often with conflicting objectives while simultaneously having to produce viable alternatives for communication with an extensive range of stakeholders (Afifi et al., 2013). Recent policy developments about space in South Africa have been the National Development Plan and the Spatial Land Use and Management Planning Act (SPLUMA) no. 26 of 2013. These have sought to provide a more holistic and implementable approach to strategic and spatial planning through sustainable, just, resilient, efficient and good administrative principles. However, the use of effective and functional-PSS to meaningfully solve spatial problems for the future has been lacking in the urban planning profession due to several factors, (Hopkins, 1999; Vonk, Geertman and Schot, 2005; te Brömmelstroet, 2013). Due to this problem, I further asked the following questions in this research.

## 1.3 Research Questions

How are Planning Support Systems used to foster spatial planning in South Africa (Gauteng[6])?

1. How are Geographic Information Systems and the Multi-Criteria Decision Analyses (MCDA) methods used as tools to develop PSS to solve locational or spatial problems?
2. What is the potential of PSS in long term spatial planning post-1994?
3. What are some of the challenges in using PSS in local government: A case of the City of Johannesburg and the City of Ekurhuleni?

## 1.4 Research Aim

The aim of this research was therefore to explore the usefulness of PSS in strategic and spatial planning to transform cities. I looked at how this can be useful for cities post 1994 in South Africa, specifically in Ekurhuleni and Johannesburg, and how new urban possibilities can be created.

## 1.5 Smart city concepts and Planning Support Systems

The smart city concept, big data, digitisation and open access to government data repositories have emerged in the academic and professional work of urban planners in recent times (Geertman, et al., 2017). Furthermore, the use of PSS to advance planning plays a critical role in the development of cities, given the shift towards the digital paradigm (Geertman, et al., 2017). From a geomatics perceptive, smart cities can be described as fully integrated, digital cities that use cloud computed technology and the internet of things for development purposes (Li et al., 2013). Li et al. (2013) further differentiates between smart and digital cities by saying that digital cities reside in cyberspace and smart cities belong to cyber physical space. Therefore, cities are moving towards being smart and digital, according to research, however, this approach is rarely used in the day to day duties of planning professions which leaves a gap between planning communities and modelling (te Brömmelstroet, 2013). Furthermore, while technology may be fast-growing and seeping into city development and urban planning, research indicates that planners find PSS too generic, inflexible, too complex as well as

[6] Although Gauteng consists of three metropolitan municipalities this research report focuses on the City of Johannesburg and the City of Ekurhuleni.

orientated not to the actual problems but to technology itself (te Brömmelstroet, 2010). Nevertheless, Planning Support Science as a new field is designed to give support to planners rather than focusing on just the system side of planning support (Greetman, 2013).

## 1.6 Research Methodology

### 1.6.1 Introduction

This chapter provides a brief overview of the research methodology whereas Chapter four presents the research methodology. The research methods provide the details of the research strategy adopted to address the research issues identified above. This includes the study area, together with the means for collecting data, the site and sample selection and the analysis. The limitations of the current research are also outlined.

### 1.6.2 Study Area

The study areas chosen for this research were the cities of Johannesburg and Ekurhuleni (see Figure 1). These two cities were selected in order to give a comparison of the kind of systems used in each municipality as well as the challenges they face, since they are both Metropolitan Municipalities located within the Gauteng City Region. The two cities were used as case studies to demonstrate how PSS can foster spatial transformation.

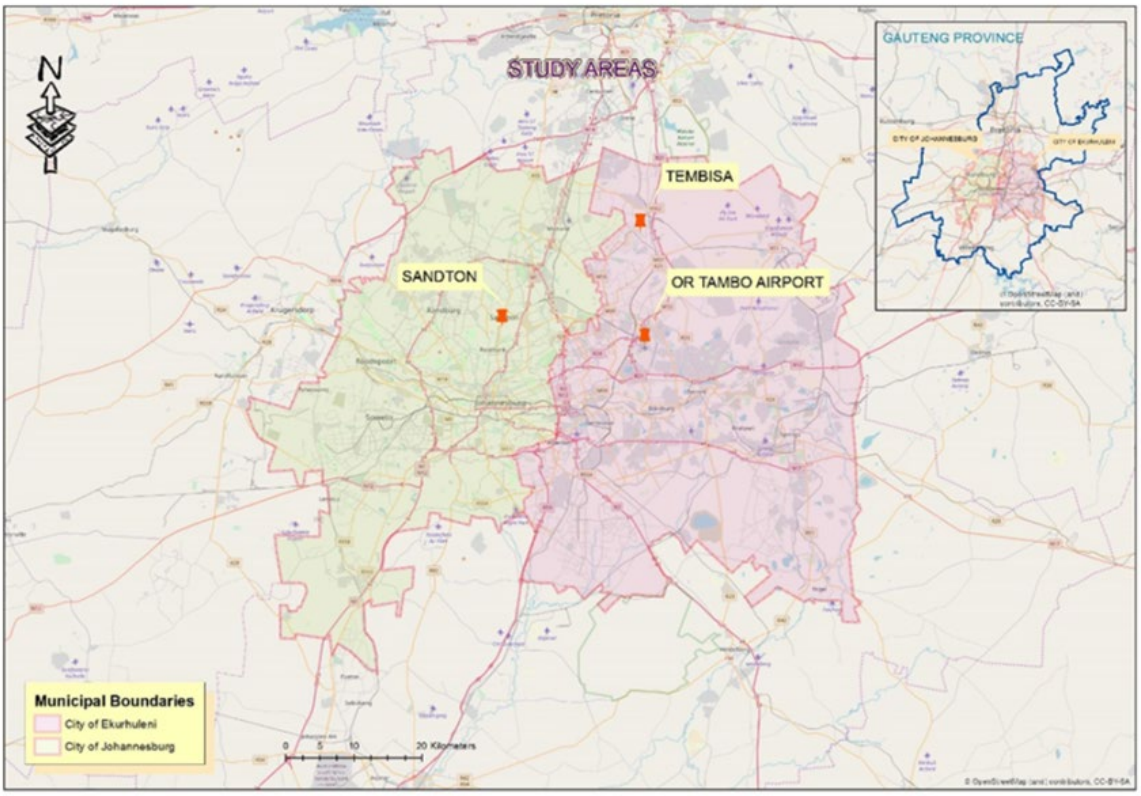



Figure 1: Study Area: City of Ekurhuleni and City of Johannesburg

### 1.6.3 City of Johannesburg

The City of Johannesburg was established during the discovery of gold in late 1886 (Beavon, 1982). The early stages of Johannesburg witnessed the growth of a collection of tents, wattle and daub shacks, covered wagons and wooden framed corrugated-iron buildings (Beavon, 2004). These small beginnings developed into first of all a large town and later into a city and lastly now a metropolitan region in Gauteng and the greater sub-Saharan Africa (Beavon, 2004).

### 1.6.4 City of Ekurhuleni

The City of Ekurhuleni (CoE) is a Metropolitan Municipality located in the Gauteng Province. It forms part of the Gauteng City-Region Observatory together with the cities of Johannesburg and Tshwane. , According to the 2016 census data, the CoE is home to a population of 3.379 million people out of the 13.4 million who live in the Gauteng Province (StatsSA, 2016). Of its population, 22.7 % are aged between 0 and 14 years, while 68.2% are between 15 and 64 years.

## 1.7 Research Design

A research design is characterized by components working harmoniously together to stimulate proficient and successful functioning of the research. Moreover, an explorative design does not seek to offer an ultimate and decisive answer to the research questions, but to explore the focal research themes with varying levels of depth. This consequently assists the researcher in unpacking a phenomenon in its natural state. Consequently, an explorative design was adopted for the current research.

## 1.8 Methodology

The methodology used for this research collected three kinds of data. Firstly, I used empirical research to explore literature on Planning Support Systems and South African spatial history and challenges. Secondly, I conducted qualitative interviews with officials from the Cities of Johannesburg and Ekurhuleni, using a purposive selection method, targeting urban planners and Geographic Information Systems (GIS) technicians. The questionnaires were sent using google forms and were analysed using the automated pie charts and graphs generated by google forms. Thirdly, I sent questionnaires to officials for both cities to understand what the challenges are in using Planning Support Systems in their work environments.

### 1.8.1 Data Collection

Qualitative data can be described as a large unit of related inquiry traditions stemming from social science as well as liberal arts (Locke, Silverman and Spirduso, 2009). In this case, literature on PSS was extensively reviewed, and the South African planning history and planning policy and planning legislation were also reviewed.

Besides primary data, the research utilised secondary data sources which are usually a representative summary or combination of existing research data sources. The secondary data sources used for this research were existing municipal reports, Web information, journals, and books as a means to supplement information gleaned from the questionnaires and interviews.

In order to further achieve the objectives of my research, interviews were conducted with personnel from the two municipalities to further understand the kind of challenges they faces

using Planning Support Systems. The City of Ekurhuleni officials were both from the City Planning Department in the Spatial Planning division. The City of Johannesburg officials were from The Development Planning and Urban Management Department in the City Transformation and Spatial Planning unit. The interviews were recorded on my mobile device and transcribed. The interviews took place on the following dates and venues:

Table 1: Interview Schedule

| NO# | Date | Time allocated | Interview duration | Venue |
|---|---|---|---|---|
| Official 1 | 12 March 2019 | 10:00-10:30 | 24:52 minutes | City of Ekurhuleni (Kempton Park): Official's office |
| Official 2 | 13 March 2019 | 09:00-09:30 | 37:56 minutes | City of Johannesburg (Braamfontein): Open boardroom |
| Official 3 | 13 March 2019 | 10:00-11:00 | 29:05 minutes | City of Johannesburg (Braamfontein): Open boardroom |
| Official 4 | 15 March 2019 | 12:00-13:00 | 51:40 minutes | City of Ekurhuleni (Kempton Park): Boardroom |

The following questions were put to the respective officials. The first question asked what spatial transformation meant for each municipality and what projects (policies or physical) each municipality implemented to foster spatial transformation. The interview questions also sought information about intergovernmental relations with other government organisations and departments to assist in achieving spatial transformation. The interviews investigated what types of PSS were used in each municipality and the challenges they faced in using PSS. Officials were further asked about the kind of support which existed in the divisions from a personnel perspective in order to determine whether planners had enough support within their respective divisions. The last question for the officials tapped how the city was implementing the smart city concept.

The collection of primary data involves the process of gathering information, which was not previously documented, and conducting interviews allows the researcher to obtain information from individuals who have specialist knowledge or skill in a field (Carman, 2004).

In addition to the analysis of documents and conducting four qualitative interviews I also did a survey which was distributed online as a questionnaire. These questionaries were included A questionnaire is a data collection tool in which written questions are presented that are to be answered by respondents (Carman, 2004). A questionnaire-based survey was administered to government officials with a total of 21 urban planner respondents in the two Metropolitan areas. The questionnaire was distributed online through Google forms to obtain a reasonable response rate. Closed and open-ended questions were used which were divided into the following themes: PSS, Geographic Information Systems, E-planning and Industry 4.0 (see Table 2). Consequently, the questions centred on the extent, applications, readiness, and perceptions about the themes.

Sampling is a process of selection from a population of interest so that by studying the sample, one may obtain a broad view of the population from which they were chosen (Trochim, 2006). A minor survey size was used in this research. Consequently, both purposive and random sampling was used since the research was targeted at town/urban/spatial planners in the two Metropolitans.

### 1.8.2 Analysis

Two metropolitan municipalities were selected as study areas and according to the results (See Figure 2), the City of Ekurhuleni responded the most from the 21 respondents, with 52.4 % of the questionnaires being returned. This could be attributed to the fact that CoE is my current employer and therefore, this means that more people could be reached from the networks over time. The City of Johannesburg gave a response rate of 47.6 percent.

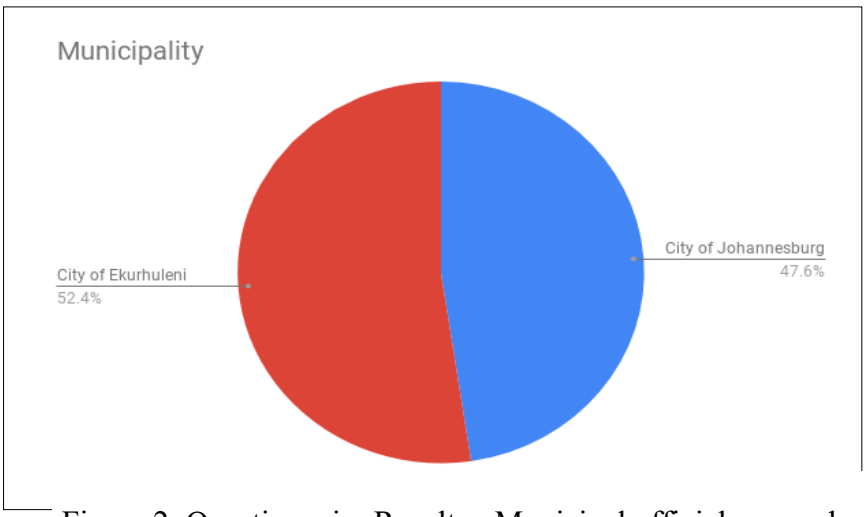



Figure 2: Questionnaire Results - Municipal official respondents

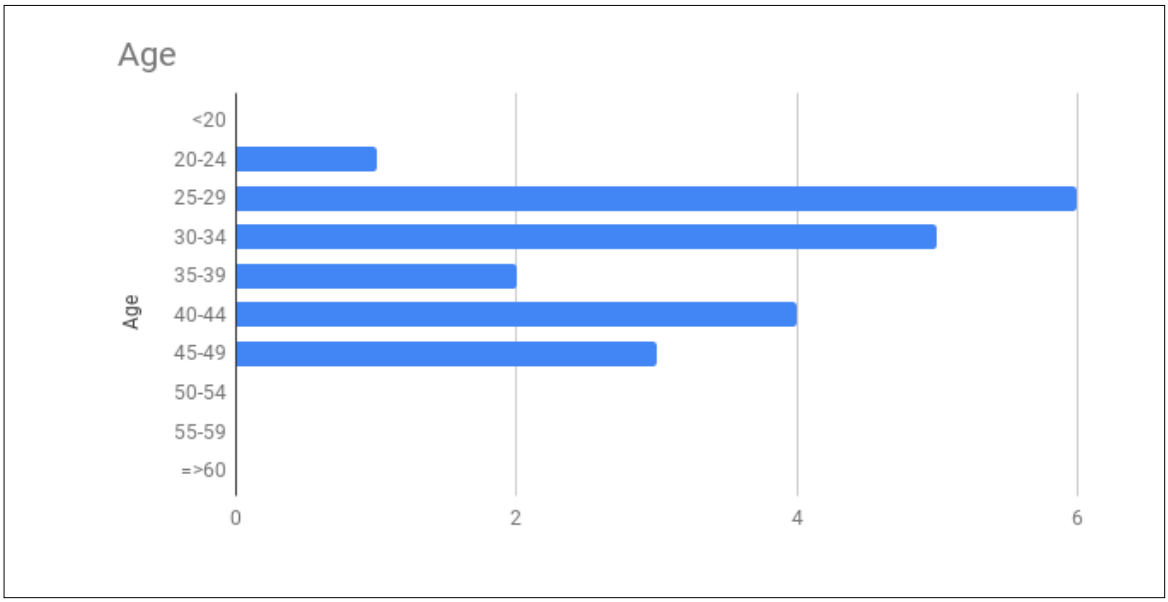



Figure 3: Questionnaire Results - Respondent Age

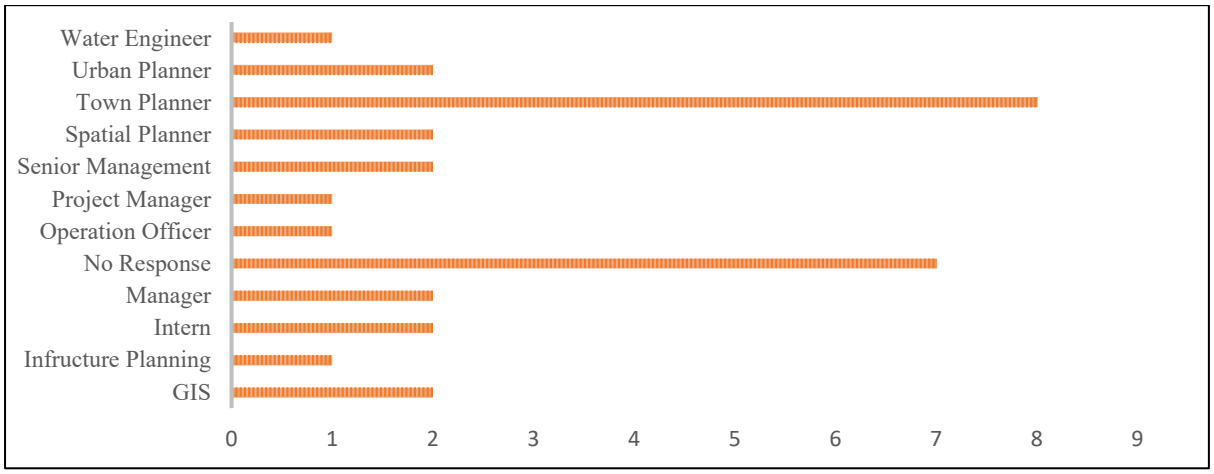



Figure 4: Questionnaire Results - Respondent Job Titles

According to figure 3, the number of people who have responded, a majority are aged between 25 and 29, who work as town planners, as depicted in figure 4. Town Planners in Southern Africa work in the Land Use Management space within the Urban and Regional Planning field. Their duties are about regulating urban settlements (Parnell, 1993). They typically receive land use applications from developers from the private and public sector, or individuals who would like a rezoning, consolidation, removal of restriction and occasionally township establishment applications. This involves making sure that all the necessary supporting documents are in

place such as locality maps, power of attorney or title deeds , and Site Development Plans (SDPs). The applicant would receive advice based on the relevant town planning scheme which is more of a blueprint planning and the Spatial Planning and Land Use Act of 2013.

Some of the results from the survey indicate that there are a number of challenges faced by both cities, hindering them from fully utilising Planning Support Systems.

Table 2: Online Questionnaire Themes

| Theme | Description |
|---|---|
| **PSS** | The extent of PSS use in municipalities<br>Challenges facing application in municipalities<br>Knowledge of PSS by planners |
| **E-planning** | The extent of e-planning use in municipalities<br>Challenges facing application in municipalities<br>Knowledge of e-planning by planners |
| **GIS** | The proficiency in and use of GIS software in municipalities<br>GIS education<br>Challenges facing GIS implementation and use in municipalities |
| **Industry 4.0** | Are the municipalities adept and ready for Industry 4.0?<br>How far are the municipalities in digitalisation of operations |

## 1.9 Conceptual Framework

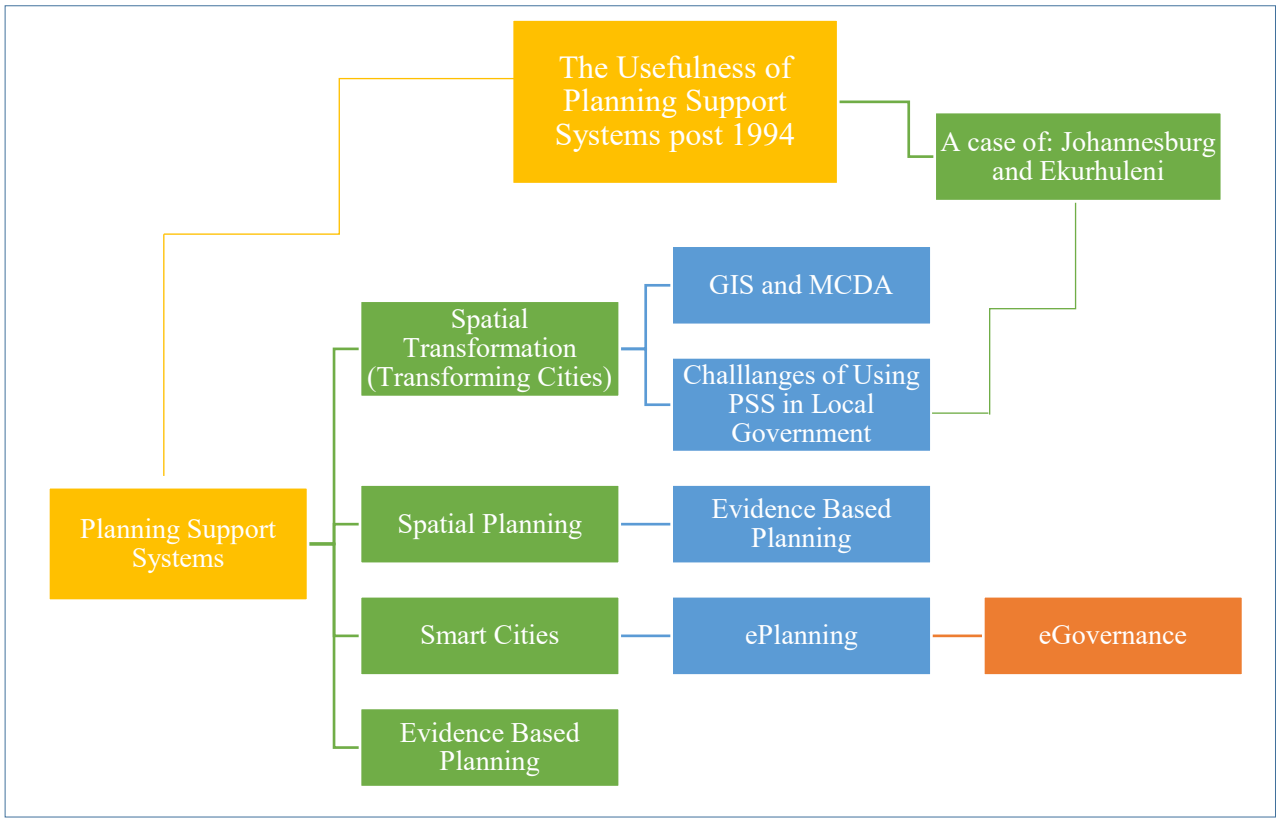



Figure 5: Research Conceptual Framework

The Conceptual Framework (Figure 5) gives an overview of the concepts and rationale around the research report. The research intended to demonstrate how Planning Support Systems could be useful to urban and regional planning in South Africa. To do this empirical research, online questionnaires, interviews and case-based studies were used to collect and analyse data. As part of the empirical study, I investigated the policy history of the country, given the spatial problems of South Africa. I further used the smart city concept as well as Evidence-Based Planning as a theoretical base for the research.

As cities have evolved, smart cities have emerged as the driving agent enabling more efficient, sustainable and resilient cities. It is also found that the Local Government and the State have embraced e-planning and e-Governance to manage cities more efficiently and sustainably and which contributes towards cities becoming smart. The Literature review in this research report is divided into two, to primarily describing case studies which have utilised GIS, and Multi-Criteria Decision analyses which have investigated Planning Support Systems which have

been developed to solve locational issues. One of the biggest challenges faced in South African planning is the ability for post-1994 urban planners to spatially transform cities successfully. In order for urban planners to successfully transform space, I then assess the challenges that urban planners face in using Planning Support Systems in the Cities of Johannesburg and Ekurhuleni.

## 1.10 Ethical Consideration

| | |
|---|---|
| **Voluntary Participation** | All participants of this research from both municipalities were given an option to opt out of participating at any point in time. |
| **Informed consent** | All participants new the purpose, benefits (if any) and risks of the research before they agreed or declined to join. |
| **Anonymity** | All participant's identities are kept anonymous and no personal information was collected. |
| **Confidentiality** | Participants identity and information is kept confidential and therefore cannot be linked to other data by anyone else. |
| **Potential for harm** | Physical, social, physiological and other types of harm was kept at an absolute minimum for this research with all participants and no animals were used. |
| **Results Communication** | I have ensured my work is free of plagiarism and research misconduct to the best of my ability and have accurately represented my results. |

## 1.11 Research Limitations

The limitations I faced for this research, were the number of metropolitan municipalities I could include; however time constrains contributed to this limitation. Having additional municipalities would provide more insight into the kind of challenges faced by municipalities.

Another research limitation was the lack of literature on the challenges faced by municipalities on the use of Planning Support Systems in South African.

## 1.12 Chapter Outline

Chapter One introduces and positions the research based on the research questions and objectives. The literature review is also presented. The Literature review is divided into two parts. The first (Chapter two) demonstrates a contemporary approach on Planning Support Systems with two case studies. The case studies are based on a web based application used to monitor and evaluate urban planning policy and a scenario planning model on the spatial future of Johannesburg based on three scenarios. The research design, methodology and finally, research analysis techniques form part of this segment. The second segment (Chapter three) of the literature review is based on Planning Support Systems that make use of the Multi Criteria Decision Analysis as method to solve locational problems. Chapter four showcases research work that I was involved in. This research work makes use of the Multi Criteria Decision Analysis method to solve locational problems. Chapter five presents the challenges in using planning support systems in local municipalities: Ekurhuleni and Johannesburg. Chapter six presents the research results and discussion. Chapter seven provides the research recommendations and conclusions. Lastly the references are listed.

## 1.13 Conclusion

In this chapter, the methodology was outlined as well as the questions in accordance with how the research was conducted in order to achieve its objectives.

The data collection process was subsequently followed by the conceptual framework. While the planners today are seeking to address spatial equality there is a huge technology paradigm that has affected how cities function and how people interact with it. The smart city concept briefly explains how this concept is able to assist in the planning of our cities going forward using PSS to do so to foster new futures. My ethical considerations have been outlined. The two study areas namely, the Cities of Johannesburg and Ekurhuleni, were also discussed to give perspective and background on the areas chosen. Lastly my research limitations were outlined.

CHAPTER 2. THE CHALLENGES OF SOUTH AFRICA'S SPATIAL FORM AND PLANNING SUPPORT SYTEMS

## 2.1 Introduction

PSSs are defined as digital tools that are developed to support planning (Pelzer, 2017). They emerged through the combined efforts taken in the areas of GIS Decision Support Systems (DSSs) as well as large-scale urban models that were purposed to support planning activity (te Brömmelstroet, 2013). Through this, planners were able to explore the 'what if' question in urban scenarios, for example, what would happen if the population increased by 1.5% or 3% per annum (Geertman, et al., 2017). From this, Geertman et al. (2017) derived that the planning of spaces is ideally improved when developed according to predicted results

This section gives a brief overview on the challenges of South African Planning and its spatial form as well as policies developed over the years. The usefulness of PSSs from a global and local perspective is also explored using different case studies.

## 2.2 The South African spatial form

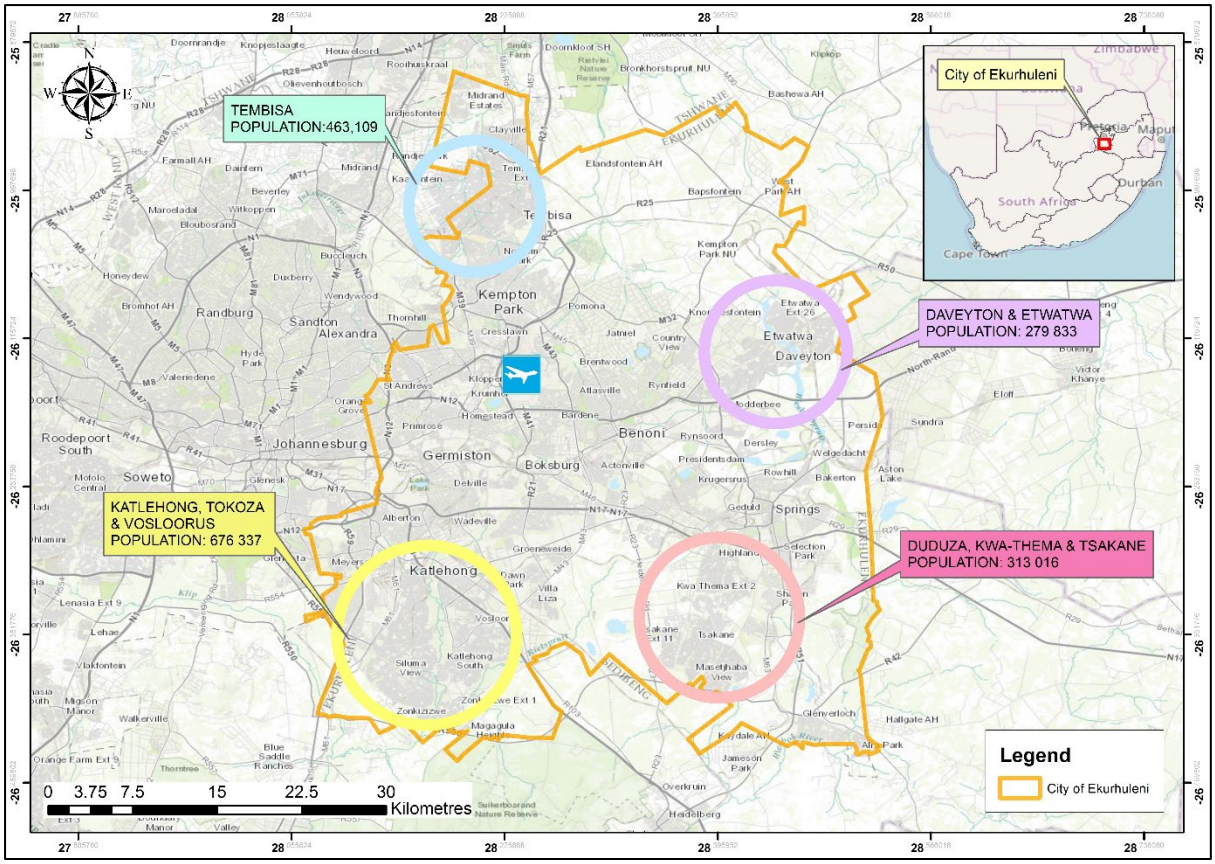
The 28th of May 1948 was the beginning of the emphasis of Apartheid as the leading ideology that would rule and govern the country until 1994 (Welsh, 2010). After this, Apartheid regime was officially abolished which meant that Black people were able to vote for a democratic government for the first time. Before that, the apartheid government shaped the South African spatial form by using influx control laws to influence urbanisation patterns and thereby restrict the movement of people into urban areas from the independent homelands (Harrison et al., 2008). One other method was the Group Areas Act of 1950 which was used to separate different race groups. These areas, located in townships[7], were also characterised by underdevelopment and unvarying urban planning (Mokoena, Musakwa & Moyo, 2017). Looking further into history, one of the first pieces of legislation used to engineer apartheid was the Native Land Act of 1913 which dispossessed land from the Black majority together with the Natives (Urban Areas) Act 21 of 1923. The Native (Urban Areas) Act 21 of 1923 was said to improve the

[7] Townships in South Africa are often referred to areas where Black people reside in urban areas or known as previously disadvantaged areas (Beavon, 1982).

living conditions of the native residents in areas located close to urban areas, in places like the townships, and also said to provide better control of work contracts and registration of residents (Van Jaarsveld, 1986). This Act, however, was another piece of legislation that sought to control and 'manage' the native and further segregate urban development and spaces. The quote below sums up some of the thinking at that time regarding housing development for the poor.

> "The administration of urban locations or villages … began to receive general and systematic attention only in 1923 with the passing of the first Natives (Urban Areas) Act … But before 1910 African urbanisation was a small, irregular and inadequately supervised development. If a good manager was appointed (and some were) it was a happy chance: there was no system and poor appointments were all too common." (Van Jaarsveld, 1986: 17)

The statement above illustrates that apartheid planning was well thought out through the emphasis on location. Coupled with influx control, cities were not well managed to suit the objective of creating spaces where Black people were restricted and not necessarily given freedom to move around in their native land. According to Savage (1986), over 17 745 000 Black people were arrested during the period of 1916 and 1985. The influx into cities was controlled by 'pass laws' which permitted a person to have access to the city only for a specified period. Furthermore, urban areas were designed to exclude Black people completely from particularly areas deemed affluent. . Figure 6 depicts how, from a spatial perspective, pre-1994 Black townships were located on the periphery of what is now the municipality of Ekurhuleni, and further depicts the conglomeration of some of the biggest townships in South Africa. The map also indicates the population size of pre-1994 Black townships that exist today, and similarly gives perspective on the numbers that some cities have to plan for. This is given that there are back yard dwellers, informal settlements, hostels as well as people who are on the waiting list that still need to be planned for. The location of these settlements must also be noted. For example, Tembisa 463 109 is the second-largest single township This is followed by Katlehong at 407 294, however as a collective Katlehong, Tokoza and Vosloorus are the largest in Ekurhuleni with a population of 676 337 according to the 2011 census data.




Source (Mokoena et al., 2019)

Figure 6: Spatial Segregation - Townships in Ekurhuleni

Housing is one of the areas that is a big challenge in South Africa and the global South (Huchzermeyer, 2011; Huchzermeyer and Karam, 2006; Mackay, 1999). Figure 6 depicts the sheer size of population that the state has to deal with in providing service delivery in order to provide efficient and effective urban governance. The location of this settlement is still a concern, given that spatially the city is currently in the process of integrating itself through various spatial targeting strategies such as the Integration Zones and Priority Areas, which are put in place by the Municipal Spatial Development Framework. However, beyond strategic documents, policies and acts, technology as well as scientific smart decision-making methods can be used to inform the trajectory of cities and rural areas in South Africa, post 1994.

## 2.3 The relevance of PSS

Despite the spatial problems that South African cities face, from a global perspective, there is no doubt that they are evolving and technology has recently become more critical in their

development. This has allowed for more efficient and innovative solutions to be established for each city to function optimally, however, given the need for cities to become smarter requires strategic planning to be implemented. In response to this, PSSs have the potential to play a role in creating smarter cities in South Africa by applying better scientific planning solutions to foster long term spatial planning to transform the urban environment. However, the willingness of planners to transform spaces for smarter cities as well as the current systems put in place can hinder the process of them seeing beyond the present. Therefore, future spatial planning as a form of transformation must be explored.

Adding to the complexity of cities, the year 2009 marked the first time when 3 billion, a little over half the population in the world, lived in urban areas. It is expected that about 6 billion will be living in cities by 2050. It is said that this shift will take place in rapidly populating countries which are described as low to middle income often referred to as the Global South. According to Sclar and Volavka-Close (2013), a majority of this demographic transformation will take place in medium and small towns instead of the already overpopulated megacities. These transformed small and medium towns will become places where people can live productive, secure and healthy lives.

## 2.4 e-Governance

While cities have become smarter, more and more government organisations are turning towards better ways of providing operational and service delivery platforms. However, as this is happening it is also found that people in Europe have less contact with municipal officials over time and subsequently have less interest in participating in city governance and politics in general (Orzan and Călin Velicu, 2013).

Moreover, the way people communicate has drastically changed with the introduction of information technology, and the communication and development of the advocacy and other collaborative websites (Donovan, Kilfeather and Buggy, 2008). Citizens have thus shown that they are willing to communicate in ways other than physical contact. Donovan, Kilfeather and Buggy (2008) argue that communication in today's world can be used by the state to attract citizen participation in the building of cities as well as providing service delivery. Some governments however resist establishing platforms where citizens can use technology to interact with citizens. In Romania for example, the lack of commitment from government

officials to make use of this technology provided creates an imbalance between people and government administrators(Orzan and Călin Velicu, 2013).

There have been various portals created around the world to improve citizen participation and government service delivery. These include online public platforms such as the Lyne and Lee Model and the Belanger model which were developed in the USA, and which focus on providing safe and protected personal data (Orzan and Călin Velicu, 2013). Additionally, the Swedish Agency for Administrative Development (SAFAD) model was created to assess the level of development and e-Government initiative evolution over time (Orzan and Călin Velicu, 2013). For this research, I further look at some of the contemporary PSS that have been developed by researchers to solve complex urban planning problems such as the monitoring of urban policies and looking at policy implications using scenario planning. I later look specifically at PSS developed using the Multi-Criteria Decision Analysis tool as well as Geographic Information Systems to solve locational problems of various cities.

## 2.5 Planning Support Systems: A contemporary approach

This section briefly looks at a contemporary approach to urban planning and will showcase various case studies of how Planning Support Systems are used in various countries to advance and assist the planning process.

Town and Regional Planning is a highly process-driven exercise that requires interval and intervention led decision making, as the profession alone requires an individual or organisations to deal with multiple factors (Wu, He, and Gong, 2010; Wallbaum, Krank, and Teloh, 2010; Kaiser, Godschalk and Chapin, 1995; Adams, 1994). The decisions made are always influenced by other factors.

In this literature review, I look at two examples where PSS was used to advance planning. The first example depicts how a web-based application can be used to monitor planning policies as a form of PSS. The application was built specifically for the Cities of London, Chicago, Melbourne and Brisbane. The second example shows how PSS can be used to forecast the urban development of the City of Johannesburg according to both policy and on the ground development. The forecasting demonstrates two scenarios and depicts how the city would look like should development unfold according to how policy experts predict. The second scenario demonstrates how the city would look according to the current development trends of the city.

### 2.5.1 Case Study 1: Planning Support Systems for Monitoring and Evaluation

The growth and change of cities over time has allowed planning regulations to guide development for citizens to improve their quality of life as well as their living experience in the city (Daniel, 2017). However, the monitoring of planning policies is often limited in practice. As a result of this, a browser-based mapping application was prototyped as a monitoring system (See Figure 7,8 and 9) (Daniel, 2017). The four cities gave a comparison of planning system structure, visualisation and suitable metrics techniques as well as data availability limited to residential land use (Daniel, 2017). This research was able to demonstrate in an automated way the bringing together of datasets to communicate spatially detailed information for the success of planning objectives (Daniel, 2017).

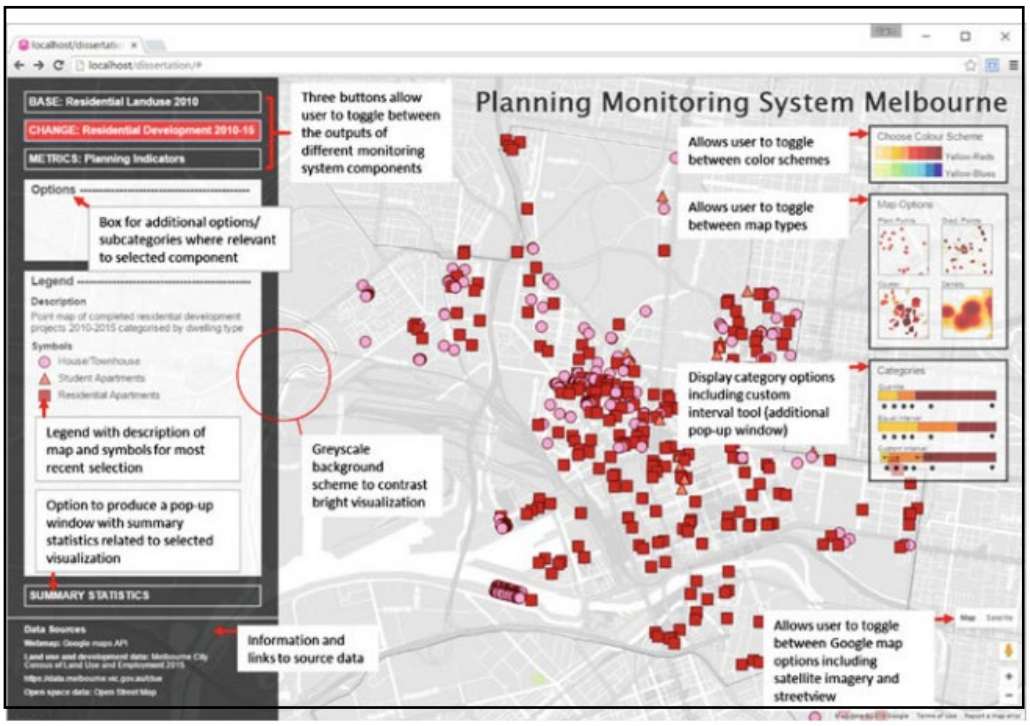



Figure 7: Case 1: PSS - Website features (Daniel, 2017)

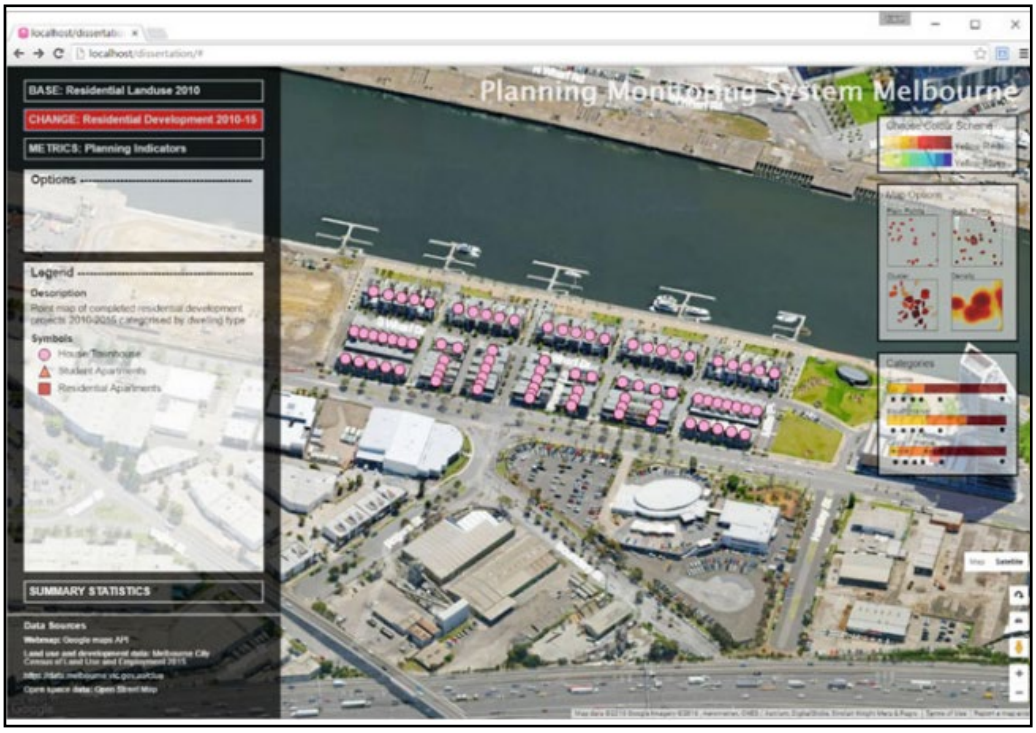



Figure 8: Case 1: PSS - Google satellite imagery visualization option of new development in the South of Melbourne (Daniel, 2017)

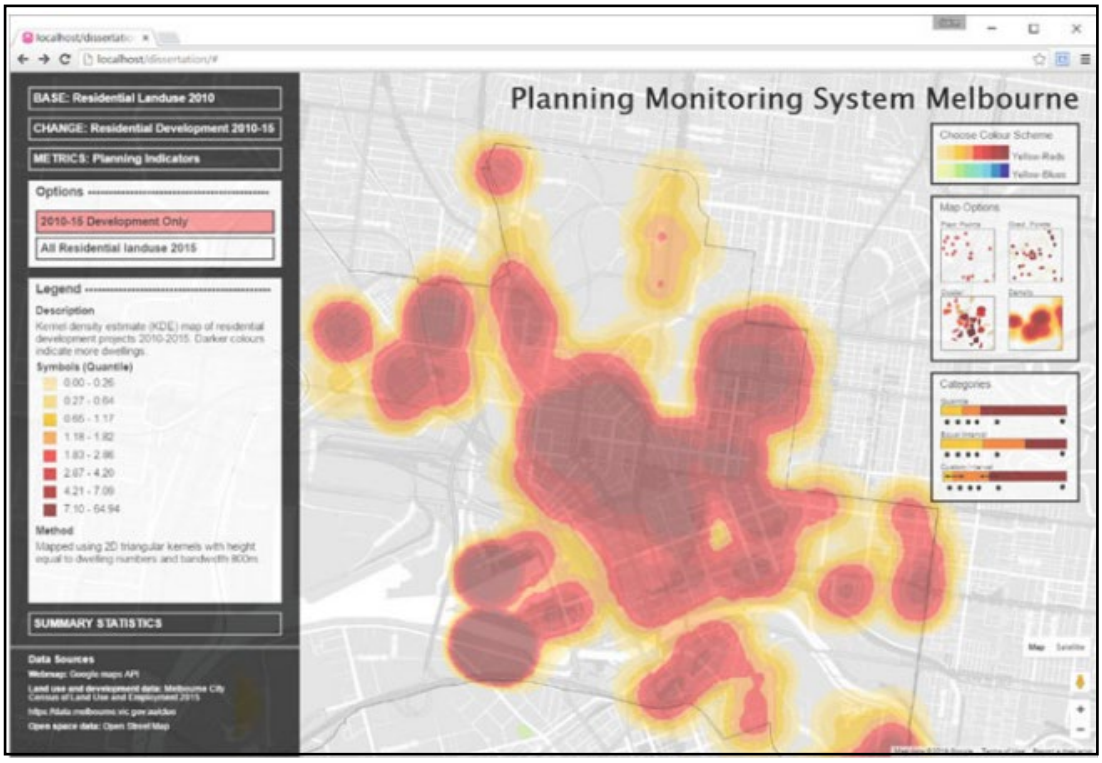


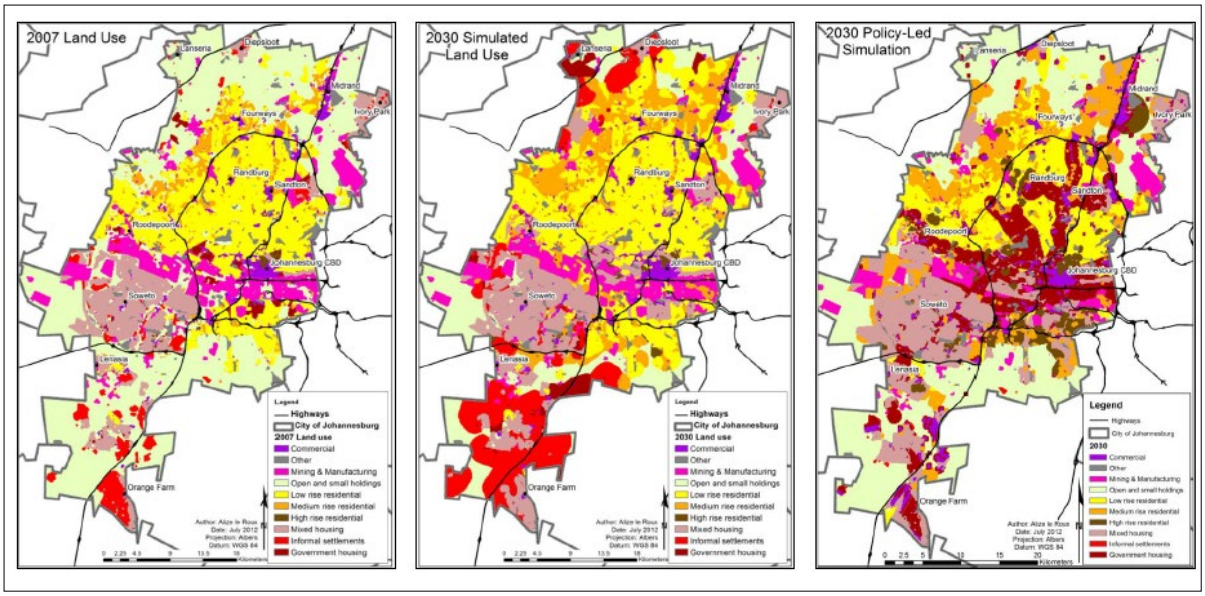

Figure 9: Case 1: PSS - Density Map display option of recently developed dwelling units (Daniel, 2017)

The planning for cities and regions involves putting together different activities to function in an integrated manner to achieve a particular goal (Williams, 1975). These activities are ever evolving, based on for example, urbanisation patterns, population increase, economic shifts, and migration (Williams, 1975). Therefore, a need exists for planners and policymakers to plan based on changing circumstances. The impact of these development changes must also be studied and demonstrated in the form of forecast planning (Williams, 1975).

In simple terms, scenario planning can be described as a set method of imagining futures and derives its origins from strategic planning and thinking (Shoemaker, 1995). Hopkins and Zapat (2007) moreover write on the importance of planners being able to work with and engage residents in shaping the future and not merely stumbling upon it. They state further that scenario building shapes the focus on planners to influencing choices and achieve bright and determined actions (Hopkins and Zapat, 2007). The following example demonstrates the use of PSS used to build scenarios in Johannesburg. Following this example, a Planning Support System was developed to identify well-located land for future human settlements in the Ekurhuleni region.

### 2.5.2 Case Study 2: Planning Support System for Scenario Planning

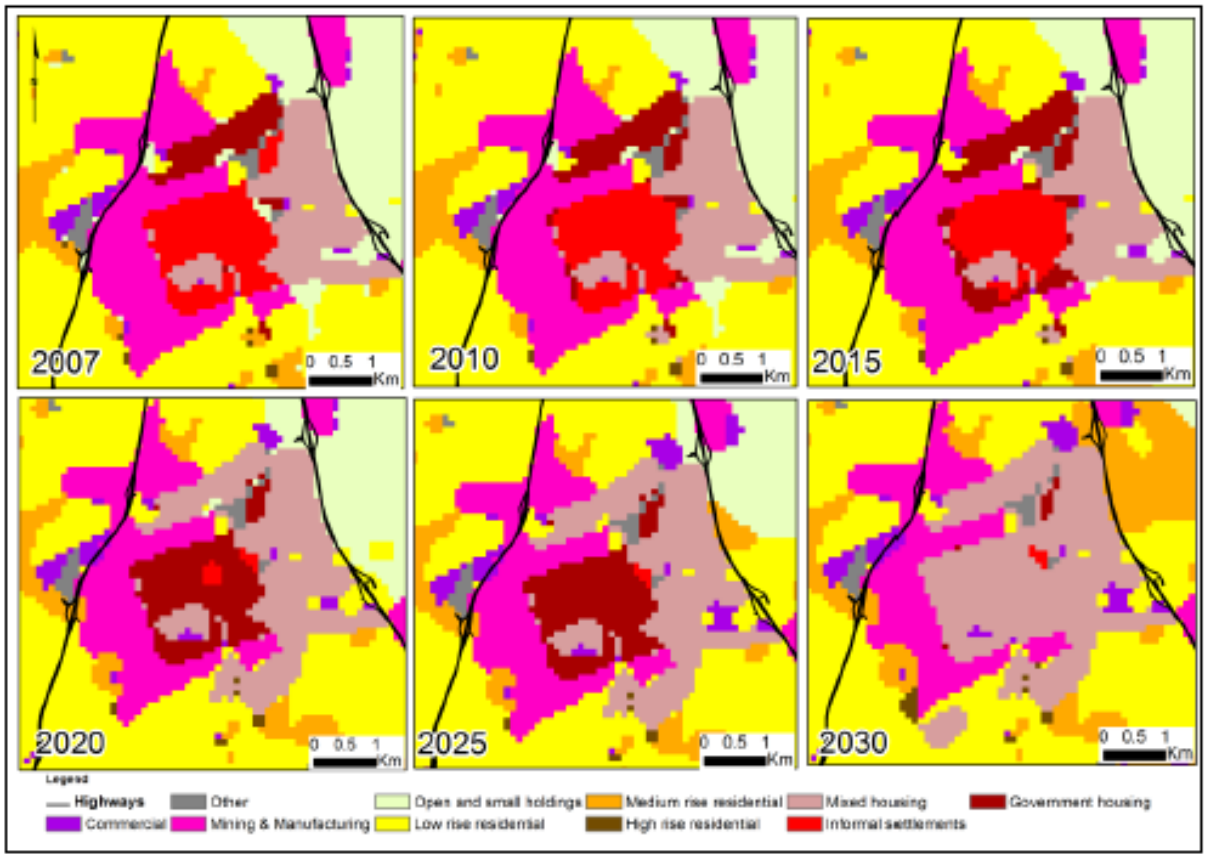
In this Scenario Planning exercise (see Figure 10), the researchers quantified the spatial implications of future land use policies in South Africa. Using the Dyna-Clute model two I see different scenarios compare spatial impacts of policy led development vis-a-vis the AS-IS Scenario method. This measures the natural tempo of development in Johannesburg in terms of spatial allocation and demand (Le Roux and Augustijn, 2017).




Source: (Le Roux and Augustijn, 2012; 77)

Figure 10: Case 2: PSS - Researcher scenario vs policy scenario

The most significant result in terms of growth patterns is the demonstration of how sprawled the city is according to the AS-IS scenario (Le Roux and Augustijn, 2017). It also demonstrated the prevalence of informal settlements throughout the south of the city according to the AS-IS scenario. Thirdly the location of high-density development which will take place according to the policy led scenario and lastly demonstrating the location of low density development along transport corridors in accordance with policy led scenario method (Le Roux and Augustijn, 2017).




Source: (Le Roux 2012; 77)

Figure 4: Case 2: PSS - Forecast maps for 2030

The researchers in these maps created a forecast up to 2030 (see Figure 11) according to the City Policy, where the metro plans to transform the area into a mixed housing development. The Alexandra Township illustrated in Figure 6, is characterised by informality, and the city plans are to transform the area by developing more subsidised units that will accommodate different housing needs for the community (Le Roux, 2012). To curb informality, the city intends to embark on converting back yard shacks into formal housing (Le Roux, 2012).

## 2.6 Smart City concepts in PSS

Various scholars have defined Smart Cities as places that have smart people, technology and Governance. For example, Meijer and Bolvar (2016; 5) have cited Washburn et al. (2010: 2)definition of smart cities as:

> ..the use of smart computing technologies to make the critical infrastructure components and services of a city – which include city administration, education, healthcare, public safety, real estate, transportation and utilities – more intelligent, interconnected, and efficient. (Washburn et al., 2010: 2)

This definition emphasises the importance of a more collaborative approach rather than focus on one element making a smart city. Taking for example, education, new technological methods have been applied in the education systems in the Netherlands and other countries to equip young and old citizens for the smart era. The Smart City is also defined according to Riva Sanseverino, Riva Sanseverino and Anello (2018) as:

> A city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and high quality of life, with a wise management of natural resources, through participatory governance. (Riva Sanseverino, et al., 2018: 28)

This definition identifies the importance of co-existing of the new and old to form favourable urban smart environments to function through participatory methods. Most cities have been able to retain the old architecture while introducing the new and modern technology, for example modern transport systems. Various scholars have also defined smart cities to include six fundamental elements that help fuel the concept. The fundamental elements are 1) Smart governance, 2) Smart Living, 3) Smart Economy, 4) Smart Mobility, 5) Smart People and lastly 6) Smart Environment (Riva Sanseverino et al., 2018; Laitenen et al., 2017). When briefly explained, Smart Governance has a lot to do with a bottom-up governance approach that is both participatory and democratic. It also has to do with being open to innovative ideas and ways as well as being a well-organised, open city government that welcomes established private-public partnerships and functional networks.

Smart living is about providing healthy and safe environments for people to live in (Scholl and Scholls, 2014; Meijer and Bolivar, 2016; Willke, 2009, Riva Sanseverino, et al., 2018). Smart Economies is about creating challenging and creative economies for various types of business to operate in such as start-ups, spin-off companies (Talbot, 2016; Riva Sanseverino, et al., 2018).

Smart Transport refers to a mobility model that is sustainable and driven by technological innovation and techniques but most importantly has the infrastructure that is based on

multimodality (Debnath et al., 2011; Riva Sanseverino, et al., 2018). Smart People refers to the ability of citizens to live in innovative environments that are capable of using city services on mobile and web applications (Thompson, 2016; Riva Sanseverino, et al., 2018). A Smart Environment is one that is smart, sustainable, and able to manage the natural resources wisely that are in urban places (Riva Sanseverino, et al., 2018). The natural environment has always been an important feature to preserve and keep, especially with recent debates about carbine emission and the need to use less energy and lean towards green infrastructure. The dominant definition of sustainable smart cities by Höyer and Wangel (2015) as depicted in Riva Sanseverino et al. (2018) is as follows:

> …a city that meets the needs of its present inhabitants without compromising the ability for other people or future generations to meet their needs, and thus does not exceed local or planetary environmental limitations, and where this is supported by ICT. (Riva Sanseverino, et al., 2018: 28)

The smart city concept, big data, digitisation and open access to government data repositories have emerged as themes in both academic and professional work of urban planners in recent times (Geertman et al., 2017). Moreover, the use of PSS in planning plays a critical role in the development of cities, given the shift towards the digital paradigm (Geertman et al., 2017). According to research, however, one of the challenges of these systems is that they are rarely used in the day to day duties of planning professions which leaves a gap between planning communities and modelling (te Brömmelstroet, 2013). Another challenge is that planners find PSS too generic, inflexible, and too complicated as well as not being orientated to the actual problems but to technology (te Brömmelstroet, 2010). Given these challenges, while Planning Support Systems have been used to advance cities, it is also evident that Planning Support Systems need to be less complex and more user friendly.

The smart city concept was first mentioned in the 1990s by Marcus and Kosh (2017) and has become synonymous with future cities. With big data available, cities are increasingly required to become information cities that employ calculated decisions based on scientific evidence and motivation (Allam and Newman, 2018). The human element, however, must not be forgotten, as it also provides information that is not only based on scientific methods but also on human experience and cultural history (Allam and Newman, 2018). This makes social capital equally

important (Williamson, 2015). Allam and Newman (2018) further describe the Smart City concept as a branding exercise that is displayed by large organisations. In the South African context, for example, there is vibrant cultural value, however, socio-economic challenges exist such as the unemployment rate, poverty and inequality, housing shortage and spatial inequality. Consequently, the smart city concept should be considered to not only benefit the affluent areas but also enrich and enhance all people's living experience (Musakwa, Moyo & Mokoena, 2017).

Policy priorities may also be realised once information is gathered and known in a particular city (Stratigea, Papadopoulou, Panagiotopoulou, 2015). Slavova and Okwenchime (2016) allude that on the African continent, however, the kind of challenges faced have to do with the low population densities, slums and informality as well as a shortage of infrastructure. These therefore pose a much more complex dilemma towards achieving smart cities strategies for the African Agenda 2063. Further challenges would be food security, unemployment and the poor quality and segregated social services (Slavova and Okwenchime, 2016). The challenge of urbanisation plays another role in the challenges or the advantages of African cities (Slavova and Okwenchime, 2016). The African Agenda 2063 envisions development as being people-driven and therefore sees people as its most significant asset (Slavova and Okwenchime, 2016; African Union 2013).

Slavova and Okwenchime (2016) argue that through various empowerment platforms, people are involved in the economic, political and social decision making processes of cities. In this case, the public participation process, therefore, needs to be strengthened as tools that will advance the future of planning on the African continent. Urban theories emphasise the role that public participation must play in order to seek more solutions to the challenges that people face (Stratigea, Papadopoulou, Panagiotopoulou, 2015).

It is said that 70% of Africans will be living in cities by 2050 and by 2063 it is expected that the African urban population will be 3 billion and 4.4 billion by 2100 (Slavova and Okwenchime, 2016). Smart models should therefore be designed according to the social compatibility of cities and planned carefully; most notably when it comes to affordability, privacy, autonomy and access. Yigitcanlar (2015) argues that the successful utilisation of smart technology for the management of cities is critical to designing the desired smart cities outcomes. In addition to these innovations, Wahidayat Putra and van der Knaap (2018) argue

that a Smart City uses technology to improve citizens' quality of life by integrating information through a multi-dimensional approach and a collaboration between research and policy. The understanding of both technology and politics will help develop a process plan for managing smart cities that will provide not only economic gains but also other public gains (Meijer and Bolivar, 2016). Moving forward, the Smart City concept will be further looked at through various definitions.

### 2.6.1 e-Planning as a critical element to the Smart City Concept

Adaptive learning has provided interactive service delivery rather than a passive receptor approach from the citizen perspective (Laitenen et al., 2017). Adaptive e-planning makes use of computers as an interactive device for engaging citizens (Institute for Future Living, 2016). The adaptive e-planning system also allows city authorises to transform how they share information with the public, hence enhancing how collaborative planning is done (Institute for Future Living, 2016).

Another growing skill to e-planning in city management is coding and computation (Williamson, 2015). The ability for current authorities to manage future cities is critical in the Fourth Industrial Revolution (4IR), as their smartness will enable more accessible city governance in the end (Williamson, 2015). Further, the standards regulating smart cities' development are software instruments transcoded to alter and shape the environment of everyday living in urban areas( Williamson, 2015). If e-planning is directed well, according to the current trajectory of cities, the governance of future urban areas will be well managed to handle the kind of changes that happen rapidly as seen with cities in the United Kingdom and Germany.

In recent times the use of social media in organisations and public sectors has seen the publication of official social media strategy or policy documents (Grabkowska, Pancewicz. and Sagan, 2013). These norms and standards are developed to direct social media practices in organisations and contain information on how professionals can interact with members of the public or the audience (Grabkowska, et al., 2013). They also contain information on intellectual property rights, schedules for daily posting and even measures on how to gauge social media impacts (Mergal and Bretsschneider, 2013).

## 2.7 Conclusion

In order for us understand how Planning Support Systems can be useful in South Africa, this chapter has briefly described some of the challenges that South African cities have faced and are still facing even today. While the agenda of the apartheid government was to segregate people according to race, the post 1994 urban planner and policy documents seek to reverse apartheid planning and pave the way for a new trajectory for urban space using smart technology to achieve that goal. As millions of people were affected by segregated Planning, these systems can now be used to foster improved Evidence Based Planning and create better living spaces especially for the poor. PSSs nevertheless must be less complex and more user friendly. This section further demonstrated two case studies that were designed firstly to improve cities through Monitoring and Evaluation of urban planning policy. The second case study show cased a scenario planning technique in the City of Johannesburg.

CHAPTER 3: THE USE OF PSS: A MULTI-CRITERIA DECISION ANALYSIS (MCDA) APPROACH TO SOLVING LOCATIONAL PROBLEMS

## 3.1 Introduction

Chapter three is an extension of the literature review on PSS. This particular chapter outlines the use of the Multi-Criteria Decision Analysis[8] (MCDA) and Geographic Information Systems[9] (GIS) to demonstrate how PSS can assist in resolving locational problems to plan for the future of cities. In this chapter I also discuss a number of case studies that utilize the GIS-MCDA tool to develop Planning Support Systems.

## 3.2 Decision support tools

### 3.2.1 Geographic Information Systems

Within the urban and regional planning field, Geographic Information Systems (GIS) have been extensively used since the 1980s as a decision support tool to facilitate the processing, visualisation and organisation of geographic or spatial data (Greene et al., 2011; Malczewski and Rinner, 2015). Geographic Information Science (GIScience) in general is the theoretical base for Geographic Information Systems (Greene et al., 2011). It formalises geographic principles in order to analyse and search for relationships created in policy-related and scientific applications by organisations and individuals with geographic information technology (Malczewski and Rinner, 2015).

GIS can also be described as a platform for visualising data and analysing Spatial Decision Support concepts (Malczewski and Rinner, 2015). Nevertheless, the most crucial operational aspect of GIS is the database which is central to the management of spatial information, and which allows for communication between different submodels (Arampatzis et al., 2004). Within GIScience, however, the Spatial Decision Support concept was only recognised in the early 1990s (Malczewski and Rinner, 2015). The need for Geographic Information Systems

[8] Multi-Criteria Decision Analysis will be referred to as (MCDA)

[9] Geographic Information Systems will be referred to as (GIS)

came into existence because of a continuous demand to solve complicated spatial decision problems within urban planning and other professions (Malczewski and Rinner, 2015).

Decision Support Systems can be defined as a computer-based interactive design to support a group of users or an individual user to attain high impact decision making systems (Malczewski and Rinner, 2015). During this section, GIS as a Planning Support System tool will be discussed and more specifically, the Multi-Criteria Decision Analysis as a decision-making tool.

## 3.3 Linking Multi-Criteria Decision Analysis and GIS

One of the new decision-making tools in urban Planning is the relationship created between two different disciplines, namely Geographic Information Science and Multi-Criteria Decision Analysis (GIS-MCDA) (Malczewski and Rinner, 2015). Multi-Criteria evaluation is described by Santé-Riveira, Crecente-Maseda and Miranda-Barrós (2008) as a weighted linear procedure that is frequently used to derive suitability maps[10]. Geographic Information Systems have also been in the lead in quantifying multiple factors to meet various spatial goals in urban planning and according to Rybarczyk and Wu (2010) in transport planning.

Multi-criteria Decision Problem involves;

> A set of alternatives that are evaluated based on conflicting and insufficient criteria according to the decision-maker preferences (Malczewski and Rinner, 2015: 23).

In another definition, MCDA;

> Provides systematic evaluation procedures and algorithms for structuring decision problems, and designing, evaluating and prioritizing alternatives (Meng and Malczewski, 2015: 32).

GIS and MCDA together can be defined as a process that combines and transforms geographical data in order to assess decision alternatives or options (Meng and Malczewski, 2015). In another definition, Multi-Criteria Decision Analysis evaluates a set of alternatives or courses of action. The evaluating process may take on various forms like ranking alternatives

[10] Suitability maps demonstrate the best suitable location for a specific purpose. For example a suitability map would demonstrate the best location to place industrial parks within a specific geographic location.

from worst to best, choosing a preferred alternative or sorting the alternatives in order classes, for example, 'bad' to 'good,' using mathematical programming to define the set of alternatives (Durbach and Stewart, 2012).

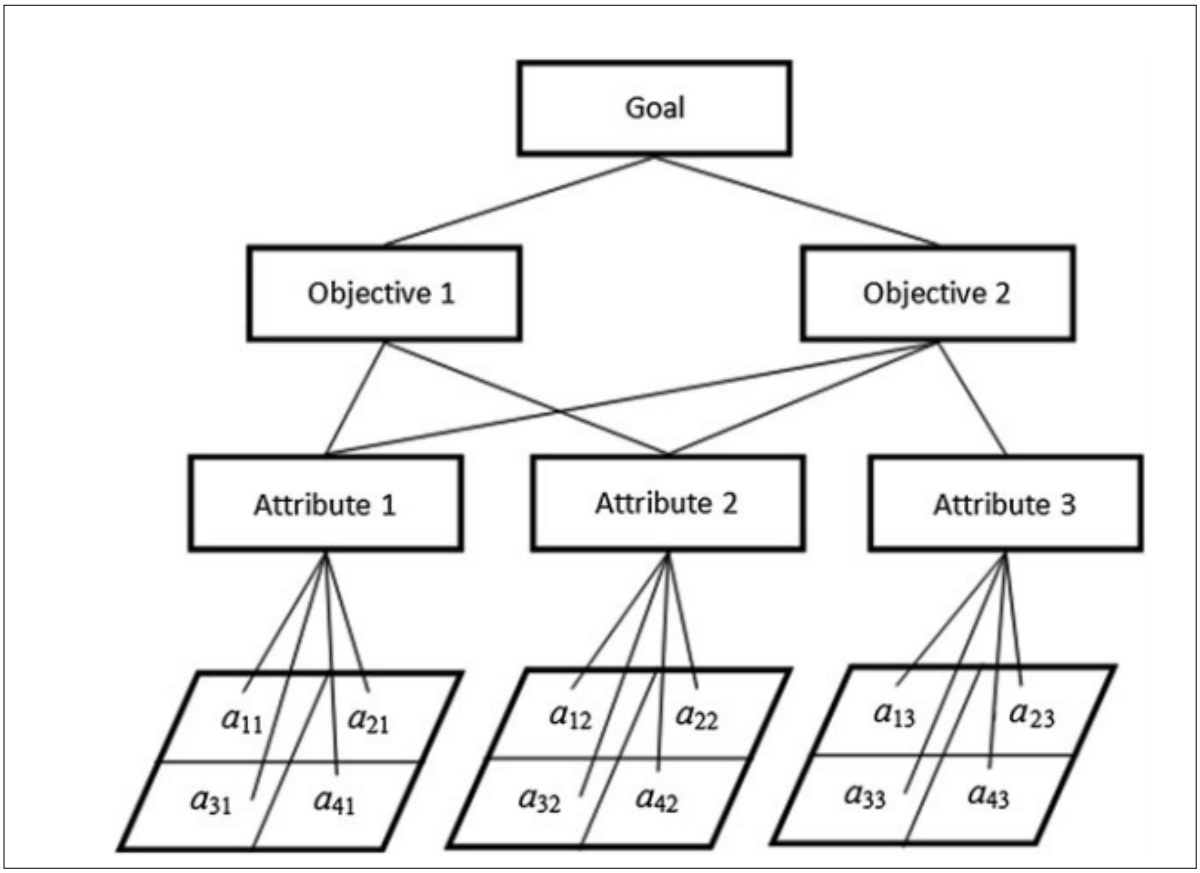
Furthermore, GIS-MCDA is formulated to transform geographic information data together with preferred information in order to obtain information for decision-making purposes (Malczewski and Rinner, 2015). These two methods have complimented each other and have become widely used within the urban planning and management sector over the years. According to Meng and Malczewski (2015), these two distinct areas of research have similarly benefited from each other because the GIS component has assisted in providing a technical and procedural platform for analysing multi-criteria decision problems (Malczewski and Rinner, 2015).

GIS also provides a platform for managing, sorting, visualising and analysing decision problems (Malczewski and Rinner, 2015; Meng and Malczewski, 2015). It allows practitioners, decision-makers and analysts to think and visualise spatial relationships in a meaningful and more sophisticated way (Malczewski and Rinner, 2015). Various elements contribute to the success of an MCDA (Malczewski and Rinner, 2015). These include decision-makers, interest groups, decision making agents, hierarchical structure, decision alternatives, feasible alternatives, non-dominated alternatives and decision matrixes (Malczewski and Rinner, 2015).

The decisions can range from an individual who is looking for a house or a group of people looking for a suitable site for developing a house (Malczewski and Rinner, 2015). From a spatial perspective, decisions are, however often made by a group and thereby making them multi decision-makers (Malczewski and Rinner, 2015). These decision-makers can be interest groups such as organisations, individuals or in organised groups having interest or share in the project or programme (Malczewski and Rinner, 2015). These groups could be supporters of a specific plan or decision, those who will be affected by a decision and those who have legal responsibility for the negotiating and meditating and sanctioning the action of the proponents (Malczewski and Rinner, 2015). Decision-makers can also be agents in a computer program format characterised by rationality and autonomy (Malczewski and Rinner, 2015). Humanistic characteristics can be found such as preferences, opinions and beliefs which allow for the representation of human decision-makers to work in a real-world virtual environment (Malczewski and Rinner, 2015). These decisions have a set of alternatives which can be

evaluated according to measurable, comprehensive, operational, non-redundant and decomposable criteria which involving objects and attributes (Malczewski and Rinner, 2015). The objectives and attributes have structures which are hierarchical, and the most general objectives are at the highest level.

The more defined an objective is, the lower it ranks in level (see Figure 12). These can then be translated and defined into attributes which are quantifiable indicators extended to objectives for actualisation purposes (Malczewski and Rinner, 2015). Hierarchical structure usually consists of four levels which are typically 1) goals, 2) objectives, 3) attributes and 4) alternatives. However depending on the complexity and detail of a problem the elements can be reconfigured to match the problem statement (Malczewski and Rinner, 2015).




Source: (Malczewski and Rinner, 2015)

Figure 52: The decision problem hierarchical structure

Decision alternatives can be defined as the number of choices available for the decision-maker to select from (Malczewski and Rinner, 2015). For example, a geographical decision has two

options to choose from, action and location. In other words being able to answer the question of what needs to be done and where should it be done (Malczewski and Rinner, 2015).

At the centre of the GIS-MSDA are decision rules or aggregation which allow decision-makers the liberty to select alternatives from many alternatives available (Meng and Malczewski, 2015). The most regularly used and sometimes combined decision rules are the weighted linear combination (WLC) and the Boolean overlay (Meng and Malczewski, 2015). The Boolean overlay uses logical statements of suitability (for example 0 or 1) that have been transformed from attributes, and then combines them by using logical operators such as (Logical AND, intersection) and (Logic OR, union). On the other hand, Weighted Linear Combination (WLC) attributes are standardised to a numeric range, and attributes are subsequently aggregated through the weighted average function (Meng and Malczewski, 2015).

According to Antunes et al. (2010), the Analytical Hierarchy Process (AHP) considers four major steps in decision making. The first step is breaking down the problem into a hierarchy of decision elements while the second is using a pair-wise comparison of these elements through the collection of data. The third step is to estimate the relative weights and lastly aggregate these to get a set of ratings for the decision alternatives (Antunes et al., 2010). Another decision making technique is the Recognition Primed Decision Making Theory (RPDM). This technique follows the naturalistic approach to decision making. Unlike other techniques it attempts to understand how decisions are made rather than define the decision making process (Antunes et al., 2010). It seeks to understand how things such as uncertainty, ill-defined goals, time pressure and factors affect decision making. This approach endeavours to also highlight the concept of situation awareness as measured against expectancies, actions and goals as well as cues (Antunes et al., 2010).

The numerical analysis in decision making techniques follows three main steps: The first step is to determine the relevant alternatives or criteria (Drobne and Lisec, 2009). The second step is to assign numerical measures to their relative importance; for instance, the weights, to the measures of performance and the criteria of alternatives. The last step is ranking each alternative by processing the numerical value (Drobne, and Lisec, 2009).

The Weighted Product Model, similar to the WSM makes use of multiplication instead of addition in the formula (Triantaphyllou and Sánchez, 1997). This means that each alternative

is compared with others by multiplying a number of ratios in each criterion (Triantaphyllou and Sánchez, 1997). Each ratio is raised to the equivalent power to the relative weight of the corresponding criterion. For example, to compare alternatives $A_p$ and $A_q$, *(where M ≥ p,q ≥1)* the following calculation formula is used (Triantaphyllou and Sánchez, 1997):

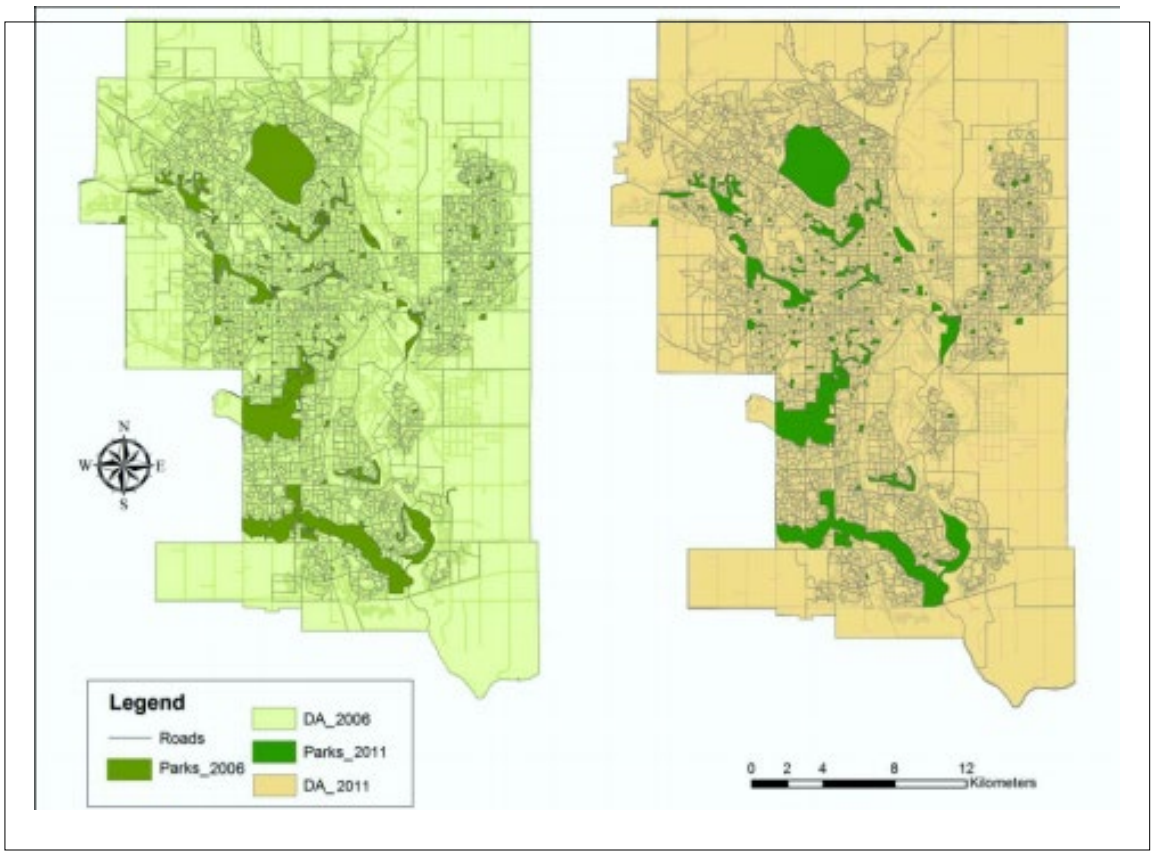
$$R\left(\frac{A_p}{A_q}\right) = \prod_{j=1}^{N}\left(\frac{a_{p\,j}}{a_{qj}}\right) *^{W_j}$$

If alterative $A_p$ is more desirable than alternative $A_q$ then the ratio $R\left(A_p / A_q\right)$ will be greater than or equal to one (Triantaphyllou and Sánchez, 1997). The best alternative in this case would the one which is better than or at least equivalent (Triantaphyllou and Sánchez, 1997). The WPM is at times named the dimensionless analysis since its formula excludes any units of measurement. Similar to the Analytical Hierarchy Process, the technique is often used in both single and multi-dimensional decision making problems (Triantaphyllou and Sánchez, 1997). The AHP uses the relative value and not the absolute measures of performance. In that case, this formula is often used (Antunes et al., 2010):

$$\sum_{i=1}^{M} a_{ij} = 1, \qquad \textit{for any } j = 1,2,3, \ldots, N.$$

### 3.3.1 Case Study 1: Calgary in Albertina (Accessibility to public-park)

In a study conducted by Meng and Malczewski (2015), the accessibility to parks in neighbourhoods located in the City of Calgary in Albertina, Canada was evaluated using both the Weighted Linear Combination (WLC) and Boolean operators (see Figure 13). As a brief background, the City of Calgary is not only known as the transportation hub but also known as the energy capital of Canada (Meng and Malczewaki, 2015). With the existence and rapid boom of oil, Calgary has been one of the fastest-growing cities in Canada and has resulted in an exponential increase in population over the years, estimated at 1 360 000 in 2014 (Meng and Malczewski, 2015).




(Meng and Malczewski, 2015; 34).

Figure 63: Case Study 1: MCDA & GIS - Spatial distribution of parks in Calgary, Alberta

According to this research, the total area and number of public parks decreased between 2006 and 2011, from 12869 to 12793 acres, and 278 and 213 parks respectively (Meng and Malczewski, 2015). Additionally, this research also found that, over five years, the number of small parks decreased by 37%, neighbourhood parks by 18% and the number of community parks stayed the same (Meng and Malczewski, 2015).

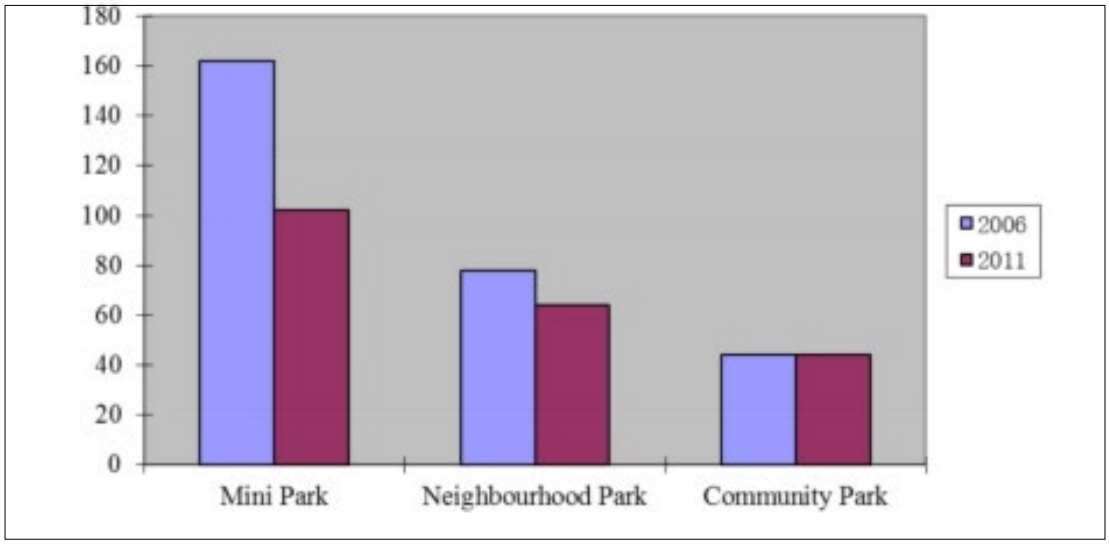



Figure 74: Case Study 1: MCDA & GIS - Count of different types of parks

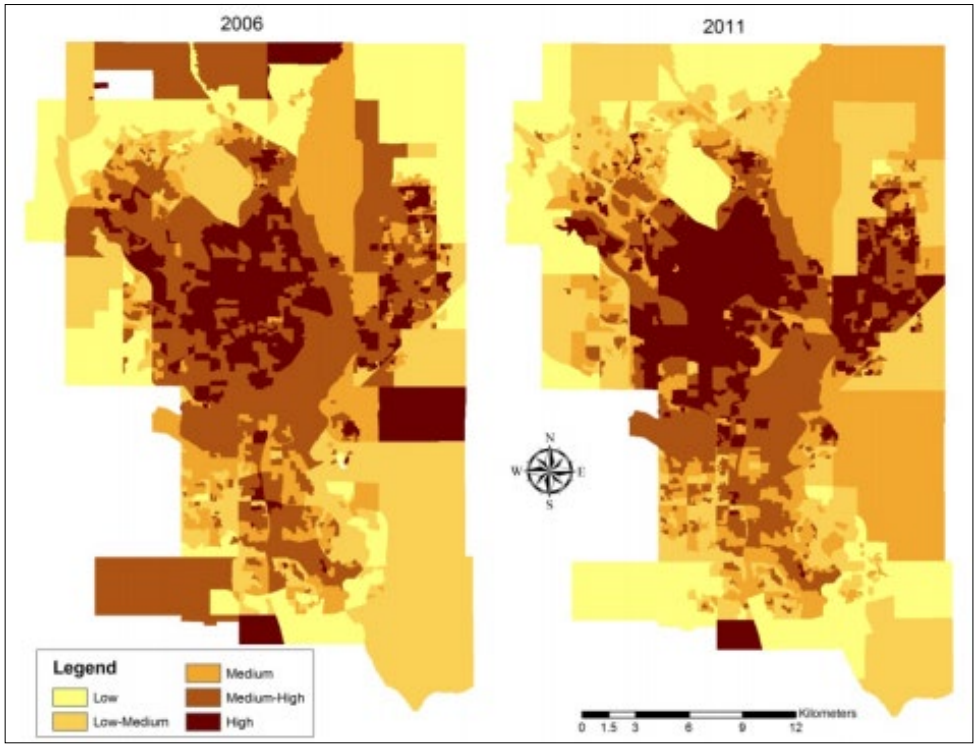
(Meng and Malczewski, 2015; 34).

The study used 2006 and 2011 census data (see Figure 14), aggregated per block which consisted of 400 to 700 people or disseminated area (DA) level (Meng and Malczewski, 2015). This was used to analyse resident's spatial distribution (Meng and Malczewski, 2015). Other datasets used were the DA boundaries from Statistics Canada, and the street network and park boundaries from Digital Multi Track Interface (DMTI) Canada.

This study used three methods to measure accessibility to quantify each type of park. The applicable measuring distance was applied per park type. Using the Network analysis module from ArcMap (ESRI, 2010a), the distance was measured outwardly from the centre of a DA (Meng and Malczewski, 2015). The distances used were 0.25 miles and 0.50 miles and 3 miles (translated to 0.4, 0.8 and 4.84 km, respectively) (Meng and Malczewski, 2015). The distance was explicitly chosen to measure reachability from the park user's perspective.

The GIS-MCDA procedures consisted of two steps, the first was the evaluation of the overall accessibility score for the parks with a decision or evaluating rule. The second involved defining of the evaluation problem within the hierarchical structure (Meng and Malczewski, 2015). The accessibility of parks is evaluated on three hierarchical levels, namely decision alternatives or DAs, attributes and goals, of which nine attributes of the DAs were considered both in 2006 and 2011. Using the ArcMap (ESRI 2010b), the spatial analysis model generated 18 attribute maps divided per year of study respectively, from the attribute weighted utilising

the number residents per DA (Meng and Malczewski, 2015). The maps (see Figure 15) were then converted using the 30m as a resolution for raster data layers to provide input datasets to evaluate accessibility (Meng and Malczewski, 2015).




Source: (Meng and Malczewski, 2015; 38)

Figure 85: Case Study 1: MCDA & GIS - Weighted Linear Combination reclassified showing accessibility patterns

The raster maps (see Figure 15) were then combined using the Weighted Linear Combination, and the accessibility score $S_j$ of j-th alternatives (DA) was calculated as follows (Meng and Malczewski, 2015):

$$S_j = \sum_{k=1}^{h} W_k P_{jk} \prod_{g=1}^{q} C_g$$

The results indicated that the populations located in the centre as well as on the eastern side of Calgary have better and higher levels of accessibility to public parks than the rest of the city living on the outskirts (Meng and Malczewski, 2015). This indicated that there are spatial inequalities concerning the location of parks in the city. A comparative analysis indicated that

the cause of inaccessibility of public parks from 2006 to 2011 is the decline of public parks in the northern parts of the city, with more public parks available in the Southern part (Meng and Malczewaki, 2015). The population distribution shift has also contributed to the accessibility patterns (Meng and Malczewski, 2015). For example, the peripheral parts of the city have shown exponential increases over the years due to the rapid expansion of the city. As such, the development and availability of parks have not been made available at the same pace as the increase in population (Meng and Malczewski, 2015).

These results display the usefulness of GIS-MCDA as a tool for those involved in the planning of public parks and specifically for the use by authorities to identify areas that need better accessibility to public parks as well as to monitor change over time (Meng and Malczewski, 2015).

The Planning Support System will enable better planning of spaces and create a friendly environment in which communities and families can flourish. A similar study employed a Multi-Criteria Decision Analysis based framework to assess the quality of public spaces (Herthogs et al., 2018). From both these studies, I observe that public spaces play an important role in creating sustainable and vibrant cities (Herthogs, et al., 2018). These spaces are platforms where social inclusion and social interaction facilitate the exchange of ideas, skills and culture, and support tourism, leisure and trade activity, amongst other things (Herthogs et al., 2018).

These examples showed how parks could be analysed to help the city plan better. However, in the next example, I look at how a PSS was developed to select the most suitable areas for developing industrial parks in the Hamadan province, Iraq.

### 3.3.2 Case Study 2: Location of industrial parks

Industrial parks in developing cities have played a significant role in urban and regional planning because of their ability to provide economic opportunities that are environmentally viable and efficient (Arabsheibani, Sadat and Abedini, 2015). Thus the example following describes, a study conducted to find suitable land for industrial parks in the Hamadan province in the central-western region of Iraq (Arabsheibani, Sadat and Abedini, 2015).

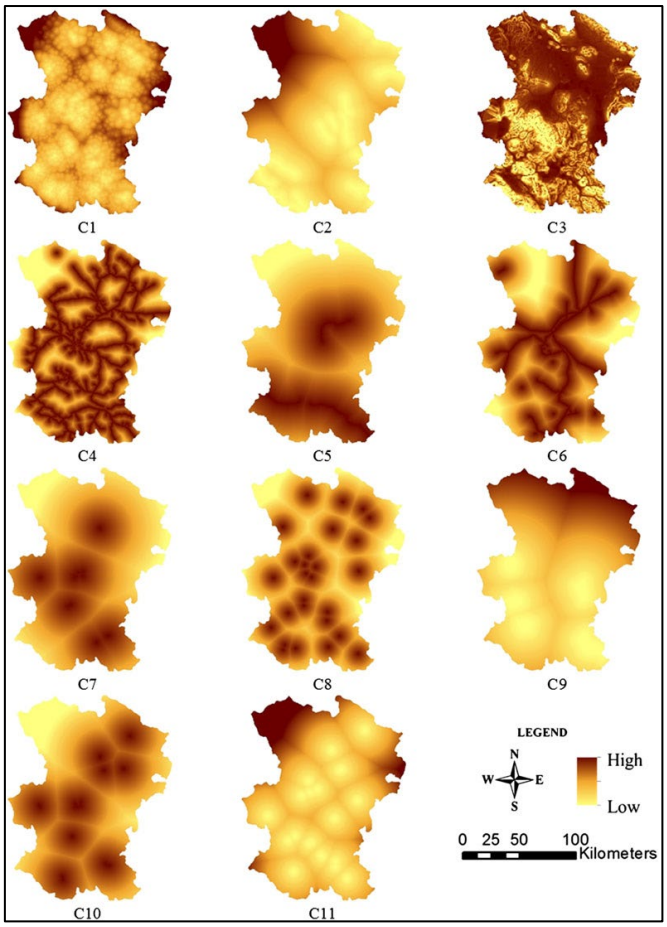
Urban development happens with economic activity in mind, and industrial development is almost inevitable for manufacturing and production purposes (Arabsheibani, Sadat and Abedini, 2015). However, very often industrial areas bring environmental hazards which may affect the surrounding residential areas as well as the natural environment, mainly if these are grouped in one area (Arabsheibani, Sadat and Abedini, 2015). It is therefore imperative that studies be conducted to find suitable locations where these can exist or take place (Arabsheibani, Sadat and Abedini, 2015). These sites have to meet desirable socio-economic and environmental conditions (Arabsheibani, Sadat and Abedini, 2015).

The advantages of selecting a suitable site are that more economic opportunities can occur in the correct area, and environmental hazards can subsequently be reduced (Arabsheibani, Sadat and Abedini, 2015). In order for industrial impacts to be reduced, land, the environment, sectoral planning tools and energy needs must be considered. In Sectoral Planning, things such as cost benefit analyses scenario building and multi-criteria analysis is an interdisciplinary approach which makes the best decision possible (Arabsheibani, Sadat and Abedini, 2015). Therefore it is inappropriate to base a decision on only one criterion because of the various goals that must be met in a project.

Consequently, hybrid GIS-Multi Criteria Decision Making theories and processes were used to assess suitable locations. GIS in such a study is essential for representing the results for spatial data aggregation, land suitability analysis and site selection (Arabsheibani, Sadat and Abedini, 2015). Consequently, hybridity is used in the integration of the fuzzy Decision Making Trial and Evaluation Laboratory, better known as the fuzzy DEMATEL (Arabsheibani, Sadat and Abedini, 2015).

The DEMATEL method was developed in Geneva and analyses relations between direct and indirect components of a system, depending on its complexity and type (Arabsheibani, Sadat and Abedini, 2015). The DEMATEL is represented through matrix algebra (Arabsheibani, Sadat and Abedini, 2015). The fuzzy DEMATEL is used together with an Analytical Network Process (ANP) in order to study land suitability for the establishment of an industrial park by calculating the final weight of each criterion as well as integrating GIS Layers (Arabsheibani, Sadat and Abedini, 2015). The reason for applying this technique is to clarify the importance of using a criterion for industrial parks and for capturing of the causal relationships between criteria as the outputs (Arabsheibani, Sadat and Abedini, 2015).

Eleven criteria were selected for new industrial parks (after much consultation with experts and the limitations of data availability for the evaluation process (Arabsheibani, Sadat and Abedini, 2015). The criteria chosen were the land costs, the percentage of land slope and the distances to the nearest railway, the nearest power station, the nearest main road, the nearest city centre, the nearest health care centre, the nearest protected area, the nearest available industrial area and the nearest main road as showed in the image below (Arabsheibani, Sadat and Abedini, 2015). The limitations for this study were the omission of two criteria thought to be useful, which were the distances to the nearest flood line and to the nearest special economic zones (Arabsheibani, Sadat and Abedini, 2015).

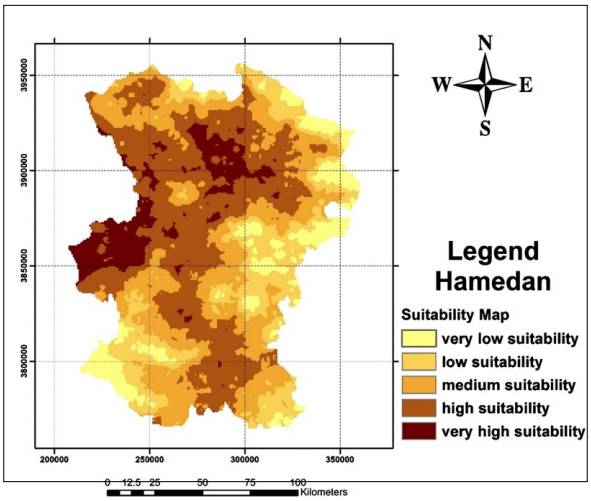



Source: (Arabsheibani, Sadat and Abedini, 2015; 454)

Map 1: Industrial Land Suitability Criteria

The map can be briefly described as follows according to the numbering. Corresponding maps: C1 – land costs, C2 – distance to nearest fault, C3 – Percentage of land slope, C4 – distance to nearest main road, C5 – distance to nearest railway, C6 – distance to nearest power transition, C7- distance to nearest water supply, C8 – distance to nearest city centre,

C9 – distance to nearest protected area, centre, C10 – distance to nearest health centre, C11 – distance to nearest available industrial area (Arabsheibani, Sadat and Abedini, 2015).




Source: (Arabsheibani, Sadat and Abedini, 2015; 457)

Figure 96: Case Study 2: MCDA & GIS - Land suitability map

The final suitability map (see Figure 16) indicates whether a particular area is suitable for industrial use. The results indicate that 15% of the Hamadan Province is ranked as Very High on suitability and 31% is highly suitable while the rest is within the medium to low classification (Arabsheibani, Sadat and Abedini, 2015).

## 3.4 Conclusion

The GIS-MCDA method as a Planning Support System has been discussed and explored to illustrate its usefulness within the decision-making process in urban and regional planning. This combination has shown that MCDA assists with the aggregating and weighting of criteria chosen to make more accurate findings. The first example demonstrated its usefulness in measuring accessibility to public parks by analysing change over time in the City of Calgary in Canada. This study was conducted because of the fast paced growth of the city due to new developments which created a shortage of public parks in the new areas. It was also discovered that some public parks were not increasing as much as they should.

The second example illustrated how the GIS-MCDM method was useful for locating new areas for industrial parks, since this type of land use and development is notorious for causing

environmental problems for surrounding residential areas. The second example illustrated this method by creating a Well Located Land Index to find strategically located land in the City of Ekurhuleni, given the challenge of segregated urban planning. The chapter demonstrates that the Multi Criteria Decision Analysis can be used to identify suitable land for industrial parks or community Parks.

CHAPTER 4: THE WELL-LOCATED LAND INDEX (WLLI) AND THE SMART LAND AND PROPERTY INDEX (SULPI)

## 4.1 Introduction

This chapter demonstrates two research projects I was involved in during the years of 2017 and 2019. The first research project included in this chapter is drawn from a paper published in the Springer Lecture Notes in Geoinformation and Geography series. The paper proceeding was presented by myself at the 15th International Conference on Computers in Urban Planning and Urban Management (CUPUM) held in Adelaide Australia on the 11-14 July 2017. The theme of the conference was Planning Support Systems for Resilient and Smart Urban Futures. The Chapter was co-authored with Prof. Walter Musakwa and Thembani Moyo, with myself as the leading author. My role in the research project was informing and selecting the criteria to be used for the modeling as well as sourcing the data. Another role I played was to write the literature review on the South Africa Spatial form. The title of the paper proceeding was *Developing the Well-Located Land Index to Establish Smart Human Settlements for the Ekurhuleni Municipality, South Africa.*

The second research project included in this chapter is a poster and a short paper project titled *The Smart Urban Land & Property Index (SULPi) as a Planning Support Systems to foster Local Economic Development in South Africa*. This project was accepted at the 16th International Conference on Computers in Urban Planning and Urban Management (CUPUM) held on the 8-12 July 2019 in Wuhan, China. While I was unable to attend the conference, my role in the project was to assist in selecting the criteria for the SULPi as well as to assist in drafting the short paper which has not been published.

## 4.2 The Well Located Land Index

The City of Ekurhuleni like other cities is challenged with finding strategic land for Human Settlement Development, and the easiest option was to develop on state-owned land next to the townships (Mokoena, Musakwa, Moyo, 2017; Harrison, Todes, & Watson, 2008; Huchzermeyer, 2003).

Coupled to that, the city of Ekurhuleni is also challenged with 119 informal settlements which constitute approximately 160 000 households who require housing, furthermore, the city faces

geotechnical challenges associated with the presence of dolomite formations. According to the Municipal Spatial Development Framework (Theory of Change), 52% of the land is dolomitic, with a majority of the medium to high-risk dolomite areas situated in townships. This is a cause for concern because, even though new engineering technology has been designed to develop low-cost housing on dolomitic land it is also costly for the city (City of Ekurhuleni, 2015). Environmentally the land is affected by wetland and conserved land constraints, which constitutes 68% of undeveloped land. Furthermore, the mining belt is inundated with shallow undermining, mine dumps, slime damps and quarries.

Given these challenges, the GIS-MSDA and AHP was used to develop a Well-Located Land Index as a PSS that would assist the municipality in finding strategic land (Mokoena, Musakwa and Moyo, 2017). The history of South African Planning has also contributed to the South African spatial form which has proved to be unsustainable from an environmental, social and economic perspective (Harrison et al., 2008; Mokoena, Musakwa and Moyo, 2017). From a policy and legislative perspective, there have been several developments regarding the location of low-income housing, and the design of layouts that must be integrated to include different income groups. These policies include the National Development Plan, The Breaking New Ground and Spatial Planning and the Land Use Management Act No.16 of 2013.

The methodology used to develop the Well-Located Land Index (WLLI) for Ekurhuleni involved the identification of Criteria and assigning of Weights, assigning of criteria rule sets and mapping and lastly computing the Well-Located Land Index (Mokoena, Musakwa and Moyo, 2017). These processes are briefly described by the authors as follows.

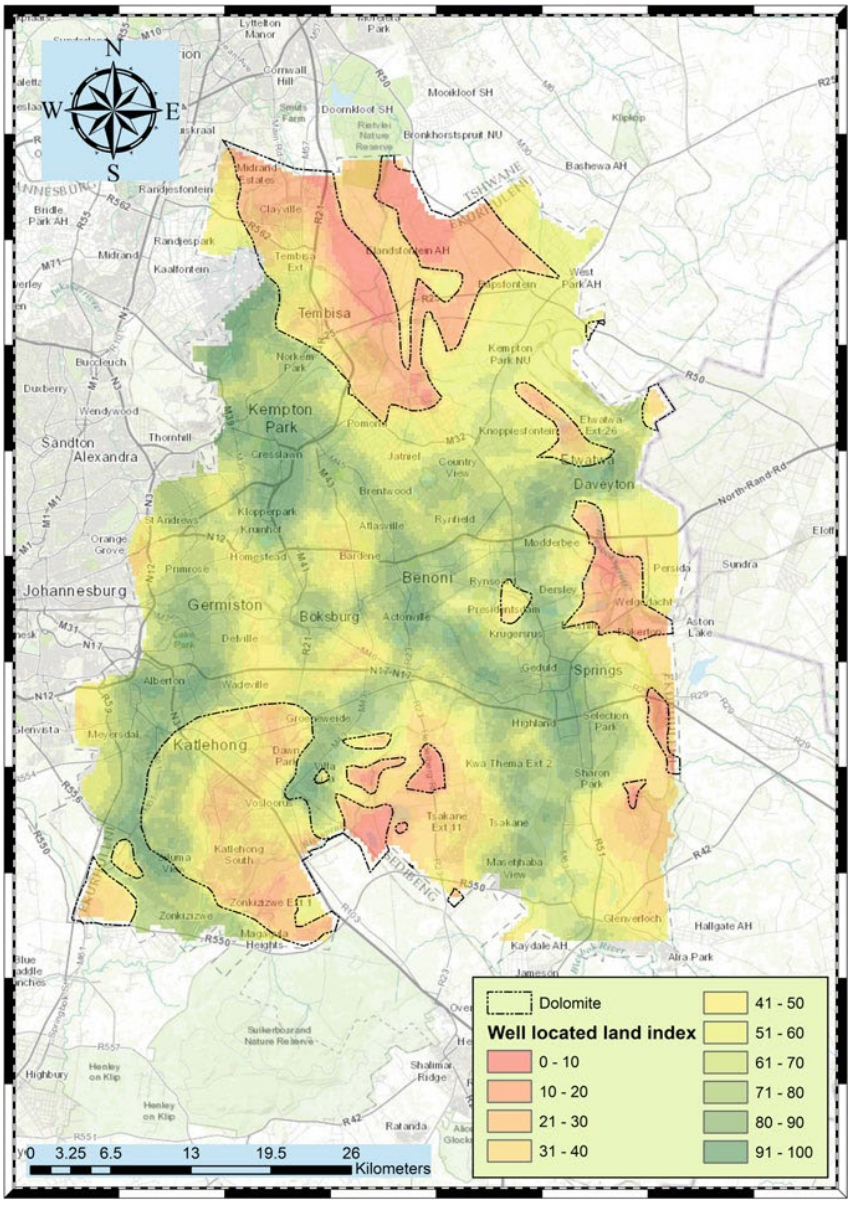
The identification of criteria for the WLLI was completed through a participatory planning workshop. The persons who attended the workshop were housing officials, urban planners, environmentalists GIS professionals and academics (Mokoena, Musakwa and Moyo, 2017). The criteria selected (see Figure 14) were channelled from literature on smart cities, human settlements and National Policy such as the National Development Plan (Mokoena, Musakwa and Moyo, 2017). Thirteen criteria were used and agreed upon by officials and academics who engaged in a Group Analytical Hierarchy process (GAHP) using a pairwise comparison matrix to weight each criterion (Mokoena, Musakwa and Moyo, 2017). From that process, a template of 78 pairwise comparison was used to run and further weight and capture results using the GAHP calculator and software by Goepel (Mokoena, Musakwa and Moyo, 2017).

Table 3: Criteria used to identify well-located land

| Criteria | Weight | Rank |
|---|---|---|
| Dolomite | 20.2% | 1 |
| Mining | 17.8% | 2 |
| Bus Rapid Transit Stations | 13.3% | 3 |
| Train Stations (Gautrain) | 10.4% | 4 |
| Train Stations (Metro) | 9.5% | 5 |
| Priority Areas | 8.5% | 6 |
| Airport | 5.7% | 7 |
| Elevation (Slope) | 4.5% | 8 |
| Major Towns | 2.7% | 9 |
| Soil Texture | 2.2% | 10 |
| Roads | 2.1% | 11 |
| Proximity to rovers | 1.6% | 12 |
| Proximity to informal Settlements | 1.6% | 13 |

Source: (Mokoena, Musakwa and Moyo, 2017; 102)

To assign rule sets and mapping involved collecting spatial data from the City of Ekurhuleni, the National Geospatial Inspectorate and the Council of Geosciences to be stored in a geodatabase (Mokoena, Musakwa and Moyo, 2017). Each rule set was identified from relevant literature after which the ruleset maps were used to categorised using a suitability scale of 1-4, where one was not well located and four was well located (Mokoena, Musakwa and Moyo, 2017). What constituted well located land was any land located within 3 kilometres of public transport facilities. Infrastructure like bus stations and railway stations should be at least 5 -15 kilometres from mining activity. The land should be within 10 km of the major town and lastly within the priority areas earmarked by the city (Mokoena, Musakwa and Moyo, 2017).




Source: (Mokoena, Musakwa and Moyo, 2017; 105)

Figure 107: Well Located Land Index Map

In order to generate the Well Located Land Index (see Figure 17), the Weighted Linear Combination (WLC) in ArcGIS software was used. This is where $S_1$ is the total score of well-located areas for a land parcel or land unit. The calculation used the following equation, where $W_i$ of the criteria chosen was calculated using the Group Analytical Hierarchy Process (GAHP), where $P_i$ represents the value of each criterion, based on a corresponding standard, and n is the number of criteria. From there, the Well Located Land Index was reclassified where 0 is not well located and 100 is very well located.

Equation 1: GAHP Calculations (WLLI

$$S_l = \sum_{i=l}^{n} W_i P_i$$

According to the results, only 30% of the land in Ekurhuleni is well located and 17 % is not well located or unsuitable. The results also show that the highly suitable land is located in the activity corridors and major CBDs such as Benoni, Kempton Park, Germiston and Alberton as well as the OR Tambo International Airport.

## 4.3 The Smart Urban Land & Property Index (SULPi)

In South Africa the participation of low income communities in economic activity has been disadvantaged by locational inequalities (Dallego & Guglielmetti, 2011; NDP, 2011; Harrison et al., 2008). Apartheid planning played a big role in segregating people through legislative frameworks which created uneven economic opportunities (Dallego & Guglielmetti, 2011; Harrison et al., 2008; NDP, 2011). Previously, Black townships were then used as sources of cheap labour to service better located areas. Nevertheless, the Alexandra Township seems to be well located, however it is a township that still faces challenges such poverty and high rates of unemployment.

The purpose of this research that was accepted as a research poster for the 16th International Conference on Computers in Urban Planning and Urban Management in Wuhan, was to identify suitable locations where Local Economic Development can ideally take place, using the Weighted Linear Combination tool.

$$S_l = \sum_{i=l}^{n} W_i P_i$$

Where $S_1$ is the total score of the Index.

$W_I$ of each criterion is calculated using the Analytic Hierarchy Process

*I* represents the reclassified value for each criterion

N is the number of criteria.

The results in figure 18 indicate that a highly suitable location for Local Economic Development (LED) is situated west of the township, since those areas are in close proximity to industrial activity and the affluent Sandton area (Makoni, Mokoena and Thembani, 2019).

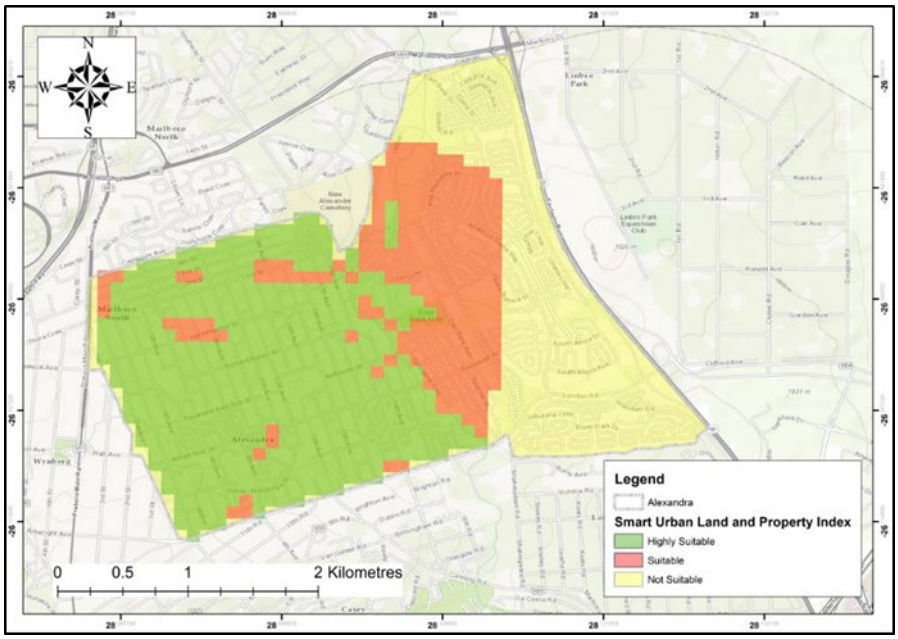



Figure 118: The Smart Urban Land & Property Index (SULPi) - research poster

(Makoni, Mokoena and Thembani, 2019)

## 4.4 Conclusion

This chapter demonstrated the use of planning support systems to solve locational problems in the cities of Ekurhuleni and Johannesburg. These two research works were both projects I was involved in that used the multi criteria decision analysis as a method to develop PSSs. The first project demonstrated how the city of Ekurhuleni can identify well located land for human settlements. The second project demonstrated how the City of Johannesburg can identify highly suitable land for local economic development in the Alexandra township. These examples show case how smart scientific methods can assist urban planners in making the best decisions for the city regarding human settlements and local economic development(LED).

CHAPTER 5: THE CHALLENGES IN USING PLANNING SUPPORT SYSTEMS IN LOCAL MUNICIPALITIES: EKURHULENI AND JOHANNESBURG

## 5.1 Introduction

This chapter discusses the results received from the survey that were sent online to officials from the Cities of Johannesburg and Ekurhuleni. This section will also briefly incorporate some of the results from the interview sessions I had with four officials from both cities.

## 5.2 Planning Support Systems

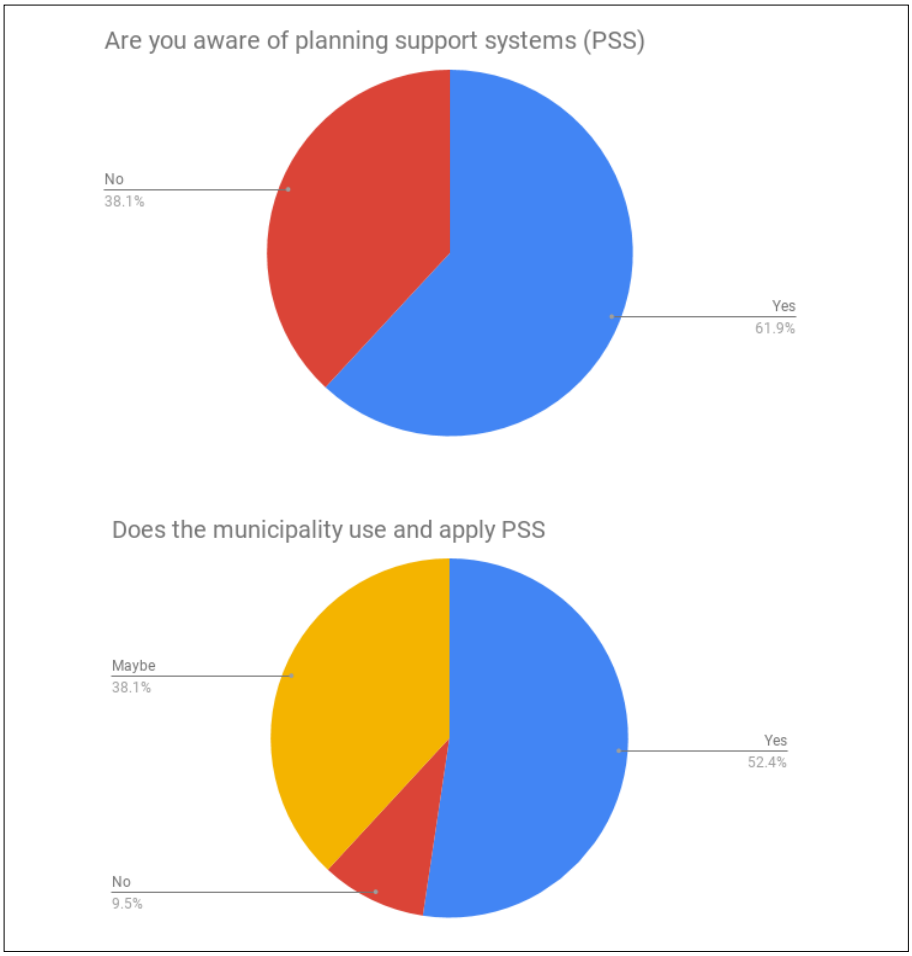



Figure 129: Questionnaire Results - PSS use by Municipality

Although PSS has been in existence for approximately 40 years in developing countries, this research shows that more needs to be done in order for critical decision-makers such as planners to know more about PSSs. The results depicted in figure 19 reveal that, 38.1% of respondents did not know about PSS. Given that the study area is made up of two Metropolitan cities, a gap needs to be filled to increase the knowledge of Planning Support Systems that will assist both the planners and the city.

However, it must be noted that both the Cities of Ekurhuleni and Johannesburg have done exceptional work with GIS to advance the cities' agendas of becoming a world-class African City and an Aerotropolis City respectively.

### 5.2.1 Do you agree that the municipality uses PSS?

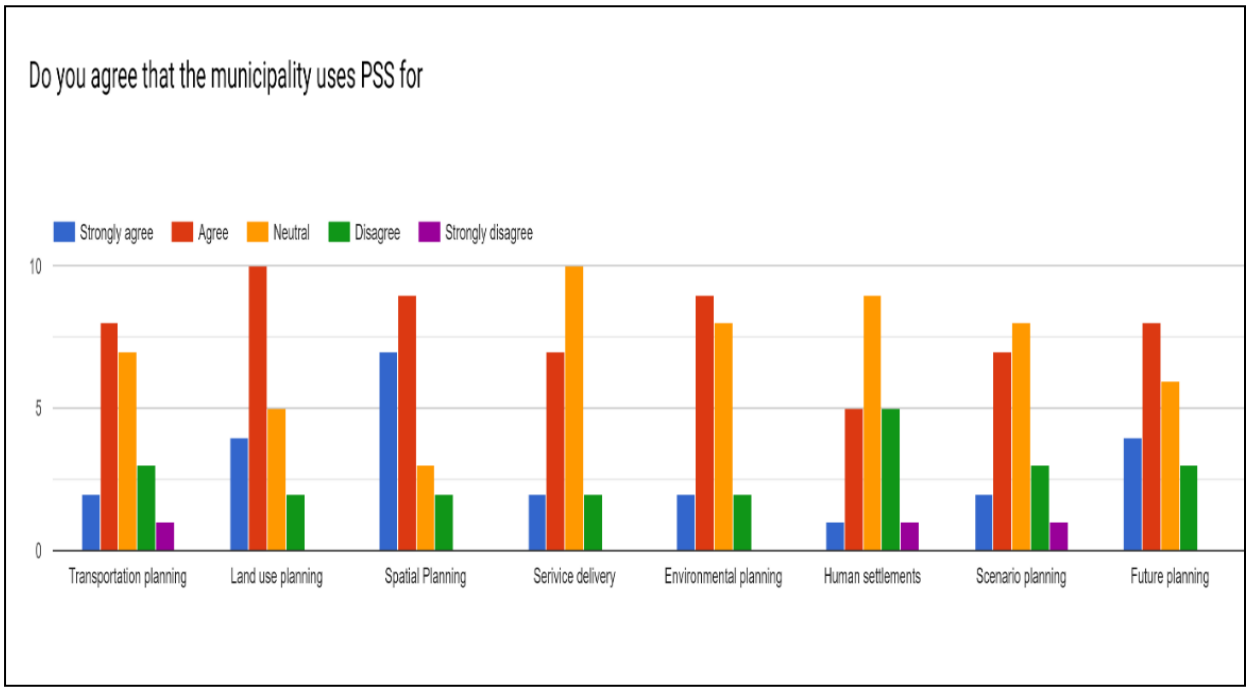



Figure 20: Questionnaire Results - Do you agree that PSS is used?

Municipalities use PSS for different reasons therefore, this question was intended to establish the uses of Planning activity PSS. According to the results, PSS is used the most for Land Use Planning. This deals mostly with the management of land through receiving of applications from developers and the state in order to change the rights of their property to suit the type of development intended. Land Use Planning is based on the Town Planning or Land Use Scheme of a Municipality.

The results in figure 20 also indicate that officials strongly agree that PSS are used for Spatial Planning purposes which is a critical part of urban planning, as it is often used to guide development from a cities' perspective.

#### 5.2.1.1 Interview Results on Land Use Planning and Spatial Planning

According to the interview conducted with officials from the City of Ekurhuleni (Interview, Official 1, 12 March 2019; Official 4, 15 March 2019) and Johannesburg (Official 2, 13 March 2019; Official 3, 13 March 2019), the GIS systems help to manage land use from a technology perspective. The officials interviewed in both municipalities indicated that they are in the process of developing an integrated system that would enable better management of land use applications. Those from Ekurhuleni, indicated that the challenge with the implementation of the system was the ability to integrate it with key departments, consequently, while the concept may be great, the implementation of the system for e-planning purposes was delayed because of a lack of coordination. Official 1 (12 March 2019) and official 4 (12 March 2019) both stated that departments within the city worked in silos and that it was difficult sometimes to coordinate activities within the city. Official 1 (12 March 2019) further stated that the reason for having an integrated system was the need to obtain critical information from various departments as well as obtain comments from them. Currently, the city only relies on the Geographic Information System for Land Use related information, but all applications are mostly dealt with on paper or hard copy basis. Respondents further stated that "the paper-based system is a challenge because some applications can get lost or delayed in the process." Furthermore, "applications such as these may only be discovered when the client inquiries about the application."

City of Johannesburg officials were clear on what their agenda was for the city, which is to spatially transform the city from apartheid planning to a just city. Some of the policy interventions they have developed, for example, are the Nodal Review Framework. This is based on an intensive modelling process whereby the city was analysed on many different levels but mainly themed around access. Using the hexagon shape, the city was assessed and existing major nodes were increased, and new nodes were established in order to align with the plans of the city (Official 2, 13 March 2019; Official 3, 13 March 2019). For example, in Soweto, Orlando and Jabulani were recognised as growing nodes that the city will look to develop (Official 2, 13 March 2019). Out of the townships, they were recognized as two critical

nodes that would realise the maximum potential for previously marginalised geographical locations (Official 2, 13 March 2019). It was further stated that although Soweto was previously marginalised, it is now becoming well located because of how the city is growing (Official 2, 13 March 2019).

Official 2 (13 March 2019) mentioned that the disadvantage which plagued the City of Johannesburg was the mining belt that currently acts as a divider between the South and North of Johannesburg, specifically the Soweto and Roodepoort areas. It was stated by Official 2 (13 March 2019) that the City had planned on developing road networks to link the city better and thereby creating new opportunities and better movement patterns between the two sides.

Another Planning policy that was recently approved to spatially transform the city of Johannesburg is the Inclusionary Housing Policy. While it does not use any Planning Support Systems or GIS Modelling it is a policy that can be used with the nodal review policy to establish well located areas for implementing inclusionary housing. The inclusionary housing policy seeks to narrow the gap between the job-housing mismatch and disjuncture because the urban space was previously designed to exclude Black people from living in well-located areas. While the state is primarily tasked with providing affordable accommodation, what the Inclusionary housing policy does is to introduce a mandatory requirement that all developers building 20 units and more must build 20% of the development to accommodate affordable housing (Official 2, 13 March 2019; Official 3, 13 March 2019). Alternatively, developers are to build 20% of their units smaller than the rest of the development, thereby charging less for the units so that different income groups may have access to accommodation.

### 5.2.2 Do you think the following are challenges and bottlenecks in the use of PSS?

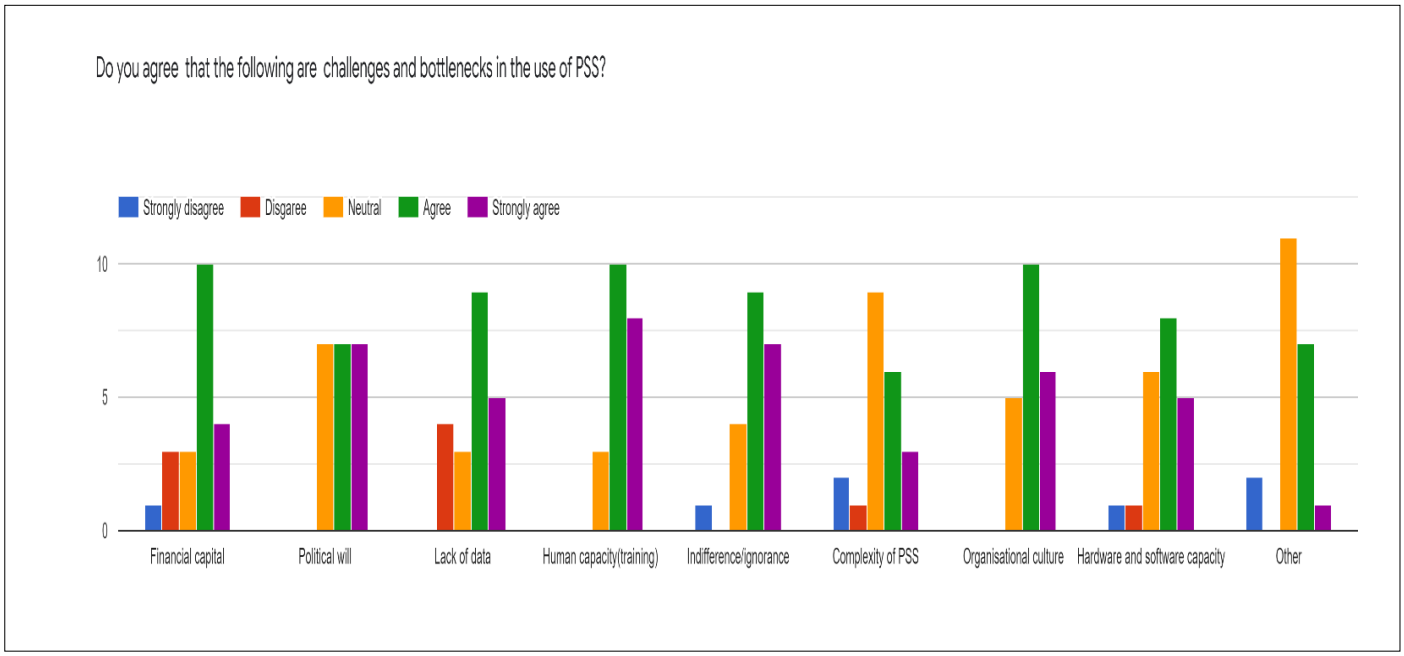



Figure 131: Questionnaire Results - Challenges and bottlenecks of using PSS

The results in figure 21 reveal that human capacity and training were the biggest challenges and bottlenecks, as not enough personnel were assigned to the development of PSS. Additionally results also indicated that indifference and ignorance were ranked the second-highest challenges along with political will when it comes to the support of PSS that must be developed further.

### 5.2.3 Interview on PSS challenges

The City of Ekurhuleni officials (Official 1, 12 March 2019; Official 4, 15 March 2019) indicated that there were not enough personnel assigned to work on Support Systems that would assist in the different tasks. This was specifically due to a shortage of funding to appoint critical posts with the City Planning Division. On the other hand, the City of Johannesburg indicated (Official 2, 13 March 2019) that they had a fairly good staff component that was correctly assigned to fulfil various tasks compared to other municipalities. They further indicated that, although they had a very good staff component, compared to the other cities around the world like New York and London, they had a smaller number of staff.

### 5.2.4 Do you agree that you use GIS for?

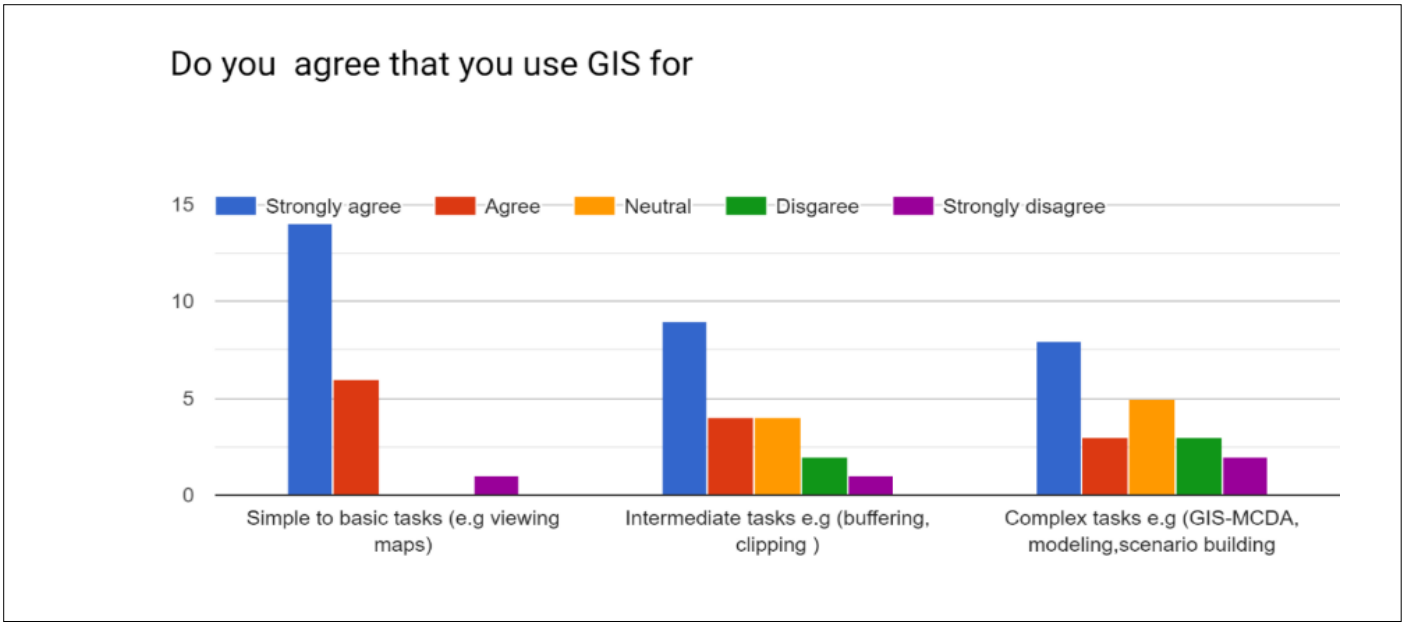



Figure 142: Questionnaire Results - Do you agree that you use GIS for?

Geographic information Systems is widely used in local government, and most certainly in the Cities of Johannesburg and Ekurhuleni. The results in figure 22 indicate that 95% of the respondents use the ArcGIS software, but only 40% have a degree in Town and Regional Planning which includes GIS training, and 20% have a post graduate degree in Town Planning which includes a GIS module. Furthermore, some have learned GIS on the job. What is worth noting is that GIS is mostly used for basic tasks such as viewing maps and less often for complex tasks such as GIS-MCDA, modelling and scenario building. While the results show that officials do not use GIS to complete complex tasks, the City of Johannesburg demonstrated

through interviews that policies such as the Nodal Review made use of complex GIS Modelling to advance the spatial trajectory of their city.

### 5.2.5 What is e-planning used for?

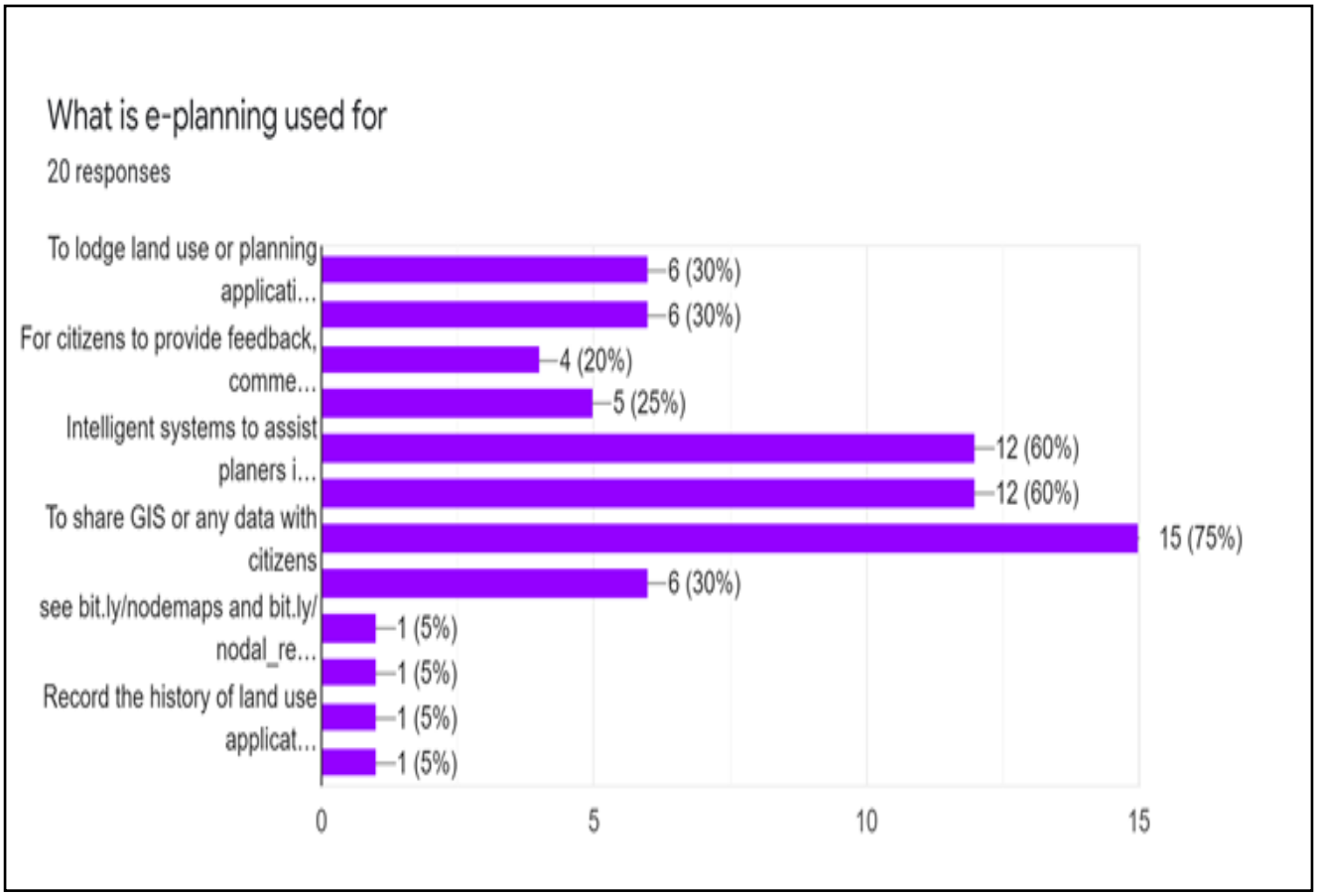



Figure 23: Questionnaire Results - What is e-planning used for?

e-Planning can be described as the interaction between planning and information technology which includes critical concerns such as policy making, governance, territorial management, citizenship, participation, and governance (Antunes, 2010). e-Planning is an extension of governance specifically for urban planning purposes. The results in figure 23 revealed that officials used e-planning: 1) To lodge land use planning applications. 2) For citizens to check on the status of their land use applications. 3) For citizens to provide feedback, comments, and any other issues on planning related matters. 4) To provide services and information to citizens. 5) Intelligent systems to assist planners in their tasks. 6) To assist planners in visualisation. 7) To share GIS or any data with citizens. 8) Data integration.

The results indicate that e-planning is not used as much as it could to help urban planners perform their day-to-day duties. Only 46% from the City of Ekurhuleni and Johannesburg indicate that they use e-planning, and the most frequent tasked performed on e-planning is to share GIS information with the public. This suggests that the capacity is fully utilized to bridge the gap between officials and the members of the public. The bottlenecks faced by municipalities include firstly a lack of knowledge of e-planning and secondly capacity. Other bottlenecks are the organisational culture, lack of political will and financial capacity. Though these did not stand out as the highest they are potent issues that could unlock the potential of both metropolitan cities to develop into recognised smart cities.

## 5.3 Conclusion

This chapter discussed the challenges that urban planners and policy makers in the City of Ekurhuleni and Johannesburg face in using Planning Support Systems and e-planning. Secondly the purpose of this chapter was to find out the extent to which such systems were used in these local municipalities. The interviews conducted with officials revealed that, while urban planning officials may have an educational background in Geographic Information Systems, the knowledge and use of Planning Support systems was moderate. What was also found is that both cities had policy documents that incorporated extensive GIS modelling through the City of Johannesburg Nodal Review and the Aerotropolise Master Plan from the City of Ekurhuleni. Both the policy documents and Master Plan are highly beneficial to the city for spatial transformation purposes.

However, the results also indicated that the biggest challenges which both cities face in using Planning Support Systems are human capacity and a lack of training. Furthermore, e-planning is mostly used to share information with the public.

# CHAPTER 6: CONCLUSION

This research has explored the usefulness of Planning Support Systems to foster future spatial planning post-1994. Two study areas were chosen, namely, the City of Johannesburg and the City of Ekurhuleni. The two cities were chosen because of their influence in the economy of the country and their spatial and structural positioning as metropolitan areas. The two cities are also plagued with spatial inequality which poses a challenge for people living far from economic opportunities, making them both sprawled areas, together with other cities and rural districts.

The research began by giving a brief background on South Africa's spatial planning trajectory. The trajectory which prevailed pre-1994 planning had its beginning in 1913 with the Native Land Act, when Black people were dispossessed of their land and moved into Bantustans in the rural areas, with limited access to the city. Townships in urban areas were also restricted because of the 'pass laws' that controlled movement. This dispossession of land resulted in Black people being further impoverished because they ultimately owned less and less land, which prohibited them from farming on a large scale. The urban environment becoming dominated by mining activity allowed cities to be formed in such a way that Black people were used as cheap labour to service mining activity and later on industrial activity. This meant that people were forcefully removed from their places of residence of choice and moved to places that were too far from economic opportunities, but also not too far to provide economic labour. This was also later seen post-1994, where RDP housing development was also developed in places that were far from economic opportunities. The mandate during that time was to build as many houses as possible to serve as many people as possible because of the existing housing backlog at the time, coupled with distorted urbanisation patterns that caused an influx into urban areas once pass laws were removed around 1994.

The smart city concept, as well as Evidence Based Planning, was discussed and explained to help understand why PSS is relevant within urban planning. Since two municipalities were chosen as study areas, governance was also discussed, as e-planning forms part of e-governance.

Different case studies were used to demonstrate how PSS is used both locally and internationally. It is the monitoring of policy that is useful to advance policy. Therefore, the first example of four cities around the world demonstrated how PSS could be used for the monitoring of planning policy . Research revealed that these are constantly formulated over the years, but very little is done to monitor whether policies are implemented in different cities. Another case study demonstrated two scenarios through GIS modelling that illustrated how the City of Johannesburg was to look like should policy be adhered to as well as how the city would look like if current development trends were to continue. The literature showed how policy makers would be enabled to identify how to close the gap. Another case study of Calgary, Alberta showed how PPS could assist the city to evaluate its shortage of parks in order to determine where different kinds of parks could be developed in the future. In another case study, the Multi-Criteria Decision Analysis (MCDA) method was used to determine the best location for industrial uses within a city. Using different criteria, it was then established that industrial activity was best suited further away from residential and other environmentally sensitive areas. The last case study was used to demonstrate where well-located land can be established for Human Settlement purposes in Ekurhuleni, again using the GIS MCDA method. The Smart Urban Land & Property Index (SULPi) research poster illustrated how GIS-MCDA can be used to determine well located economic development in the Alexandra township in Johannesburg. These case studies sought to answer research questions about how the GIS-MCDA method can be used a tool to develop Planning Support Systems.

The research, found, through the review of case studies and empirical research, that the role of planning support systems can yield better decision-making results for the Cities of Ekurhuleni and Johannesburg. The research also focused on the GIS MCDA methodology, in the literature review, to showcase how this can be used to develop PSS for cities. The study questionnaires revealed that there are a number of challenges in both municipalities hindering the use of Planning Support Systems. These are financial constraints, capacity, skill and a lack of political will to follow through the good plans that need to be implemented by various Departments such as City Planning from Ekurhuleni and the Spatial Transformation unit from Johannesburg.

In order to answer the second research question on what the challenges were in using Planning Support systems in local municipalities, data was collected using online questionnaires and interviews. Online questionnaires were then given to officials and 21 officials responded. The questionnaires were centred around; Which systems the two municipalities used?; What the

challenges in using PSS are?; What the levels of education are regarding Geographic Information Systems?; and Wat social media platforms they use?.

From the results, one gathered that PSS is not used to its fullest potential, especially because the level of education for GIS specifically is not very strong amongst planners. One also observed that e-planning is mostly used to share spatial data with the public and other officials. e-Planning, for example, can also be used to process land use applications online for both the public to submit and officials to process for example in the City of Johannesburg. In that way, land use applications can be fast-tracked to achieve better turnaround times. The results also demonstrated that the challenges faced by municipalities in using PSS include the lack of political will, funding, and a lack of capacity.

It is thus concluded that more work needs to be done to create smart cities in South Africa. While PSS proves to be useful, the City of Johannesburg is more advanced through employing e-planning and PSS to spatially transform the city and equip it to become smart.

It is therefore recommended that further research should examine the key decision points that can help build a PSS to assist in the implementation of transforming South African Cities.

It is further recommended that scenarios be modelled for both Cities of Ekurhuleni and Johannesburg from spatial and land use perspectives. For example, the City of Ekurhuleni could review the way in which the city would be affected if informal settlements were to continue growing rapidly and how this would affect the planning of future Human Settlement projects. It is further recommended that a PSS be built to look at how the Aerotropolis could have an impact on Township Economies in the City of Ekurhuleni.

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