An Exploration into Urban Agriculture and Rooftop Gardens in Johannesburg

A Research Report submitted to the School of Architecture and Planning

By

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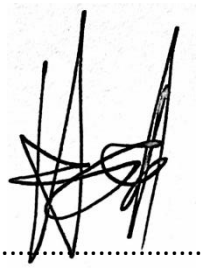
DECLARATION

I declare that this research report is my own unaided work. It is being submitted for the degree of Masters of Architecture in Sustainable Energy Efficient Cities to the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other university.



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Abstract

This study arises from the insight that the critical role of green infrastructure in urban areas is often not focussed upon at the same level and intensity as "standard" infrastructure such as roads, water and electricity. The key research question guiding the study revolves around whether urban agriculture should be included in the design process of buildings in Johannesburg, and how this could subsequently address the inter-relationships between city and building scale, aesthetics versus biodiversity as well as addressing the critical challenge of water scarcity through the process of greening the city. With this in mind, this study argues for a potential shift in land use control, whereby urban agriculture could be strictly regulated as a specific land use typology similar to the commonly recognised uses such as industrial, commercial or residential.

An overall qualitative approach was undertaken using the theoretical underpinnings envisaged by Lehmann (2010) and the 15 principles of Green Urbanism, to gain an understanding of the role players and processes involved in the building cycle, as well as urban agriculture development. Key role players were identified, and interviewed, substantiating how policy insight is necessary in practice.

The focus of this research report was on the building, and specifically the potential that buildings may offer a contribution towards green infrastructure, by providing such outcomes as passive thermal control and food security. Key comparisons were made between cities that go beyond the implementation of urban agriculture as an "extracurricular" activity, and fully embrace the holistic view of green urban development and sustainable cities. Examples have been taken from London, Toronto and Singapore regarding how rooftop gardens and urban agriculture have been included into the urban fabric. Johannesburg has a few initiatives, which are greatly reduced in scale when compared to these other cities, however, the local context needs to be considered when investigating the reason for this. Considering the importance of the benefits of such programmes (such as food security and job creation), it can be concluded that this inclusion of urban agriculture in the planning phase should be prioritised as an important intervention for urban development.

Key Words: Green Roofs, Urban Agriculture, Green Infrastructure, Policy and Practice, Johannesburg

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Acronyms

CBD – Central Business District

CUFCP - Chicago Urban Forest Climate Project

FAO – Food and Agriculture Organisation

GBCSA – Green Building Council of South Africa

GIS – Graphic Information System

IDP – Integrated Development Plan

JMOSS - Johannesburg Metropolitan Open Space System

LAI – Leaf Area Index

PV - Photovoltaic

RSDF – Regional Spatial Development Framework

SANS – South African National Standards

SDF – Spatial Development Framework

SHS - Sustainable Human Settlements

UDF – Urban Development Framework

UN – United Nations

USDA – United States Department of Agriculture

CHAPTER 1

1 - Introduction and Background to the Study

1.1 Introduction:

The topic of sustainable and energy efficient cities and buildings has gained interest for a large portion of modern urban history. Sustainability itself has a very broad definition, and can be divided into four main types, these being: human, social, economic and environmental (Goodland, 1995). While the human, social and economic sustainability definitions focus on the individual, social and manufactured capital values gained through various forms of education and investments, the environmental sustainability concept attempts to, *inter alia*, quantify the natural environment by balancing input and output systems which are used by humans. The general argument for environmental sustainability is that natural capital should be protected, with waste emissions being minimised and "harvest rates of renewables must be kept within regeneration rates" (Goodland, 1995, p. 5). With a focus on reducing waste, the strategy of energy efficiency is aimed at dealing with lowering energy consumption through efficient technologies including passive thermal control interventions and related behaviour change where possible.

A further focus of energy efficient methods presents the theory of green infrastructure being an integral part of urban development and sustainability, often referred to as 'urban greening'. The concept of greening applies to the general trend of sustainable development and not solely planting vegetation in the hope of mitigating the impact of development on the natural environment. The role of green infrastructure in urban areas is often not focussed at with the same level of intensity as standard infrastructure such as roads, water and electricity by both the state and developers. Lehmann's (2010) 15 principles of green urbanism guide the initial interrogation of concepts surrounding green sustainable developments which can be expanded to niche subjects such as urban agriculture and rooftop gardens. Within this concept of sustainability and greening, food security and production is brought about in order to reduce energy used in transporting food great distances, and being able to localise food production. With this in mind, there may be a potential shift in land use control and policy, whereby urban agriculture may be strictly regulated the same way that a specific land use typology such as industrial, commercial or

residential are currently viewed. There have been many studies regarding vegetation being incorporated into both urban areas and buildings as a passive cooling element (Munzer, 2015), however not a great deal of investigation into whether the type vegetation used can be harvested on a large scale.

The focus of this research report will be on buildings specifically and the potential they have for contributing to green infrastructure by providing such outcomes as passive cooling and food security. The report hopes to find the relevance and a possible qualifying rationale to include such interventions into the building design cycle through a possible policy intervention. The building types generally associated with rooftop gardens are commercial, office or high density residential, as these are the types most often present in a city's Central Business District. The core argument will focus on the benefits provided by adding agricultural components to buildings, and specifically where in the design process these components can be incorporated. Comparisons will be made between cities that do not simply implement urban agriculture as an ancillary activity, but as a primary contributing factor to green urban development and sustainability. The comparisons will focus around implementation and scale of urban agriculture on rooftops, as well as policies that guide such interventions. Considering the food security benefits of urban agriculture in places such as Cuba, Canada, Argentina and Austria (Arosemena, 2012), the inclusion of urban agriculture in the planning phase could be considered an important intervention for bringing urban development from a linear process towards a more cyclical process of production.

A further definition of what agriculture means within the scope of this report is required, as the term will be used more broadly than simply referring to a general agricultural model of growing food for consumption. The primary focus is on the various processes involved with developing and designing areas where urban agriculture can thrive, using a range of spaces, with the directive to moving projects to urban rooftops. The concepts of food production and food security are an additional means to justify the increased need for creative urban agriculture solutions. This report will seek to broaden the scope of the term 'urban agriculture' to include all methods of growing vegetation for both consumption and aesthetic purposes.

1.2 Background and Rationale:

The urban development of cities, such as Johannesburg, has occurred at such a rapid rate, that decision makers and developers are grappling with energy efficiency and sustainability concepts. The issue of food security is also high on the social and urban well-being agenda, due to recent droughts and other social factors such as unemployment, poverty and lack of access to community agriculture projects. The term 'Food Sovereignty' was introduced by Via Campesina, and deals with the right of people to have access to "healthy and culturally appropriate food produced through sustainable methods and their right to define their own food and agriculture systems" (La Via Campesina, 2011: in Draft Peoples' Food Sovereignty Act No. 1 of 2016, p. 8). Urban agriculture has found its way into certain areas in Johannesburg where small initiatives are under way, such as in Marlboro Gardens, Alexandra and Joubert Park. These are social benefit initiatives aimed at uplifting local at-risk communities by training individuals to grow and produce food for their local community. Initially their sole purpose was to focus on urban agriculture for produce within the city, in an attempt to understand if there is an approach for inclusion into the new building process or even retrofitting it into existing buildings. However, it soon became apparent that there is a broader scope of agriculture in the form of aesthetic gardening within the urban environment, which leads to a greater overarching theme, namely green infrastructure which needed to be understood. Below is a representation indicating how the components of green infrastructure, agriculture and landscaping intersect. It can be seen how urban agriculture and rooftop gardens require input from all three of these spheres, and a further breakdown of urban agriculture into four important sub-categories. For this research report, the internal urban agriculture sub category will indicate any type of horticulture within a building. The external sub category will include both horticulture and agriculture that occurs in an external environment. Within these two subcategories, there can be a further delineation between aesthetic and productive urban agriculture which may occur in both internal and external environments. The ornamental aspect refers to the strictly aesthetic goal of beautifying a selected area, while productive urban agriculture has the goal of producing goods for further use and consumption.

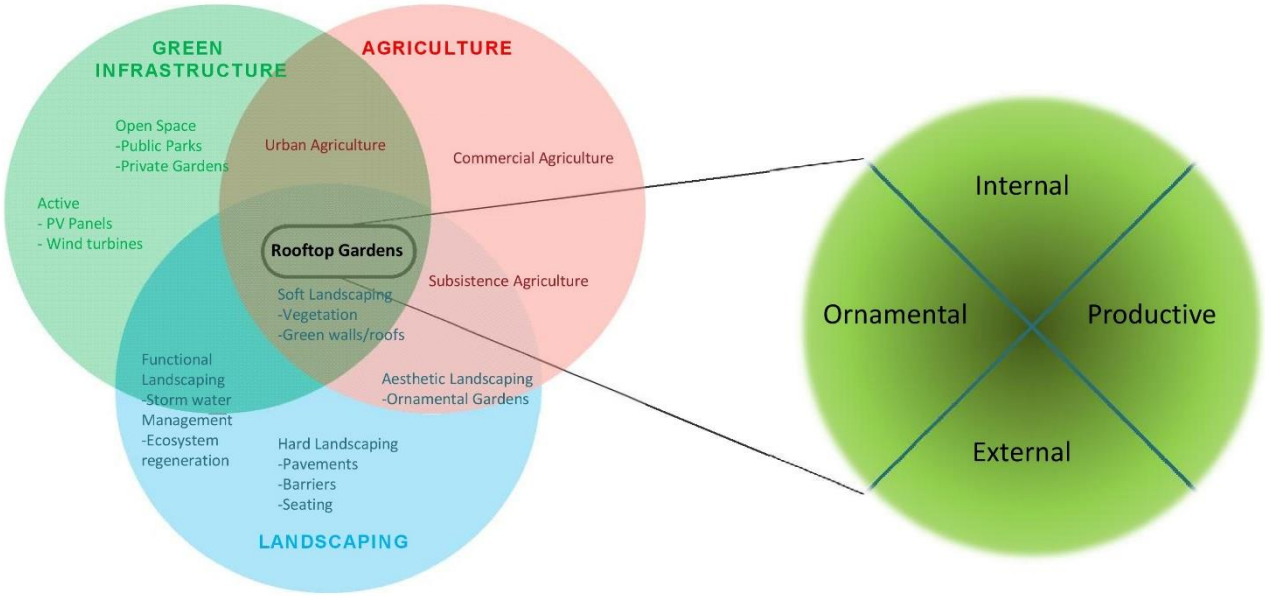

Diagram 1: Locating Urban Agriculture and Rooftop Gardens

As an example within this framework, the Chicago Urban Forest Climate Project (CUFCP) was commissioned in the early 1990s to investigate the role of vegetation in urban areas and specifically how it can reduce urban climate issues such as the heat island effect, water runoff and reducing atmospheric carbon dioxide (Nowak; 1994; p. 83). While Johannesburg is a relatively green city in terms of vegetation, a great deal of this vegetation is not necessarily indigenous to the Highveld (www.joburg.org.za). This introduces the dilemma of the type of vegetation being used in 'greening' the city and begs the question of whether urban agriculture is a 'green-washing' concept. There seems to be a niche in the development of the city, whereby urban agriculture for consumption may be able to assist with a whole range of problems currently facing both urban developers and inhabitants. The scale at which an urban agriculture intervention might be useful and ultimately sustainable, in terms of cost, efficiency and maintenance, is a major factor guiding additional research into the subject. The concept of scale is also influential on the choice of title for this report, choosing agriculture rather than horticulture as the core theme. The idea is that urban agriculture might be viewed as the large scale productions seen in rural areas in the form of farms, rather than the small scale backyard style of horticulture. It will be necessary to provide a clear definition of what is intended by the term urban agriculture in this research report.

Further to the question of scale, there should be an interrogation of whether this particular intervention can assist energy efficiency at all, or if it will simply burden the urban environment. Havana, Cuba and Copenhagen, Denmark both have subsistence urban agriculture programmes which are quite advanced in their function and inclusion into the urban fabric (www.architectural-review.com, 2014)(http://www.cityfarmer.info/, 2016), and therefore it may be assumed that such an intervention could work in a variety of different urban concepts. These assumptions should be cautioned against, as local context and culture play an important role in how such programmes are introduced and carried out. As mentioned previously, Johannesburg has a few initiatives which are greatly reduced in scale when compared to these cities that have included urban agriculture in their planning process, and therefore, a greater investigation into their functioning and possible constraints is required. While the dream of having productive spaces which produce consumable vegetation is positive, the reality of designing gardens and spaces with other basic types of vegetation will need to be considered. As stated in the introduction, this research report will look at a broader definition of urban agriculture, not limiting the vegetation type to consumable agricultural goods, but ornamental agricultural goods too, and finding out when, how and why to choose the vegetation type in the design process.

The building design cycle is helpful in describing where the incorporation of energy efficient technologies and processes may fit (Chi-Nguyen Cam, 2013). The initial visualisation stage involves the conceptual design, detailed design, analysis, documentation approvals and fabrication of materials. The construction, operation and maintenance phase then take over and transform the designed vision into the functioning building, which will be renovated or demolished at later stages of its life. The importance of the visualisation stage is crucial for making sure the correct materials, technologies and vision for the building are set so that the building phase and eventually running or occupation of a building can occur smoothly.

An often overlooked portion or stage of the building production cycle is the negotiation to obtain rights in order to proceed with the visualisation of a given building, essentially finding out what the 'box' looks like, in which a designer or architect can work. Along with these town planning rights of physical restrictions, there are also rights which need to be established for which the land may be used for. Once these rights have been obtained, there is another set of legislative conditions which need to be complied with in the form

building plans. Recently in the City of Johannesburg Municipality, both forms of legislation have introduced measures which try to incorporate sustainable and energy efficient standards.

In the town planning phase, which look at the land use rights and development control aspects of a property, there is an addendum called the Sustainable Human Settlements Assessment Guidelines (SHS) (City of Johannesburg, 2010). These guidelines are intended to assess a development's compatibility in the spatial integration, environmental and employment sectors. Under the environmental assessment category, energy efficiency and biodiversity are given as the two sub-categories, with questions and scores relating to renewable energy sources, recycling, passive climate interventions, heat island mitigation, stormwater management and open space retention or development. The scores are considered part of the application; however they are not prescriptive to an application's approval.

With regard to the building plan process, the SANS 10400-XA requires architects to take climactic zones into consideration and building envelope requirements such as: orientation, shading, floors, fenestration, external walls (ISOVER Saint-Gobaine, 2016). This is a prescriptive requirement for submission of building plans, and failure to submit the XA calculations would result in plans either being pended or denied approval. It should be stated however, that this in no way delineates how well the XA calculations are checked or enforced, but rather a procedural requirement in order for plans to be fully assessed. The question of how these calculations are subsequently checked or enforced will not be considered in this report, as this would deviate from the primary focus on green infrastructure.

Diagram 2, below, represents the building life cycle which can be used as a guide to pinpoint where policy and design interventions may be best introduced.

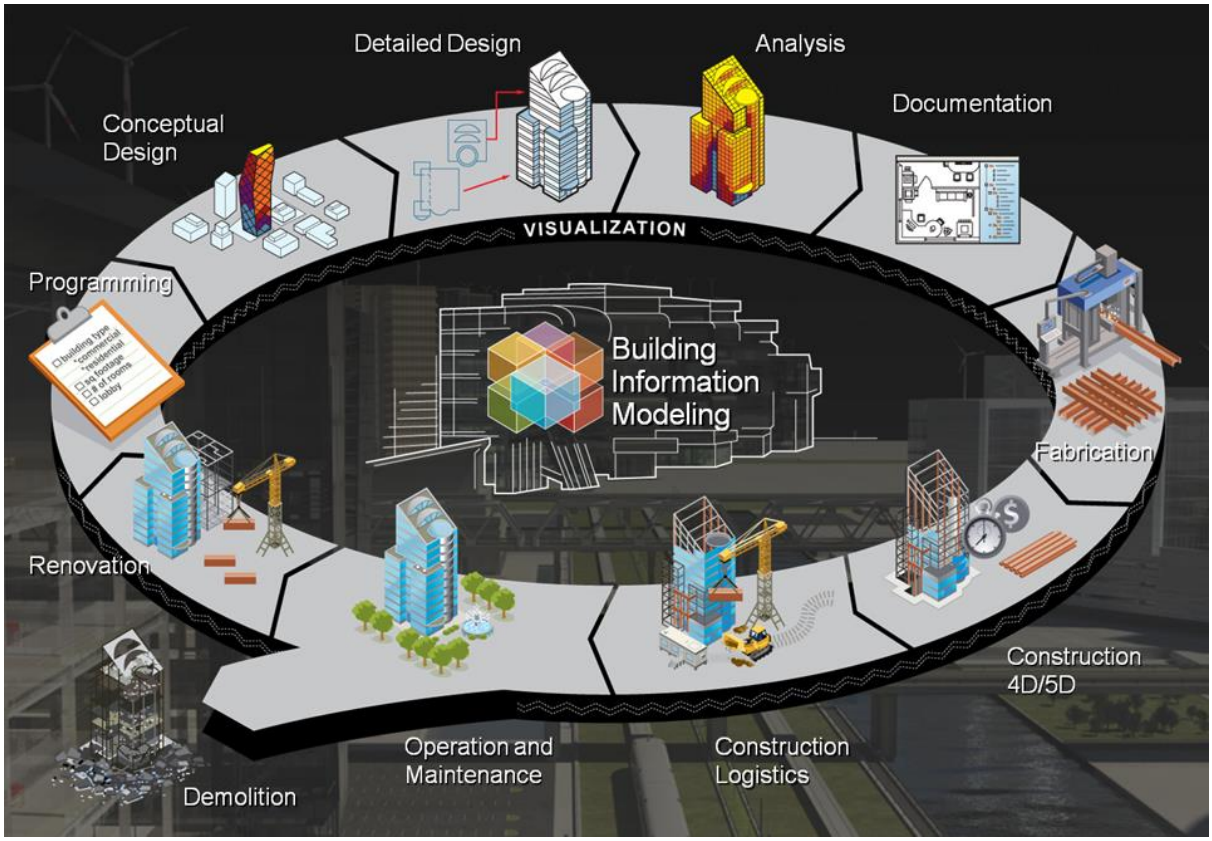

Diagram 2: Building Life Cycle and Integrated Design Process (Source: Chi-Nguyen Cam, 2013)

The rationale for this study stems from an interest in the biological element of the city, and specifically urban agriculture as it relates to food production. The design and function of an urban farm within the city, and specifically within or on top of buildings could result in positive energy saving initiatives, which individually are small, but may possibly have a larger overall impact on the city as a whole. There are a few examples of urban agriculture programmes in areas such as Marlboro Gardens and Alexandra, however, these are on natural ground level, and not within or on top of buildings. These programmes focus on food security and the growing of consumable vegetation, however, there is need for clarification when it comes to growing various types of vegetation within an urban environment and what type of factors influence consumable and aesthetic plants. While

the benefit of this type of initiative can definitely be justified in theory, as done by Rowntree, McPherson and Nowak (1994), a more practical investigation is proposed here, targeting the reality of trying to develop an urban agriculture programme within a city such as Johannesburg, where various dynamics are different. Policy is one such dynamic, which would be a guiding factor into developing such programmes, as it can provide the framework needed to support and encourage various stakeholders to introduce specific types of green infrastructure into the city.

1.3 Problem Statement:

There are a number of cities such as Paris and Toronto, which have started implementing green infrastructure policies. Within these cities, one of the most underutilised and neglected spaces has been found to be rooftops, often equating to the majority of coverage within a city. These green infrastructure policies therefore sought to utilise these idle spaces, and turn them into active contributors to the urban environment. The importance of engaging with developers on issues such as green infrastructure is vital if energy efficient and sustainable principles are to be employed at a local and regional scale. The way policy engages with those who it affects needs to be interrogated at length so that broad decisions are not forced upon a situation, exacerbating the problem due to lack of compliance with that particular policy.

1.4 Objectives of the Study:

The initial objective is to analyse current projects, to see if smaller urban agriculture initiatives are viable in the current Johannesburg climate and urban landscape. Using literature to find what the general good practice system is for urban agriculture and green roof systems, differences and similarities will be drawn so that a better understanding of urban agriculture in a Johannesburg context can be developed. Once this has been established, the subject of whether these initiatives could be designed in a way to assist with energy efficient concepts such as passive climate control would be explored. The ideal outcome would be an incremental design approach, initiated by the necessary policy for urban agriculture to be included as either a South African National Standards building compliance (SANS 10400-XA) or Sustainable Human Settlements (SHS) addendum to the design and retrofitting process of buildings.

1.5 Research Question:

The research question is whether urban agriculture should be included in the design process of buildings in Johannesburg, and whether this can unravel the conundrums of city and building scale, aesthetics versus biodiversity and the role of water scarcity in trying to green the city.

1.6 Sub-Questions:

- How could the aesthetic design be incorporated into urban agriculture to encourage this intervention?
- What scale is required in order for both the building and community or urban system to benefit?
- What type of urban agriculture system (hydroponic/organic/potted) could be beneficial in the design of new buildings as well the retrofitting of older buildings?
- Is urban agriculture not suited to a water scarce climate, or can recycling be an alternative method for introducing such a concept?
- Would this intervention assist in passive climate control internally and externally?
- What policy interventions would be required to both support and encourage this type of development?
- How could urban agriculture and rooftop garden development be used to benefit a broader range of the population, especially those living in subsidized housing?

1.7 Conceptual Framework:

The conceptual framework for this research report is established on the three themes of sustainability, energy efficiency and urbanisation. The theme of sustainability can be quite general as it applies to a number of sectors, and it directly influences the green urbanist school of thought along with the previously mentioned sectors of ecology, economics, and social sustainability. It also influences the idea of urban greening and the green building industry, by creating a type of branded awareness that society thinks it should subscribe to. Similarly, energy efficiency has a significant role in influencing green urbanism, resource availability and sustainable concepts, and the general move towards conserving resources such as power and water. This theme is broad in interventions ranging from PV panels, wind farms and open space development. The energy efficient theme is also supported by

resource availability, with technological advancements attempting to supplement the gap between supply and demand, and possibly reduce consumption altogether.

The urbanisation theme can be seen as describing the cause for the rise in energy consumption and the need for urban planning controls, which require some sort of association with sustainable development. With the rise in urbanisation, the demand on the natural environment increases, firstly to supply energy for the day to day functioning of the city, and secondly the supply of food and food security to the inhabitants of the urban areas. This concept of food security is further rooted within the sustainability theme, and finds its way into the green urbanism principles. Therefore, along with the urban planning controls, the need for urban greening, and the specific idea of urban agriculture to offset the high demand for products being transported large distances, becomes evident.

	Green Infrastructure		**Energy Efficiency and Climate Change**		**Food Security**		**Water Conservation**	
	New Build	Retrofit	New Build	Retrofit	New Build	Retrofit	New Build	Retrofit
Johannesburg's Existing Practices	JMOSS		SANS 10400-XA; SHS Indices	SANS 10400-XA; SHS Indices	The Zero Hunger Strategy (2009)		Johannesburg By-Law (as envisaged by the Municipal Systems Act (Act 32 of 2000)	Johannesburg By-Law (as envisaged by the Municipal Systems Act (Act 32 of 2000)
National and International Practices	City of Toronto Green roof Bylaw (2009)				Integrated Food Security and Nutrition Programme (2002)		National Water Act (Act 36 of 1998)	
Practice gap for Joburg	Bylaw and Guideline	Bylaw and Guideline	SANS 203	SANS 203	Bylaw and Guideline	Bylaw and Guideline		
Policy support/Intervention			Green Star Rating					

Table 1: Policy and potential areas for intervention

Table 1 provides an example of the types of policy at local, national and international scale, dealing with the concepts of green infrastructure, energy efficiency and climate change, food security and water conservation. The list is not exhaustive, however it illustrates that there are policy intervention gaps in Johannesburg at various levels of decision making. Table 2 highlights the difference between prescriptive policies which are employed, and those which serve as guidelines for urban development. It can be seen that there are very few prescriptive policies, and the majority serve as guidelines allowing developers to

motivate for specific developments, and decision makers to have a set of parameters within which they can approve development. It can also be seen that there are a number of frameworks in place which serve to guide urban development at various levels, but very few prescriptive measures are in place for ensuring these specific frameworks are followed and adhered to.

	Scale → Policy ↓	**Building (individual)**	**Block (Group)**	**District (Local Neighbourhood)**	**Region (Suburb)**	**Metropolitan (City)**	**Provincial**	**National**
PUBLIC SECTOR POLICY	Precinct Plan		Guideline	Guideline	Guideline			
	UDF		Guideline	Guideline	Guideline			
	RSDF		Guideline	Guideline	Guideline	Guideline		
	SDF					Guideline		
	Town Planning Schemes	Prescriptive (Individual Property Controls)						
	By-Laws					Prescriptive		
	IDP					Guideline		
	Gauteng Planning and Development Act (2003)						Prescriptive (oversight on Local Government Land use Management)	

Table 2: Prescriptive policies, guidelines and their associated scale

	Scale → Policy ↓	Building (individual)	Block (Group)	District (Local Neighbourhood)	Region (Suburb)	Metropolitan (City)	Provincial	National
PUBLIC SECTOR POLICY	Precinct Plan		Guideline	Guideline	Guideline			
	National Water Act (1998)							Prescriptive
	JMOSS					Guideline		
	SHS Indices	Prescriptive						
	SANS 10400	Prescriptive						Nationally applicable
	SANS 204	Guideline						Nationally applicable
PRIVATE SECTOR INTERVENTION	Green Star Rating	Guideline (Prescriptive in order to obtain a rating)						

Table 2 continued: Prescriptive policies, guidelines and their associated scale

It can also be argued that resource availability would need to be a large consideration for any type of agriculture, and therefore influence the scale of production. Similarly, interventions considered within an urban space should also take scale into account, as the cost benefit of certain projects might not be beneficial when their scale is considered compared with their impact. An example of this could be that rooftop gardens are relatively costly to implement, and if their impact is supposedly on food security, the scale may not be appropriate to the large urban population, and therefore not as beneficial as an intervention

using PV panels which could supply power to a greater number of the population. It becomes an exercise in financial viability where expenses versus profit are analysed, rather than social and environmental benefit versus expenses.

It therefore becomes relevant to analyse the planning process to understand where the decisions are made regarding the outcomes of development. The building design process has specific points where certain types of interventions can be considered, after which these interventions would be very costly, and have further unintended structural implications if they were to be implemented. The final product of this design process relates specifically to a building design, which would be assessed by a municipality, with the hope that there is compliance with all regulations such as fire and safety, infrastructure provision, structural integrity and any other additional standards seen fit such as energy efficiency. The diagram below attempts to show how all these themes are linked, and all lead up to the final building design.

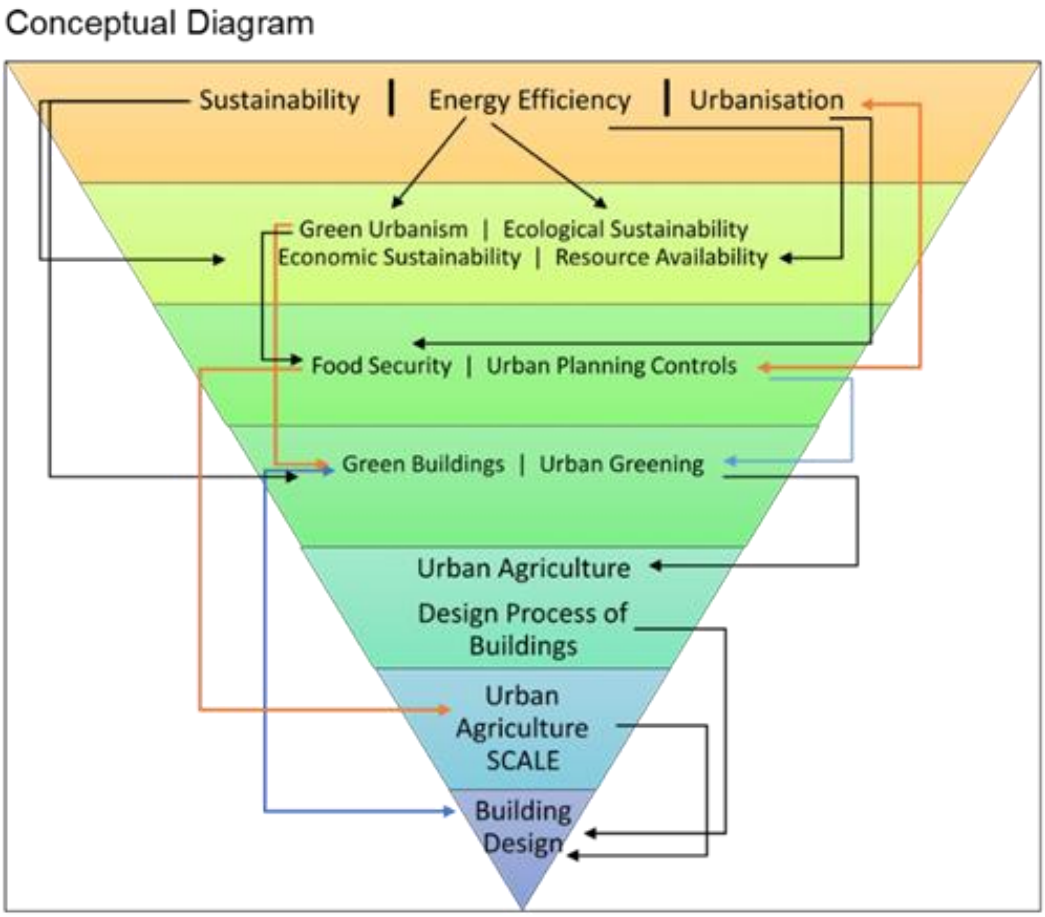

Diagram 3: Conceptual Diagram

1.8 Working Hypothesis

The envisaged resolution of this study is that a gap in the policy may be identified relating generally to green infrastructure, and specifically to urban agriculture and rooftop gardens. The working hypothesis is therefore that a prescriptive policy is needed to allow for the inclusion of urban agriculture on rooftops in the design process for both new builds and retrofitted ones.

1.9 Delimitation of scope

This study focused on the design process of urban agriculture, highlighting various principles gathered from professionals. The inclusion of specific case studies as secondary data provided a contextual and visual representation, allowing the attention to remain on process and procedure, rather than attempting to provide a final design for rooftop gardens and urban agriculture. The study sought to engage with relevant policies and frameworks such as the SANS 10400 and planning schemes. The outcome was not to develop a new policy, as this would have required extensive investigations into policy development, which could not be done within the limits of this study. Therefore, this study attempted to recommend an amendment or alteration to existing prescriptive policies, so that they may include a greater number of alternatives for energy efficient and sustainable urban development. Regarding urban agriculture, this study focuses on the flora aspect of agriculture in general, and does not focus on the larger term which incorporates livestock. This was done on purpose in order to further refine the subject to the specific topic of rooftop gardens.

1.10 Outline of Chapters:

Chapter 1 provides an introduction to the themes and key questions being investigated in this report. Chapter 2 addresses the literature review and guides the questionnaires which focus on the design aspects, challenges faced and creative interventions of rooftop gardens and urban agriculture in Johannesburg. Chapter 3 focuses on the research strategy employed in this study, where designated projects are investigated and a selection of professionals interviewed. There is an attempt for variation in subject sites, specifically, a corporate rooftop project, a private rooftop project and a social development project, allowing input from varied perspectives and providing a greater opportunity to investigate the actual relevance of such interventions. Chapter 4 assesses the findings from the various

projects and interviews conducted, and attempts to assimilate the knowledge from Chapter 2, with the practical context experienced by various professionals in the built environment. Chapter 5 concludes the findings of this research report, and makes recommendations for further investigations.

CHAPTER 2

2 - Literature review:

2.1 Introduction

The purpose of this literature review is to establish an understanding of how rooftop gardens and urban agriculture are being used as tools in supporting the concepts of sustainability and energy efficiency. Within the built environment, there are a number of policy and design processes which result in the final concrete environment seen in modern cities.

2.2 Sustainability and Energy Efficiency

"The relationship between the built and natural environment has traditionally been one of complete opposition. Both terrestrial and aquatic ecosystems are drastically, and often times irrevocably, altered during the process of urbanization" (Paul and Meyer, 2001; in Carter and Keeler, 2007, p. 350). Rees and Wackernagel (1996) delve into the historical development of urbanisation which seeks to explain when cities began to change the way humans interacted with the natural environment. More importantly, the idea being established that there was a great migration towards an urban environment, being stimulated by the industrial revolution (Rees and Wackernagel, 1996). Nassar (2013, p. 339) states that the city is no longer defined by 'city borders' due to sprawling suburbs. He further indicates that the "biggest challenge for cities and towns nowadays is integrating the requirements of sustainability" (ibid). This movement of trying to green cities and make them more sustainable and energy efficient has been defined by the term 'Green Urbanism'. Beatley (2000) investigates this concept and highlights the point of including a variety of structures such as policies, programmes and design for successful implementation (Beatley in Nassar, 2013, p. 339). Within the broader context of green urbanism, there are a number of characteristics which can lend themselves to the promotion of urban agriculture. The primary objectives such as living within the city's ecological limits, achieving a circular urban metabolism, local and regional self-sufficiency, liveable neighbourhoods and communities, give direction for where exactly creative interventions can be directed (Nassar, 2013, p. 340). Lehmann (2010) derived a further 15 principles which can be considered useful for the implementation of green urbanism.

- Principle 1: Climate and context
- Principle 2: Renewable energy for Zero CO2 emissions
- Principle 3: Zero-waste City
- Principle 4: Water
- Principle 5: Landscape, Gardens and Urban Biodiversity
- Principle 6: Sustainable Transport and Good Public Space (Compact City and Poly-Centric Cities)
- Principle 7: Local and Sustainable Materials with less Embodied Energy
- Principle 8: Density and Retrofitting of Existing Districts
- Principle 9: Green Buildings and Districts, Using Passive Design Principles
- Principle 10: Liveability, Healthy Communities and Mixed-use Programmes
- Principle 11: Local Food and Short Supply Chains
- Principle 12: Cultural Heritages, Identity and Sense of Place
- Principle 13: Urban Governance, Leadership and Best Practice
- Principle 14: Education, Research and Knowledge
- Principle 15: Strategies for Cities in Developing Countries

The three principles which were prioritised for this study are:

1. Landscape, gardens and biodiversity;
2. Green buildings and districts, using passive design principles;
3. Local food and short supply chains

(Lehmann, 2010, p. 6-8)

Landscape, gardens and biodiversity can be seen as primary drivers for any urban greening project, and their contribution to the greater infrastructure design of the city is reasonably understated. By linking landscaping and biodiversity principles to green buildings and

districts by using passive design principles, a clear trajectory towards urban agriculture and building landscaping can be envisioned. The spaces used by buildings for landscaping can vary from internal atriums, to external pause spaces and rooftop gardens and landscapes. The argument for including food production in these landscapes stems from the principle of shortening the supply chain for food, and developing the concept of local farming and neighbourhood markets. Lehmann also indicates that green urbanism is actually an "interaction between three main pillars", of energy, biodiversity and urban planning (2010, p. 3). From these principles, urban greening can be seen to have multiple benefits for the concept of energy efficiency and sustainability, and as such, can be used as a conceptual framework to inform policy development and design approaches to this particular area of development.

2.3 Urbanisation

Urbanisation can be seen as a key factor in the emergence of urban agriculture as the migratory shift from rural to urban as mentioned previously. Stewart, Korth, Langer, Rafferty, Da Silva and van Rooyen (2013) give a good summary into the background of urban agriculture and make the point that "The twenty-first century has often been described as 'the first urban century'" (Stewart et al, 2013, p. 2). The evidence of this rapid urbanisation is evident by the fact that only 13% of the world's population lived in urban areas around the early 1900s, while it is predicted that by the year 2030, sixty percent of the population would be living in urban areas (ibid). With this growth in urban population, sustainability became an important concept in the early 1990s (Allen, 2009) and a great deal of literature about what sustainability and sustainable development means, has been established. With the rise of modern cities and the relatively recent trend of urbanisation, the degradation of the natural environment became evident with specific issues such as water regulation and supply, soil erosion and quality, waste management and localised climate changes having an increasingly negative impact (Carter and Keeler, 2007). Allen asks the question "Sustainable cities or sustainable urbanisation?" in an article where there is a classification of the term sustainability (Allen, 2009, p. 2). The four key types of sustainability mentioned are economic, social, ecological and political, of which all four make up urban sustainability (ibid). It also seems that the idea of globalisation has received the greatest blame for unsustainable development, allowing numerous products to be transported great distances,

consuming large amounts of energy during the process. With this in mind, a connection between the idea of sustainable development and green urbanism can be drawn, where local production can assist in energy efficiency by shortening transport routes, creating liveable places and greening of the urban landscape.

Before we can consider the specifics of urban agriculture, it is necessary to delve into the role vegetation has on the urban environment itself. Rowntree, McPherson and Nowak (1994) underline the importance of vegetation in their contribution to the United States Department of Agriculture (USDA) Forest Service's case study of the Chicago Urban Forest. They state that the purpose of the study "is to add to our knowledge of how vegetation in and near cities affects the human environment" (Rowntree, McPherson and Nowak, 1994, p.1). Furthermore they indicate that at the particular time of the study "little is known about how this green infrastructure creates benefits and costs for people" (ibid). The authors make a strong argument for the fact that vegetation is one element within the urban environment which can be manipulated in order to benefit the inhabitants at a cost-effective and renewable manner.

2.4 Rethinking Landscape

Urban areas, and specifically cities, function in very particular ways, and are often interpreted differently, depending on the perspective of the user. A person living within the CBD would have unique experiences compared to those of a person travelling through, or visiting for recreational enjoyment. Does this perspective then alter how a city functions? Or is it merely an abstract vision of a well-oiled machine that functions the same, no matter who the users are or what activities are involved? Ultimately the model of a city can be seen as one of consumption, where commercial space dominates, and little is tangibly produced other than tertiary services (www.un.org; 2016). Further to simply consuming more, "cities concentrate disproportional parts of the economy, resource consumption and the decision making power in most countries" (United Nations University - www.urban.ias.unu.edu, 2016), meaning a great deal of the decisions regarding development are conceived and ratified in cities. Can this possibly be changed so that cities are rather transformed into a space which produces tangible goods that traditionally come from the urban periphery such as vegetable produce, or even recreational parks and gardens?

By including the rooftop garden concept into policy there could be the implementation of two things. First is the enforcement of energy efficient benefits via a passive climate control method for the internal building structure. This would be hard to enforce, as it is the owners' right or prerogative to cool the interior using air conditioners and use alternative methods to do so such as solar. However the external factors such as stormwater runoff, reduction of the heat island effect and aesthetic treatment (similar to how sidewalks need to be built to the satisfaction of council for pedestrians), will be easier to enforce from a policy point of view. Enforcing this is another question altogether, as rooftop gardens have clear benefits and yet planners and architects do not use them. What then are the ethical considerations of professionals to encourage a set of design principles, which have a benefit to individual buildings, as well as the general urban environment? The general settlement patterns which have occurred over the years focus on a number of changing elements, such as CBDs, transportation nodes, decentralisation of urban areas into suburban environments and other similar constructs. The underlying cause could be the inherent nature of planners, architects and decision makers to create the most liveable and efficient urban area for the local population. The city can be generally seen as a consumer of elements and producer of waste, due to the majority of energy and products being produced on the urban periphery such as agricultural farms, industrial estates and power stations, and then consumed within the urban development boundary. Is there a possibility that this typical urban landscape can consume less, or even produce certain primary products such as energy and food, reducing both monetary and environmental cost by localising products and minimising energy consumption? Would interventions change this urban landscape physically, or is it purely a behavioural change that would occur? And finally who would be responsible for initiating and maintaining such a change?

Rethinking the urban landscape allows the introduction of the argument between aesthetic design versus purely biodiversity-based design. Thompson (1998, p. 159) discusses a brief history of "Environmental ethics and the development of landscape architectural theory", where the author investigates the progression from pre-1960s landscaping for purely aesthetic purposes, negating any sort of consideration for an ecologically balanced design, to the present day designs seeking to be realigned with visions of what sustainable landscaping should look like. There are two main categories spelled out by Thompson:

anthropocentric, which places humans at the centre of the moral universe, and non-anthropocentric, which has the view that all living things have an intrinsic moral value which man owes a duty to (1998, p. 159 - 161). Within each of these two divisions there are further alignments of thought which are summarised as egocentric, homocentric, bio-centric and eco-centric. These further breakdowns can be of importance when trying to understand the thought process behind certain development controls and trends such as sustainability, energy efficiency and land economics.

The *egocentric* point of view is one of self-interest and focusing on benefits of the individual, even if it is mutual benefits of individuals by agreement (Thompson, 1998, p. 160). Comparatively, developers seek to maximise their profits of their particular individual building, and focus within the building environment. Physical manifestations of this can be seen with individual zoning controls which limit the building's capacity, with further internal designs such as climate control elements and internal layouts which satisfy the occupants of the individual building.

The *homocentric* concept is based on the thought of the "Greatest good of the greatest number", whereby a particular concept or environment is implemented or designed to suit and benefit the greatest number of people interacting within that particular environment. This could be identified as a public space or landscape where certain design elements are put in place to assist with concepts such as efficient movement within a space, public furniture, or even aesthetic design concepts to turn a space into a place.

The *biocentric* position introduces the idea that all "members of the biotic community have moral standing" (Thompson, 1998, p. 160), and allows the development of animal rights and acknowledges the value of plants and animals as individual forms of life which are equal to humans, not simply subservient to them.

The *ecocentric* position differs from the biocentric idea, in that whole ecosystems are taken into account rather than just the individual plant or animal. This holistic view of interactions between plants and animals presents the idea that everything is somehow linked and is essentially one large organism, greatly popularised by the Gaia theory which was conceptualised by James Lovelock (Lovelock and Margulis, 1973)(Lovelock, 1989).

If these four perspectives are applied to the urban environment, a comparison between owners, tenants, individual buildings and precincts can be summarised in the following manner. The egocentric perspective could be applied to the building owner who views their particular building as the most important and looks for the economic benefits which can mutually benefit the tenant and owner. The homocentric perspective can apply to multiple tenants of a building, who could all benefit from energy efficient buildings in terms of cost savings, as well as passive interventions which may improve the general health and environment of their particular building as a whole. The biocentric perspective would apply to specific green interventions of a particular building, such as solar power or passive cooling interventions, which would be morally guided by environmental protection guidelines, rather than the traditional homocentric guidelines of protecting the human interest. The ecocentric perspective can apply to planners and decision makers who view the city as a whole, and therefore how each building can interact with the environment. This speaks directly to the idea that certain interventions, such as rooftop gardens, can actually benefit the urban environment as whole, not just individual buildings, by offsetting issues such as the heat island effect and stormwater management.

By changing the urban landscape from a consumerist homocentric environment, to a more ecocentric producer, there may be a shift in how cities and urban areas actually function in relation to their sub-urban, peri-urban and rural counterparts. Thompson suggests that there has been a definite shift in terms of how the urban landscape has been viewed with the pre-1960s focusing purely on aesthetics, shifting through the mid-1960s to the end of the 1970s, where there was a large push for environmental awareness (Thompson, 1998, p. 164). Most notably the era of sustainability occurred from the early 1980s and is still the dominant rhetoric within the built environment currently (ibid). Within the urban landscape, infrastructure has also taken on a new dynamic, with traditional infrastructure needing to be reassessed as urban populations grow and technologies change. A more recent recognition of green infrastructure as a key component with in the greater urban setting has been defined, with a large focus on incorporating and protecting various ecological mechanisms.

2.5 Green Infrastructure

Parks and green spaces in urban areas are important facilities which the general public tend to use, however their structure and incorporation into the urban fabric are often overlooked. Within most major cities there are open spaces such as Central Park in New York, Hyde Park and Kensington Gardens in London, and Bagatelle Park in Paris, to name a few well known examples. South African cities are no different when it comes to including these types of green spaces, which sometimes form an interlinked green belt within the city. Johannesburg has an excellent example in the form of a long green belt stretching from the Melville Koppies all the way along the Braamfontein Spruit, linking the Johannesburg Botanical Garden in Emmarentia, to Delta Park, and even as far down as smaller parks abutting Witkoppen Road, Bryanston. These green spaces form part of a larger network collectively termed 'Green Infrastructure', which provide a number of additional services to both the city structure and the urban population (www.planningguidance.gov.uk, 2016). Streets Reconsidered (2010, NP) states that "Green infrastructure may be defined as infrastructure that provides and promotes a network of natural systems within the urban environment and has the potential for energy generation". Within this particular understanding of what green infrastructure is, there are still two distinct approaches. *Active* green infrastructure involves the use of technologies such as solar panels and wind turbines to harness nature's energy and generate energy (*ibid*) with the objective of reducing environmental degradation caused directly and indirectly by modern technologies and lifestyles.

The more *passive* type of green infrastructure involves the "interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits" (Benedict & McMahon, 2001, p. 5). This green infrastructure does not only focus on open spaces such as parks, but includes playing fields, street trees, private gardens, streams, canals, green roofs (containing vegetation), blue roofs (containing weirs to control storm water), rain barrels and even permeable paving (www.nyc.gov/stormwater, 2016). Often, this green infrastructure is employed as either a stormwater management technique (Facteau and Caruso, 2011; Rogers and Hiner, 2016), or a public environment upgrade with aesthetic benefits (www.planningguidance.gov.uk, 2016). However, these are applicable

primarily to how this type of infrastructure affects the environment on a scale larger than one property or building.

The term green infrastructure is particularly broad, and can have many applications which vary in scale, from the single dwelling unit, to regional parks. Green infrastructure is purposeful in what it describes, even though it includes a very broad range of functions. Rather than a simple implication of green space development, green infrastructure directly relates to similar hard infrastructure developments which require active maintenance and restoration (Benedict and McMahon, 2001, p. 7). Furthermore there is also the view that infrastructure is not an option, but rather a necessity, suggesting that the development and maintenance of green infrastructure is not only beneficial to urban areas, but actively required for proper functioning for the general public environment, not only individual buildings. A major consideration for developing green infrastructure is the necessity to develop a type of planning model which can give directives to where and how it should be recognised, planned for, designed with and implemented. Benedict and McMahon (2001) state that there should be a holistic design, similar to the transport system or water system of a city, and that planning should be comprehensive, strategic and public so that many professions and communities can be involved. By doing so, there is less chance for fragmented growth of green infrastructure, which could lead to degradation and ultimately the failure of green infrastructure. With the existing strain placed on green systems such as parks and rivers due to pollution and lack of maintenance, the shift towards viewing these systems as infrastructure could and should help with an urban area's green agenda.

This research report intends to narrow the focus down to urban greening processes, which can be viewed as a sub-set of green infrastructure. These processes also have a number of components which need to be investigated, such as green roofs, urban agriculture, various design guidelines used in these components, and the policy which could assist in delivering these components to the urban population. It is acknowledged that green infrastructure is the overarching theme, and that the term urban agriculture has been applied in a certain manner to incorporate all forms of cultivating, both for consumable plants, as well as aesthetic ones. A succinct justification for this approach has been termed by Arosemena (2012): "Urban agriculture must not be thought of as an isolated fact, but as the sum total of processes that constitute its agroalimentary system" (*ibid*, p. 67). The agroalimentary

system is defined as the full process of growing, processing, packaging, transportation, distribution and consumption of food (ibid). For the scope of this report, the term *urban agriculture* pertains to variable growing methods, where the purpose is not solely to sell produce, but rather focus on the growth of flora in general, within urban areas, spaces and ecosystems.

2.6 Urban Agriculture

Arosemena (2012) states that the "arrival of the city and of industrial agriculture more than a century ago, a process of segregation began between food-growing areas and urban settlements" (*ibid*, p. 15). Therefore the term 'urban agriculture' brings together the two seemingly opposite activities of urban living and rural agriculture. However there has not really been a set definition, which leaves a broad idea of what urban agriculture actually is (Arosemena, 2012). The generally accepted definition for urban agriculture, introduced by the UN's Food and Agriculture Organisation (FAO) is "farming practices developed within cities in order to satisfy the needs of the urban population. Activities considered by the FAO to constitute urban agriculture include horticulture (general plants*), the raising of livestock, the production of forage and milk, aquaculture (aquatic organisms*) and silviculture (cultivation of trees*)" (Arosemena, 2012, p. 16) (*Own clarification). Arosemena goes on to establish a further definition as "Any activity to do with the growing of food near a city when the final destination of this product forms part of the urban agroalimentary system (production, distribution, consumption and management of the organic waste created)" (2012, p. 20). The focus of urban agriculture is therefore generally accepted as the production of some type of vegetation for the purpose of consumption.

A brief departure from this conceptual definition is necessary in order to investigate the comparison of urban agriculture as a sub category of green infrastructure. As discussed previously, green infrastructure includes a great deal of technologies and concepts feeding the energy efficient and sustainable movement. It may be necessary to include a number of types of gardening under the broader term of urban agriculture, as they may fit under the broader term green infrastructure, but could add value to the urban agriculture term. Specifically, general sub-urban aesthetic gardening which occurs in typical backyard gardens which is generally not viewed as 'agriculture' in terms of production, but rather a methodical process of maintaining aesthetic vegetation.

Historically the development of gardens can be found as far back as Mesopotamian and Egyptian civilisations, where the focus was on food production for the greater population (Arosemena, 2012, p. 21). The Romans began the production of fruit trees and brought the garden within the city walls, leading up to the medieval gardens which began growing aromatic plants such as lavender "combined with ornamental flowers like the rose and the lily" (ibid). The progression through history of agriculture in the broader sense, back into the city has had many different views "from pure utilitarianism to a purely aesthetic conception using ornamental plants" (Arosemena, 2012, p. 22).

It can be argued that with each passing stylised type of urban greening, the core principle is that there is an expression of the predominant world view of that particular era or time (ibid). The transition to the modern day city and the incorporation of green belts, green infrastructure and green urbanism quite clearly has a favourable inclination for integrating and preserving the natural environment. It should be stated however, that as with all previous changes in guiding philosophies, the theories and ideas need to be thoroughly and rigorously investigated, so that the "green-washing" effect does not take hold. Green urbanism lends itself to the justification of combining aesthetic gardening and urban agriculture under a similar title with the principle of 'landscape, gardens and biodiversity' (Lehmann, 2010), where the focus is on growing in a given space, with the intent of encouraging biodiversity and vegetating the concrete. While this theory supports the argument as indicated, a far deeper understanding and scrutiny of the guiding principles should occur, so that it does not become a simple manifesto, but a commencement of follow up theories and processes.

There is also clarification that not all types of urban agriculture are appropriate for every city and that each city would need to develop their own by-laws which should govern the type of agriculture allowed within the city (Arosemena, 2012, p. 16). With this in mind, the three motives stated by Arosemena for urban agriculture to develop in cities revolve around the migration towards urban areas; political changes and economic crises; and the focus on sustainability and producing local produce (2012, p. 33). Each of these motives can be seen as reactionary to the modern development of cities and the influx of people, raising poverty and pollution levels. Traditional city models often focus on the development of higher density residences, commercial zones and industrial sectors, with little to no focus on

agriculture (Arosemena, 2012, p. 35), but they do cater for green spaces such as parks and rivers. The conflict for planners becomes apparent when a traditionally rural activity is introduced into the urban environment, and the inclusion or integration of such an activity is not considered. Again, scale should be mentioned here, as small backyard gardens containing produce do not pose a nuisance or threat to the nature of the surrounding environment. However, if this scale was to increase, and issues surrounding pesticides and fertilizers arose, strict control would be required to restrict any degradation of the local environment.

The concept of urban agriculture is not new to the built environment, with many architects and urbanists attempting to "increase the percentage of greenery in urban built-up areas and bring back the vanishing urban green space" (Wong et al, 2003, p. 353). If one were to try to pin-point the juncture at which the traditional industrial urban environment arose, it could be traced all the way back to the Romantics of the late 18th and early 19th centuries (Thompson, 2009, p. 158). There has been a more recent push in the early 20th century with examples such as the concept of the Garden City by Ebenezer Howard (1898) and Le Corbusier's introduction of rooftop gardens (1926), as more contemporary examples of urban agriculture in the broader sense of the term.

While these early introductions of greenery back into the urban landscape focused on aesthetics and the potential for biodiversity, a secondary effect of growing plants which produced food took off at smaller scales, typically found in backyards. It could even be argued that the growing of herbs and similar types of small plants inside the urban home could be classified as urban agriculture, as was the case with 'Kitchen Gardens' of the medieval times, where herbs and aromatic plants were grown within the castle or settlement's defensive walls (Arosemena, 2012, p. 21). The scale of urban agriculture is an important control factor in terms of regulation and effectiveness when trying to investigate where and how the urban population can proceed with this concept.

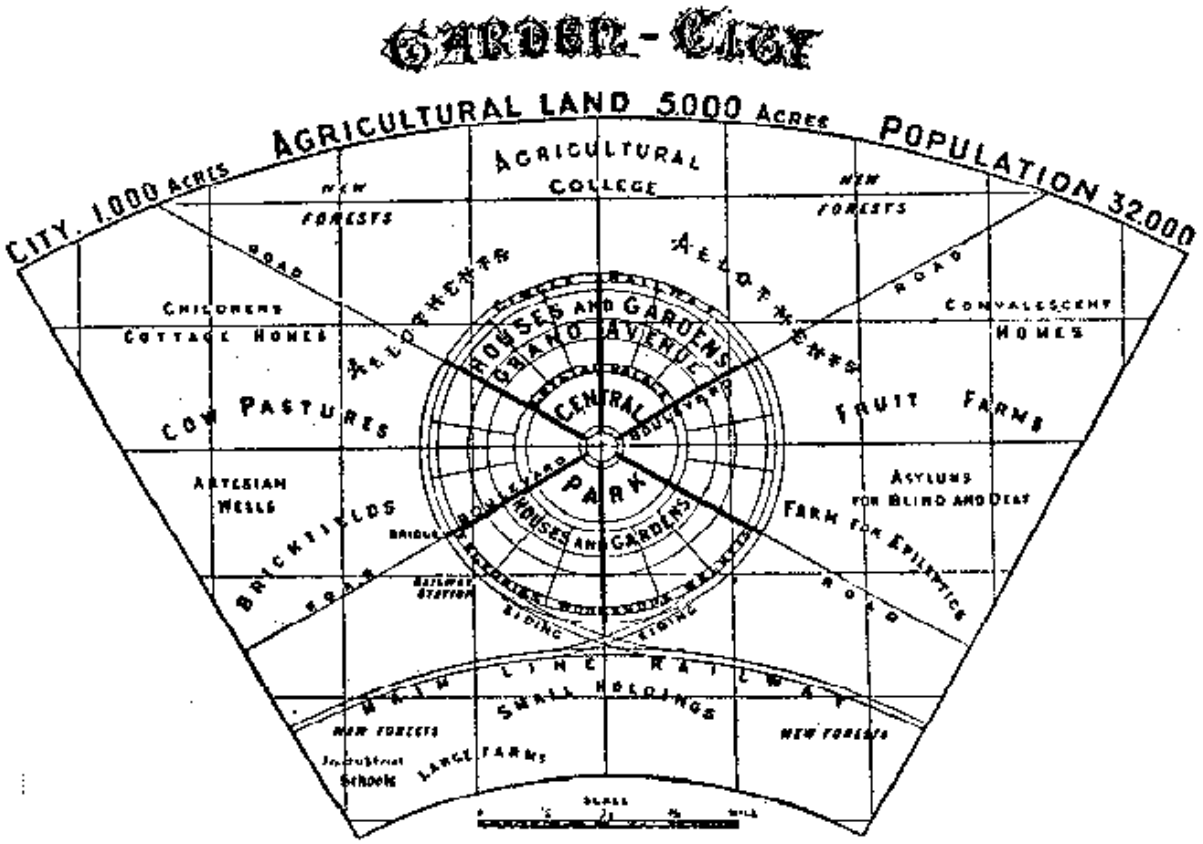

Diagram 4: Ebenezer Howard's Garden City (Source: Cornell University; Accessed 12 January 2017)

Estimations of how much space is required to feed a person will vary from country to country, and more importantly between individuals (www.farmlandlp.com, 2012). An ecological footprint for an individual, city, country or even the planet, is often referred to when consumption trends are discussed. This ecological footprint establishes the impact of an individual or group based on what their daily lifestyle demand and supply is on the natural environment (Global Footprint Network, 2016). Often the term "biocapacity" is used to define the biologically productive land areas which are required to sustain this demand (ibid). While this ecological footprint is a good indicator for sustainability progress, the pertinent point of space required for growing food for a person will give a spatial representation of the food footprint of a person. The estimation for an average person in the United States has been very roughly done by Bradford (2012) for Farmland LP, where the use of the USDA's area calculations, and other published papers to gather a mean of consumption versus space. The estimation is approximately one acre of land needed to feed a person for a year (www.farmlandlp.com, 2012), which brings about the question of

whether urban agriculture is actually a viable concept to even attempt in the limited special environment of the city.

Image 1: One Acre of Land Feeds a Person for a year (Source: Kindersley, 2011)

While addressing this question it is necessary to take a holistic view of the benefits of urban agriculture, and specifically the benefits of good design and production at a building scale. Mougeot (2005) cites the Millennium Development Goals in the investigation of urban agriculture and food security. It is therefore clear that the concept is high on the ranking of interventions in order to assist with sustainable urbanisation (Mougeot, 2005, p. 11). An interesting proposal is that urban agriculture actually becomes a distinct land use typology in the policy schemes used for development control, such as a commercial, industrial or residential zoning clause (ibid). The viability of urban agriculture in one particular case study done in Rosario, Argentina, can be broken down into four categories as follows:

• Social (degree and type of participation, gender aspects, institutional development, respect for cultural diversity, increase in the beneficiaries empowerment);

• Economic (genuine income generation, commercialization, costs of production, human resources, inputs);

• Technical (introduction of vermiculture as a waste processor, intensification and diversification of production); and

• Environmental (water quality, presence of pollutants in soil, vermicomposting and vegetables, treatment and exploitation of house wastes, biodiversity status)

(Spiaggi, 2005, p. 188)

While the descriptions are specific to this particular case study, the broader categories are useful in deciding how to evaluate an urban agriculture project. From these categories, the technical category is the most relevant to the designing of urban agriculture projects on an individual building scale, as the technical layout, design and possible policy guide will have a direct impact on the construction of the building.

Philips lists a comprehensive legislation and policy reform which occurred in San Francisco in 2011 that "created new zoning for urban agriculture and a July 2012 ordinance that sets goals and timelines for how the city government can better support urban farmers" (2013, p. 256). A point regarding scale is that within various development circles of urban agriculture, there is a recognition that the focus should not be on quantity of produce, as these urban agriculture projects could never sustain the whole urban population over a long term period (Philips, 2013, p. 257). The idea is to try and connect urban residents to the broader food system while providing green space that has ecological benefits in the form of green infrastructure (ibid).

There are three key drivers for urban agriculture, namely the ecological, social and economic factors (Arosemena, 2012, p. 18), which are very similar to the four categories for viability mentioned previously. The drivers differ due to the actual function of the connection rather than the perceived viability brought about by these factors. Specifically: the ecological connection speaks to urban waste being used in urban agriculture such as composting or water recycling; the social connection requires the involvement of farmers who live and farm in the same city; and the economic connection introduces self-provisioning of urban farms who may be able to support the urban population to whatever degree is relevant (Arosemena, 2012, p. 18). The key idea is that everything is kept localized within the city, reducing transport costs and recycling waste products so that each city is almost self-contained in terms of how it impacts the global environment. Further

development into urban agriculture, as an incorporated concept into the building scene, may allow for interesting prospects. The intended path of this study was initially driven by the idea that urban agriculture is a form of energy efficiency, by localizing food production and allowing for food security, which encouraged sustainability. If this concept is taken further, as suggested by the research question, and incorporated into the building design process, there is the possibility that state-provided housing may actually solve a secondary issue of food security as well as that of housing. If the standard state provided house were to include a 'green roof' which allowed households to produce their own food as well as the solar geysers already provided, this would be hugely beneficial.

2.7 Urban agriculture and buildings

Building specific interventions are popular to discuss and illustrate, as they can provide an aesthetically pleasing result that deviates from the normal concreteness of the city. Munzner (2015) highlights a case study in Wroclaw, Poland, where a project called 'The Infinite Green' shows the benefits of greening a structure with various plants. The case study shows the type of plant used at the outer and inner portions of the structure, as well as the temperature differences felt at each location. Four important ecosystem management requirements which can be seen from case studies such as 'The Infinite Green' include the documentation of all components and potential relationships; the view of processes that generate benefits and costs at different but related scales of time and space; inter-regional and inter-generational effects; bringing private and public land owners and managers together for a common purpose (Rowntree, *et al*, 1994, p. 2). There are a great deal of design elements which need to be considered. However, one of the most important sociological points is that food is needed by all, and has played an important role in every single culture (Philips, 2013, p. 4). It is also important to note that on this basis, the design of an urban agricultural project needs to be appealing to those who use it, and that each culture will need a different design. What can be useful in this matter is using the local climate and social system to influence the design process, so that a useful product can occur.

The building scale is therefore useful as a starting point to understand what is required from an individual erf, before trying to apply a larger framework, which would benefit the urban population in general. There is a clear understanding when it comes to the larger scale, in

terms of peri-urban and rural farms, as well as the very small scale of an individual who has a 'food pantry garden'. Philips (2013) systematically delineates the various scales that an urban environment can have, and builds on the ideas of technological interventions as well as policy structures which would assist the development of urban agriculture. While scale is an important factor, the underlying question of whether it is viable to grow a garden on a rooftop, which has an artificial soil depth needs to be asked. Certain types of plants clearly need a greater soil depth and type in order to grow, and this could affect the plant's growth very differently between rooftop and natural substrate. There is a point regarding the fact that "green roofs can be carefully designed to emulate ground-based habitats by carefully controlling substrate type, substrate depth, plant species and providing additional habitat features (e.g. deadwood and sand piles)"(Olly et al., 2011, p. 311). There is a definite process which would be required in order to properly grow and maintain rooftop gardens within the city, and this indicates the importance of integrating the ideas of who is responsible for maintaining gardens and what their actual cost-benefit is, as many current projects come across as opportunistic challenges rather than well-developed projects.

While the initial appeal for this study was a focus on urban agriculture, as the City of Joburg highlights the importance of food security, it has become apparent that there is a broader scope which needs to be addressed. Urban agriculture focusses on the production of food within the urban area, and the rooftop agriculture concept seems like a unique initiative from a production point of view where buildings could start providing consumables and benefits as opposed to simply consuming energy and giving off waste (Carter and Keeler, 2008, p. 351). There has been a great deal of research into the actual energy saving benefits of roofing systems and the greening of roofs using either solar panels or various types of flora. In 2015, "France passed legislation that requires all new commercial buildings be built with green roofs" (Cameron, 2015, NP). This legislation specified that the interventions must include partial coverage of the roof with either solar panels or a rooftop garden (ibid). Benefits extend further than simply offsetting electrical energy efficiency and creating aesthetically pleasing roofs. The rooftop gardens concept "not only insulate the building with their thermal mass, but they also filter water and help prevent excess runoff and storm water overflows" (Shaw, 2015, NP). While urban agriculture is one dynamic of trying to green a city, the broader subject of how to actually green a roof using a variety of different

methods, not only consumable vegetation, needs to be clarified before trying to justify solely an urban agriculture approach.

2.8 Green roofs

Similar to the term “green buildings”, “green roofs” is a broad term which can imply one of two generally accepted approaches. The first is ‘green’, as in terms of energy efficiency and sustainability, where roofs play an integral role in changing the building’s consumption of energy using various interventions such as solar panels, insulation and various other materials which can assist in offsetting the carbon footprint of a building. This particular method often seeks to address the interior environmental problems of temperature and energy use of office equipment for individual buildings. An example of this type of roof is the cool roof, which is “designed to maintain a lower rooftop temperature than traditional roofs while the sun is shining” (Urban and Roth, 2010, p. 3). The intervention is reasonably simple in that is requires the roof’s surface to be painted with a white or other type of reflective paint, allowing solar energy to be reflected rather than absorbed by a roof (*ibid*).

The second term defines the actual greening of the roof using flora to either produce an aesthetically pleasing environment, offset the radiative heat given off by a building, or produce some type of product in the form of food. This approach focuses on the exterior effects of the building, however, benefits are taken into account of the internal contributions to passive climate control. Both approaches are valuable, and this research report acknowledges the different uses roofs can assist in changing the internal and external environments. As stated in Chapter 1, the focus will remain on the second definition of green roofs, looking primarily at the physical greening of roofs using flora. In order to further understand and question roof gardens and urban agriculture, the purpose and function of each type of garden was considered in order to ascertain if there should be a generalised approach or purpose. This addresses any policy or development assistance or encouragement which may be needed to further the green roof agenda.

Within the urban agriculture sphere, there is a breakdown of different types relating to the size and intensity of farms or land. This creates a basic framework when it comes to granting land use rights and zoning, and is further explored under the Zoning section of this research report. Olly, Bates, Sadler and Mackay (2011) have defined two main types of

green roof gardens which allow the initial scope to be encapsulated. "There are two main types: (1) *intensive green roofs,* which are usually heavily landscaped 'gardens' that require regular maintenance and a substrate depth of 20 cm or more, and (2) *extensive green roofs*, which have a substrate depth of 2-20 cm and usually require little maintenance (Oberndorfer et al., 2007 in Olly et al., 2011, p. 311). Substrate depth and vegetation height are two considerations which could have very different implications for buildings and their surrounding environment. Substrate depth could have one of two outcomes for the development of green roofs, namely if it is considered before the building process, and the type of roof structure which would be required to support increased load depending on the type of vegetation used. The greater the substrate depth, the heavier the load, and possibly the larger the vegetation type used. The greater substrate depth could also be implemented as a water storage facility, decreasing runoff.

The second implication regarding substrate depth, would be if it is considered as a post construction intervention, where the actual structure would limit the depth, rather than the depth limiting the structure. These implications would clearly impact any type of building control developed to include green roofs in the plan's development stage of a building. The detailed design of substrate depth and vegetation type would be necessary in order to properly assess any impact a rooftop garden would have on both the building and the surrounding environment. This is currently not the case in Johannesburg, with uncontrolled rooftop gardens occurring as a recreational activity rather than a controlled building function. The view of these rooftop gardens would need a shift in paradigm, where they are treated similar to building functions such as temperature control units, lighting, lifts and other monitored utilities. The technical aspects of green roofs therefore need to be clearly understood and explored to find if there is an optimum substrate type and depth, and what the impact of different vegetation will be for all stakeholders involved.

2.9 Climate Resilience and Considerations:

"Climate change has the potential to transform food production, especially the patterns and productivity of crop, livestock and fishery systems, and to reconfigure food distribution, markets and access" (Nelson et al., 2009, in Vermeulen et al., 2010) . The subject of climate is included briefly because of the potential it has to change how society will deal with its surrounding environment, specifically relating to food production and habitable areas. Due

to the focus of this research report being Johannesburg, which can be considered a water scarce city (City of Johannesburg, 2016), any changes in climate will affect how the City responds to associated incidents such as drought and flooding.

Climate resilience is sometimes referred to as a tool or state of being which deals with the subject of harsh climates, however it no longer refers to just infrastructural issues (King, 2016). This research report will not deal with the arguments for or against climate change, but rather deal with the factual basis of current climate type for cities. As such, the resilience of an urban area is a consideration, due to the involvement of a number of functions such as policies, governance and management structures at various levels (King, 2016). The resilience of a city relies on both preparedness and subsequent coping mechanisms which need to deal with severe weather and climate changes. Nasa (2005) describes weather changes to mean the shorter term conditions such as temperature, precipitation and general atmospheric occurrences over a relatively short time frame, whereas climate refers to the average weather conditions over a longer period such as a thirty year span. These considerations prove vital when addressing issues such as stormwater and building environments, specifically relating to developing an energy efficient and sustainable building or urban environment.

Quite clearly, resilience is taken into account when agriculture is involved, as food security affects both urban and rural populations as a whole. The prediction of a particular climate can assist in areas such as: drought and flood prevention via stormwater treatment and water storage facilities; agricultural development when planning crop type, planting and harvesting times; and finally disaster management and prevention for the general population of at-risk areas (Hanson, 2002). Therefore climate is a major consideration when investigating resource management and in particular energy efficiency. Penney (2008) uses a useful figure which describes what climate resilience looks like, and lists procedures to adapt to changing climate, as well as technologies which can be used to mitigate against factors believed to be contributing to climate change.

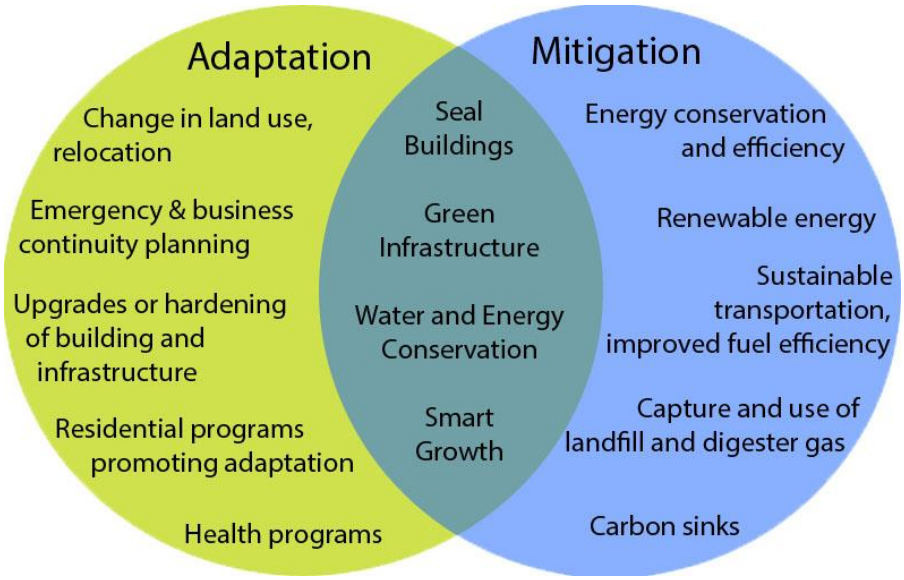

Diagram 5: Adaptation and Mitigation in relation to climate resilience (Penney, 2008)

The two spheres shown, adaptation and mitigation, deal with climate issues and how urban society tends to deal with them. Adaption refers primarily to the evolving of an entity over time as a coping mechanism to their environment (Losos, 2015, NP). Mitigation on the other hand is reducing "risk or loss from the occurrence of any undesirable event" (The Economic Times, ND, NP). There is a greater focus of planning and policy involved in the adaptation sphere, and energy conservation, renewable energy projects and sustainable transportation models making up the mitigating sphere (Penney, 2008). Where the two spheres intersect, Penney indicates that concepts such as green infrastructure and smart growth represent the resilience of a given area, as they are approaches which seek to both adapt urban areas, as well as use technologies to mitigate against damaging climate change. Therefore, conceptually, green infrastructure can be seen as an attempt to combine the hands-on approach of mitigation techniques with the more policy-based adaptive sphere. It seems that the majority of strategies currently employed are either adaptation or mitigation, and green infrastructure and smart growth strategies are more contemporary approaches to this combined approach.

How does green infrastructure assist energy efficiency? The benefits of urban greening can be directly seen in a number of ways. "Shading from strategically placed street trees can lower surrounding temperatures by up to 6°C, or up to 20°C over roads" (Matthews and Byrne, 2016). Vegetation grown on rooftops and inside buildings can assist with passive

climate cooling, while external vegetation can provide a habitat for various fauna to live in (ibid). Green infrastructure can be seen as a type of buffer, or absorption material when compared to the generally hard concrete surfaces of a city or urban area and therefore a crucial part of the energy efficient movement. This green infrastructure will rely heavily on the type of climactic conditions present, and this will have an effect on the type of green infrastructure used, specifically the type of plants which would be indigenous to a particular climactic region.

2.10 Advocating rooftop gardens:

The working hypothesis for this study revolves around whether green roofs should be included in the design process for buildings, and the possible enforcement via specific policies. This extends to both new and existing buildings, insofar as new building plans being designed and existing building plans being amended. In order to fully assess whether the design process needs additional control measures, it is necessary to advocate for the measure which is intended to place a possible further restriction on the building plan process. It would be counterproductive to add an extra measure to a process which already has a number of controls in place, to simply fulfil a green washing agenda that does not actually benefit the urban environment. The fundamental question is therefore how green roofs affect the urban environment as a whole, and what the cost benefit would be on individual buildings. Rooftop garden concepts have been around for a number of years, with Le Corbusier and Jeanneret (1926) listing roof gardens as part of their "Five Points towards a New Architecture". The five points they investigate are: the supports; the roof gardens; the free designing of the ground-plan; the horizontal window; and the free design of the facades.

The contribution green infrastructure can make to the urban environment has been investigated for quite some time. One of the most noticeable changes for living entities is temperature. Urban areas have experienced a phenomenon known as the 'urban heat island effect', which depicts the concrete urban environment as noticeably warmer than the surrounding rural areas (Carter and Keeler, 2008, p. 351). One of the interventions designed to alleviate and control these temperatures is air conditioning, which is generally expensive to run and contributes to energy consumption and ultimately adds to carbon emissions (Matthews and Byrne, 2016, NP). Therefore there has been a movement to implement

urban greening strategies (ibid) which would aim to reduce the temperature in urban areas. This particular example is relatively specific, and identifies temperature as the problematic entity which needs to be addressed. The important question which needs to be asked is therefore, why interventions are taking so long to implement, if the problem and solution have already been identified for an extended period of time already. Matthews and Byrne (2016), further state that their "international research shows that planners are not always comfortable with this idea", and that the introduction of green technology is occurring slowly (ibid). There are policies underway in both France and Australia, where key interventions aim to reduce the urban heat island effect, increase environmental performance and effectively manage climate change impacts (Matthews and Byrne, 2016, NP). The challenge faced by professionals trying to implement green infrastructure in urban areas is the fact that it is a relatively uncertain process. It seems that the slow implementation is primarily due to the fact that a number of extra professionals such as engineers and environmental practitioners would need to be consulted in terms of issues such as root systems, drainage plans, structural strength relating to larger types of vegetation, vegetation type according to locality and climate and long term cost of maintenance (Matthews and Byrne, 2016, NP).

The argument for thermal protection of buildings through green infrastructure has been investigated quite rigorously, and the benefit in terms of reducing the heat island effect is strongly backed by the performance of these individual buildings. Kumar and Kaushik (2004) mention findings which postulate that "planted roofs contribute not only in reducing thermal loads on the building's shell but also in reducing urban heat island effects in densely built areas having a little natural environment" (Eumorfopoulou and Aravantinos in Kumar and Kaushik, 2004, p. 1505). The difference in air temperature between planted roofs and standard ones has been found to be between 4-5°C (Kumar and Kaushik, 2004, p. 1506). The point which was raised in particular in the study was that a number of studies had been done regarding individual buildings and related roof performances. However there was a need for an improved model which could incorporate thermal modelling of green roof components as well as variations due to every building being different. The purpose of most studies regarding the technical aspect of green roofs and their effect on thermal performance and thermal load reduction, is the leaf area index (LAI) and foliage height, and

how the variation in these, affect the thermal performance of a building (Kumar and Kaushik, 2004, p. 1506). The below representation shows the higher the LAI, the greater the leaf surface area covering a surface below.

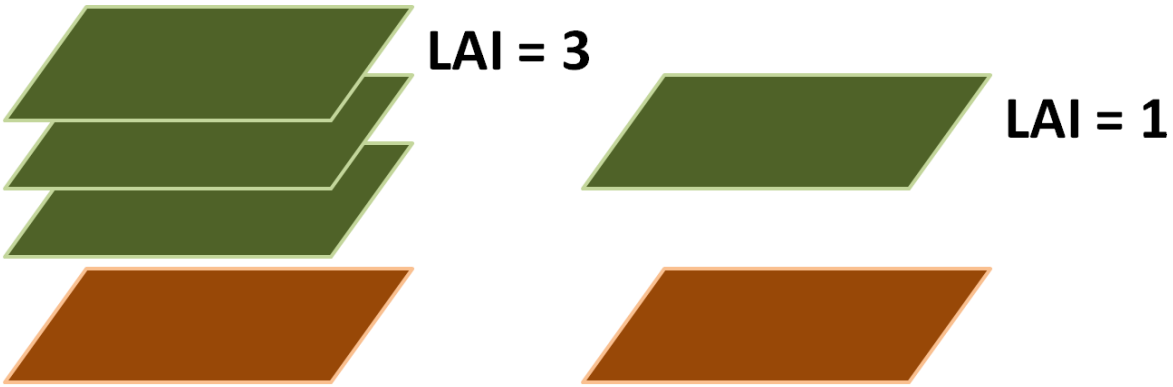

Diagram 6: Representation of Leaf Area Index (LAI) (keywordsuggest.org, Accessed: 7 February 2017)

The basic proposition is that the size of the surface area of the leaves of a plant, as well as the height, may affect thermal transfer into the surrounding environment. In one particular case study it was found that there was an inverse relationship between LAI and reduction in peak canopy air temperature and mean temperature variation, with the greater LAI resulting in a reduction of mean temperature variance from 11.6°C to 3.6°C, and a peak temperature reduction of approximately 9.3°C (Kumar and Kaushik, 2004, p. 1508). The heating flux which enters the roof is an important consideration when investigating green roofs, especially in their design, as this determines the potential coverage and foliage height as well as type required in order to reduce the heat absorption by a specific amount (ibid). The study concludes that the larger LAI can reduce the flux by nearly 4W/m², and that green roofs can have a passive cooling potential of 3.02kWh per day (2004, p. 1510). This particular case study allows a brief response to the question regarding scale of urban rooftop gardens. With the conclusion that the larger LAI decreases the overall canopy air temperature, it can be deduced that the radiative heat given off will be lowered as a consequence (Akbari, 2005). Increasing the LAI can be seen as combining various rooftop gardens in order to create a larger surface area which would ultimately act as one single entity, allowing the scale to be changed from simply a building scale up to either a block or city scale depending on the cost benefit and legislation guiding green infrastructure.

The benefits of earth covering methods such as green roofs provide a clear benefit, however, the question of cost, lifespan and maintenance of such projects will be expanded upon in order to further justify the development of rooftop gardens. A secondary consideration within the case studies mentioned, is the fact that the buildings used seem to be relatively low, at approximately five storeys. Is there a height or bulk restriction when it comes to internal cooling or is it irrelevant due to the barrier that is created limiting the amount of heat entering a building? Essentially, would a floor to area ratio become a consideration, and look to introducing a 'floor to garden ratio'?

The technical aspect of green roofs can become quite difficult if we consider that there are actually three parts to it. Del Barrio (1998) differentiates between the canopy, soil and roof support layer which all have their own effects on the surrounding environment and structure. "The most significant benefits of green roofs, such as storm water retention and a cooler microclimate in urban areas – are hard to quantify or to put a dollar value on them. However, these benefits, combined with the improved roof longevity and thermal insulation of a green roof, can easily outweigh the increased first costs for most installations" (Wong et al, 2003, p. 354).

A case study which investigates a more technical aspect of rooftop gardens and the relationship between energy efficiency in commercial buildings in Singapore was carried out by Wong, Cheong, Yan, Soh, Ong and Sia (2003). The case study looks at a number of vital design principles regarding aesthetics, roof types, vegetation type, vegetation density and soil depth (Wong et al, 2003, p. 355). Controls for the case study were set out limiting the height of commercial buildings being investigated to five storeys, and three different roof types, being exposed angled roof, typical flat roof and roof developed with a garden (ibid). Vegetation type was also an important consideration with the controls being turf, shrubs and trees (ibid). The last comparison focussed on the soil depth, and the effect different soil depths would have between 100 mm and 900 mm (ibid). The findings were summarised as follows: rooftop gardens could save 1-15% in annual energy consumption, 17-79% in the space cooling load (the amount a space is cooled) and 17-79% in the peak space load (the peak temperature experienced in a space). These numbers were based on a standard soil depth, with the additional comparison revealing that an additional saving of 1-3% on annual energy consumption could be achieved purely by having an optimum soil depth.

Interestingly, the vegetation type showed that shrubs in 300 mm deep soil were the best performing garden type, achieving a saving of 15% annual energy consumption, 79% in the space cooling load and 79% in the peak space load. The optimum soil type was also noted to be dry clay soil, and the depth of 900 mm for the particular design without any rooftop garden. The findings also confirmed that peak heat transfer was reduced significantly with the installation of a rooftop garden (Wong et al, 2003, p. 363). These results may seem contradictory to the earlier case study involving LAI and canopy temperature, where the increase in foliage height and LAI were beneficial to reducing the radiative heat effect. The key difference is that the increased LAI relates to the reduction in the heat island effect, and focusses on the external environmental impact, while the second case study relates to the internal environment and energy saving potential with passive cooling and reduction in heat transfer into the building itself. It could therefore be deduced that a combination of the two approaches would be the ideal situation, whereby a portion of the heat island effect could be dealt with, and an additional portion could cater for the internal passive climate control. The question of which is more important could be further investigated, and factors such as water consumption by the selected vegetation, and purpose of the project, whether passive climate cooling is beneficial for certain buildings. Particularly important is that the second case study deals with a five storey commercial building. Would similar results occur if the building height were to change, and if so, would the primary goal then change to heat island reduction rather than internal passive cooling which might be dealt with by internal landscaping?

The implications of substrate depth and vegetation height will give an indication of the type of green roof most suitable. Further consideration can be given to whether raised beds or pallet boxes are used, or if the garden is applied directly to the roof, with weight and waterproofing precautions taken. The benefit of having raised beds or a modular design is that they are easily changed and reasonably mobile compared with the built-in garden. There is a concern that any type of rooftop garden will experience more stress than a ground based garden and will generally be “exposed to a higher frequency and intensity of drought stress” (Olly et al., 2011, p. 315). A point brought up regarding the biodiversity of habitats is the fact that areas which have experienced drought or some other type of disturbance early on in establishment, create hardier flora and fauna which are able to have

a greater succession rate (Olly et al., 2011, p. 316). This argument could work in favour of green roofs providing an ideal environment for promoting biodiversity, even though they may not function in the same way as a ground-based garden. Therefore it should be noted that while green roofs are good interventions for greening the city, they will not act as exact replacements for the natural floral habitats which cities often lack (ibid). Furthermore the point of greenwashing is of great concern when taking green roofs into consideration, especially if there is no control over the type of vegetation grown and water consumption. The impact of ill designed green roofs could negatively impact a building or its surrounding environment, especially if it is seen as a replacement for existing ground-based habitat (Olly et al., 2011, p. 315), but may, in certain situations, be used as a protection mechanism for promoting biodiversity. Clearly, the trade-offs need to be carefully considered regarding aesthetics, biodiversity, climate control.

The City of London provided a number of case studies which investigated different strategies undertaken within the city. Each case study had specific key drivers, and individual contexts which guided the design and implementation of each project. What is notable is that each case study experienced similar barriers in terms of development control, however varied in terms of actual physical restrictions such as roof slope and substrate depth (City of London, 2011). Four case studies which can be focused on are: 1 Poultry; 150 Cheapside; Guildhall; and The Museum of London.

1 Poultry highlights the two points of accessibility and aesthetics. The initial idea was to have a public open space within the City of London, however, the rooftop is now being used as an exclusive restaurant and bar (City of London, 2011). The project took a long time as there were various consents required, however, the building's design could not be altered as the initial plans which were submitted a number of years previously, were the ones to be approved. This restriction of adhering to strict guidelines can be seen as both a safety mechanism for keeping building regulations, however, the limited flexibility can also be seen as restrictive if an alteration to the original idea needs to be made. The primary benefit of this project is listed as improving the roofscape, with the trees being visible along surrounding streets and the ideal provision of an outdoor amenity for the restaurant. There are also thermal insulation and rainwater attenuation benefits which support the

development of this particular roof. The image below indicates the clear attention paid to the aesthetic upkeep of the roof top garden.

Image 2: 1 Poultry rooftop garden, London (City of London, 2011)

150 Cheapside uses a mixed green roof approach, where there is the traditional "Sedum Blanket", covering the main rooftop, planters on the lower terraces and the inclusion of photovoltaics. An important consideration for this particular project was the fact that the rooftop is visible from the viewing balcony of the Stone Gallery at St Paul's Cathedral, and as such the aesthetic considerations were a high priority. A more pertinent point regarding the actual type of plant species used is the fact that the sedum blanket was not indigenous, as it was created in Germany. The project team therefore attempted to offset this by including planters with indigenous species on the terrace portion of the building. This relates to the point raised about the shift in principles from various decades which may have focused more on aesthetics than biodiversity principles.

The Guildhall project highlights the use of both hard and soft landscaping, again for aesthetic benefits with the inclusion of an enhanced biodiversity rooftop. One of the challenges described in this project was the retrofitting issues limiting the reinforcement of various structures. This meant that there was a weight limit and therefore a limit to the

type and variation of the substrate. The image of the Guildhall shows the mixed approach to hard and soft landscaping, with smaller plant types due to the restricted substrate depth.

Image 3: The Guildhall, London (City of London, 2011)

Pocket habitat at Exchange House, Broadgate Estate is a modular planting system which was developed to increase biodiversity, with the focus on retrofitting buildings which might have structural limits. The benefit to this type of modular intervention is that it can be altered to suite a variation of roof types, as well as plant types. The substrate depth can be altered easily, which is valuable for both plant selections as well as impacting on the amount of water attenuation desired.

Image 4: Pocket Habitat, Exchange House, Broadgate Estate (ARUP, 2015)

The selected case studies highlight a number of varied approaches to rooftop gardens, with an attempt to show hard versus soft landscaping, a varied purpose of public and private gardens, as well as unique interventions which have come about due to difficulties of either budget, space or structural restrictions.

2.11 Cost Benefit Analysis of Green Roofs

Advocating for the application or adoption of green roofs can be a reasonably easy task, as there are definite identifiable benefits, as well as implicit gains for the urban environment at large. The building industry has experienced a push to take all sorts of additional factors into account with new developments, starting off with the town planning process of selecting the correct rights for a property and locating the development accordingly. Factors such as proximity to public transport, protection of the natural environment or supplying open space for habitat protection, stormwater management and any additional energy efficiency protocol which may be followed, all need to be laid out before any development takes place (Carter and Keeler, 2008, p. 351). Once these rights have been granted the process of designing the building can be finalised by an architect, and this is

where details such as grey water re-use, landscaping, energy management and other such interventions can be included (ibid). As with any type of new development or concept, the unavoidable topic of cost needs to be addressed. The cost benefit analysis as undertaken in this research report focuses primarily on the actual building costs and subsequent benefits post town planning processes. The emphasis therefore remains on the green roof concept rather than any other processes which may detract from the research question.

The green roof concept introduces an aesthetically pleasing approach to reducing energy consumption, with added benefits such as storm water management and occasionally assisting in small food production projects. These benefits allow roofs to become multifunctional structures and spaces (Carter and Keeler, 2008, p. 351), which shifts the traditional function of simply providing a covering for buildings. There has been a great deal of literature regarding the design of rooftop gardens from an architectural and landscaping point of view, however, "little research has been done to evaluate the costs and benefits of green roof systems for urban applications" (Carter and Keeler, 2008, p. 352). The much publicised benefits of green roofs usually relate to the environmental savings such as the reduction of embodied energy and life cycle costs focussing on single buildings (ibid). A good indicator used by Carter and Keeler (2008) uses a measurement of net present value over a given period for specific comparable sites. These indicators further the cost-benefit analysis for green roofs, not only from an environmental standpoint, but also the investment and return aspect for buildings for both private and public sectors.

As with any development, the construction and maintenance process is a good starting point. In the case study by Carter and Keeler (2008), a point regarding the traditional cost of a roofing system versus the green roof could not be based on equal experience as the green roof system has not actually been sold or used extensively as a commercial product worldwide for very long (*ibid*, p. 354). The traditional roof system used the lifespan of 20 years based on the waterproofing guarantee, while the green roof life span was placed at about 40 years. This was due to the fact that green roofs seemed to protect the waterproofing membrane from UV damage and physical disturbance (ibid). The actual construction costs placed the green roof at approximately twice as much as the conventional roofing system, and the maintenance for both was considered to be on a bi-annual basis (ibid).

Storm water management, energy use and insulation are three factors which are used as primary considerations for the cost benefits. The argument for savings on stormwater attenuation is based on the idea that green roofs should retain a certain amount of water, and as such less volume arrives into the constructed stormwater system. This may result in a reduction of necessary pipe size and maintenance of the system overall, essentially leading to a lowering of costs. A counter argument to this is the fact that green roofs are very good at dealing with storm water retention for annual minor storms "but are less effective at retaining significant portions of runoff from the larger 25-100 year storms. Stormwater systems are typically designed for these larger storm flows" (Carter and Keeler, 2008, p. 361). While the downsizing of pipes may be irrelevant, the benefit, even if minor, to the reduction of maintenance costs of the stormwater system should be included in the cost-benefit. The energy saving category will be directly related to the insulation benefits provided by the green roof.

As discussed in the technical portion, the diminished heat gain, and lowering of temperature variations allows for a benefit of passive climate control. This benefit however has generally been worked out to between 3.3% and 8% (Carter and Keeler, 2008; Wong et al., 2003), which is a reasonably modest saving for the cost of the green roof system. Air quality has also been included in the cost benefit analysis done by Carter and Keeler (2008), with the benefit coming as NO_2 emission credits. Again, the lack of literature and attempting to generalise specific filter rates for trees, grasses and shrubs makes it difficult to fully quantify and qualify this benefit (*ibid*, p. 358).

A second unquantifiable benefit of green roofs is the reduction of the heat island effect and the increased habitat space created. It is clear then that the cost benefit analysis will most likely only include a strictly objective economic perspective, where social benefits are slightly more subjective and have more room for error and interpretation. Therefore the benefits of extending the life and protection of the roof, the minor reduction of energy costs and stormwater management, all add up to a reasonable saving. It is highlighted that roof gardens should be implemented in higher density areas, as they will be using previously disused spaces, rather than trying to find valuable open space within a highly developed city (Carter and Keeler, 2008, p. 360).

The high cost of green roofs has been attributed to the fact that they are a reasonably new concept when done properly with a set plan and specific materials. While there might be an argument that a potted garden or raised bed may be similar, the specific green roof concept discussed in this research report seeks to fully develop the roof into a green space. With this in mind, the more green roof systems are introduced into the city, the more alternatives will be developed as competition grows, and most likely a reduction in cost.

2.12 Design Process:

"The roof surface can easily be overlooked as a space that can be designed into an environmental amenity for the building" (Carter and Keeler, 2008, p. 351)

Design and the principles of design are ever evolving subjects, with a great deal of thought influencing the history and future of both subjects. Design itself is quite often subjective, and relies on either a user or decision maker to confirm the designer's final product. The principles which guide each designer could be seen as less fanciful, and established on core beliefs which are guided by society, religion, politics and even economics. Thompson (2009) questions the idea of pluralism and further introduces the idea of 'trivalent design'. Pluralism can be seen as an alternative to monoism or dualism, which limit the input values to one or two specific fundamentals. Pluralism suggests a diverse input system, but not simply acknowledging diversity, rather engaging fully with it and creating a dialogue (Eck, 2006). From this understanding the development of trivalent design can be understood. The three foundation stones for landscape architecture values, used as the core principles for trivalent design, can be summarised as ecology, community and design (Gray, 1995: in Thompson 2009). Univalent design will have a high focus on only one of these values, such as the aesthetic values seen in the modernist landscaping of the earlier part of the 20th century. Bivalent design would therefore have a higher focus on two of these values, while trivalent design focuses on all three. At times, there might be an unbalanced focus within this trivalent design, which leads to a higher focus on either aesthetic, social or environmental values. This type of uneven focus would lead to issues such as the conceptual conundrum of 'green washing', whereby the design is generically termed to focus on a number of aspects, however a greater emphasis is placed on the environmental value, leaving the social and aesthetic values to suffer. The importance of acknowledging this, is to understand whether the introduction of certain design measures would positively

impact a given environment as a whole, or if there would be a negative impact at some other point in the design process. The trivalent concept is a fairly good representation of how various spheres interact with each other and the type of approach they will influence.

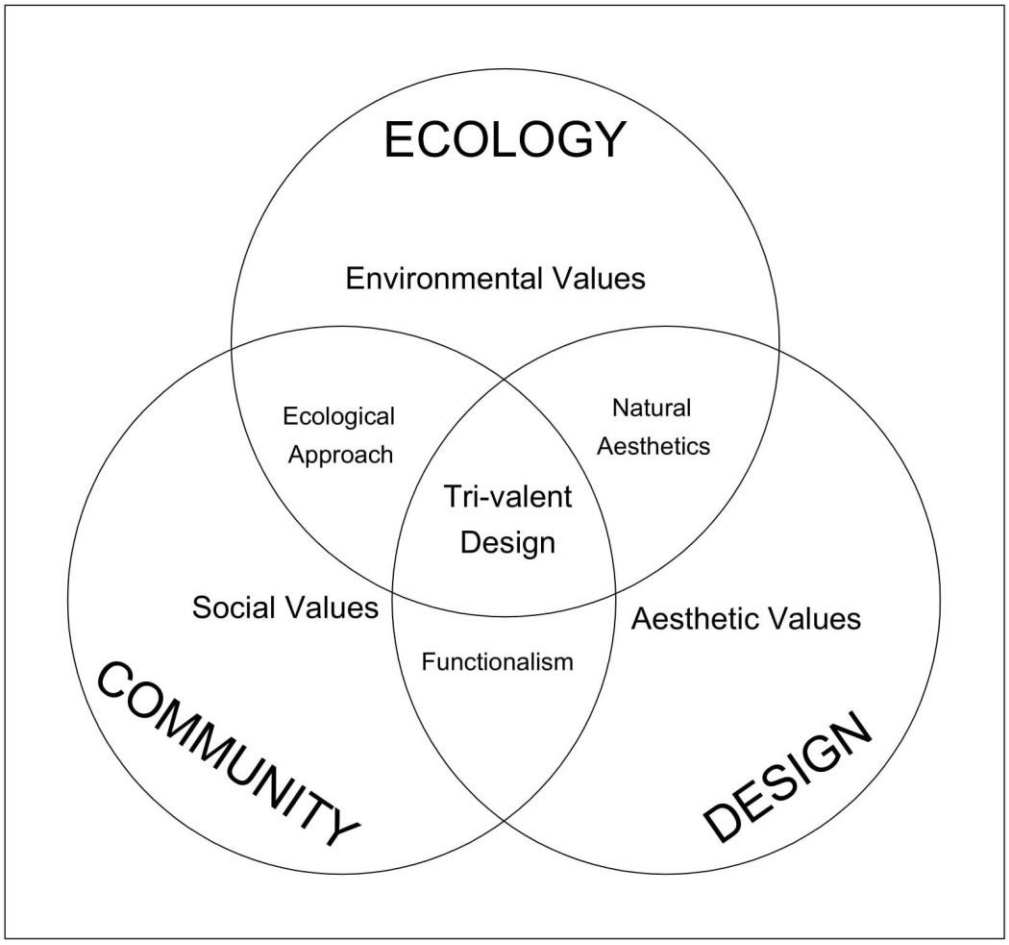

Diagram 7: Trivalent Design (Source: Adapted from Thompson, 2009)

Roofs are often the footprint of the building they serve, and can be used in a number of ways including an additional floor level used as a balcony, rooftop garden or storage area. Design approaches for green roofs have developed quite rapidly, with European examples showing extensive growth from the 1980s due to state departments issuing grants and incentives for the development of green roofs (Peck and Kuhn, 2003, p. 3). The different types of green roofs have been discussed previously; however the key difference between intensive and extensive roofs should be revisited for the purpose of analysing the design process. Extensive green roofs are often not designed for use by the general public or building users, with their design being of low maintenance, low cost, low diversity and

generally shallower soil depth and therefore lower weight (Peck and Kuhn, 2003, p. 4). The intensive green roof design usually has the intention of creating a user friendly environment which will cost more, have a deeper soil depth, higher diversity and maintenance requirements (ibid). With both types there is a standard design layering which includes the plant layer, growing medium, filter fabric, drainage layer, insulation, waterproof membrane, a general protective layer which sits directly on top of the roof (www.growinggreenguide.org, 2016). Peck and Kuhn (2003) summarise the design guidelines and implications into the following considerations:

- Use: Every rooftop garden or urban agriculture project will have a specific use in mind when being designed. The primary use should therefore be specified at the start of the design process, as this will influence a number of factors including substrate depth, plant type, layout and most importantly where the bulk of the funds will be directed. If the case studies mentioned in this research report are used as an example, a purely aesthetic rooftop design using larger vegetation types would require a deeper substrate due to root systems. However if the only purpose of the rooftop garden is to insulate the building, a drier clay based substrate would be used along with shrubs.
- Location: The location and orientation of the roof and garden are important so that factors such as sun and shade orientation, wind exposure, the general climate of the area as well as the specific microclimate which would all affect the design of the garden.
- Structure: One of the most important factors to take into account would be the type of structure the garden will be designed for. The added weight load of soil and vegetation play a primary role in determining the extent and type of rooftop garden. As with most renewable energy concepts, retrofitting an existing building is usually more difficult, as the existing structure would be the limiting factor in terms of load bearing allowance for a rooftop garden. This could be changed if the owner wishes to upgrade the existing support structure, however this could be very costly. The benefit of including a green roof in the initial design phase of a building, would be the fact that the weight of the substrate and vegetation can be incorporated into the structural load calculations. There is evidence that in countries where green roofs

have been widely implemented, there are lightweight alternatives for substrate type, other than soil, which has been said to weigh up to 1 597kg per cubic meter.

- Access: Access to the roof needs to be considered for two reasons. The first relates to the construction of the green roof, and how the materials will make their way onto the roof. The question of who has access is the second issue, as most buildings will have restricted access and therefore not necessarily be open to the general public. If it is open to a larger group of people, both tenants and the general public, there needs to be satisfactory access and egress routes designed into the garden so that there are not obstructions in the case of an emergency.
- Roofing: The design implications which could arise from the roof type relate directly to the type of waterproofing employed, as well as the gradient of the roof. The type of waterproofing is important for warranty reasons as well as any interaction there might be between substrate and organic material contained in the waterproofing material. Traditionally, rooftop gardens are developed on flat roofs, with a slight gradient in order to assist drainage, and special precautions should be taken around any drainage systems which may be included in the roof design. There are examples of roof gardens developed on roofs with a greater slope, and consideration needs to be taken to mitigate against the slumping of substrate and vegetation.
- Plants: The type of preferred plants will be dependent on the type of green roof system employed. An intensive green roof system can potentially allow for any type of plants, as the maintenance and cost will most likely both be high. The extensive roof type would most likely contain plants which are indigenous to the area, however, due to the harsher nature of the rooftop environment, it is suggested that plants “native to drylands, tundra and alpine slopes” be used with examples such as grasses, mosses, sedums and wildflowers (Peck and Kuhn, 2003, p. 12). If urban agriculture for the purposes of food production is to be employed, it would most likely be comparable to an intensive green roof programme, with higher costs and maintenance requirements.
- Construction, installation and maintenance: In terms of design, the construction and installation process requires planning of moving materials to the roof, what time of the year planting occurs due to heat and rainfall patterns, and what plants will be

used, how they are treated and even their availability. The continued maintenance after the construction process is crucial, as this essentially, develops and grows the garden into the envisioned design. For intensive gardens, daily routines would most likely be necessary to maintain the plants, with extensive gardens only requiring weekly maintenance. Maintenance would also include regular inspections of the waterproofing membrane for leaks, and possibly even soil analysis to make sure soil quality is maintained.

Further considerations also include insurance and liability issues which would need to be verified whether the roof is installed professionally. There may also be certain approvals required for the installation of both extensive and intensive green roofs, as structural concerns, vegetation size and species may have regulations guiding them. A final aspect which has not necessarily been investigated in this set of design principles, is the question of irrigation.

Permaculture is a term which has been defined as a process which works with the natural environment, usually simulating and mimicking nature (Franco, 2016). This general overview of working with the natural environment supports the idea of green infrastructure, and as such, further design principles founded on the permaculture movement can assist with directing green infrastructure design projects. Holmgren (2002) lists twelve principles of permaculture which Franco (2016) further integrates into sustainable architecture projects. The first principle of observing and interacting with the subject environment allows better judgment of what interventions may be required, including using existing natural processes to a project's advantage.

This existing natural environment can refer to a number of factors such as sunlight, water or wind, which leads directly onto the second principle of harnessing and storing energy. This not only refers to renewable energy sources, but also the embodied energy in structures, as it "makes no sense to raise large skyscrapers full of solar panels if your single construction generates a huge waste of resources and a series of negative externalities in other areas."(Franco, 2016, NP). The third principle focuses on yield, as measurable productivity is the generally accepted standard to reach with regards to energy efficiency. When it comes

to design, the term “yield” can also refer to the satisfaction of the user, as this is the desired reward which cannot be measured via credits or payment.

Principles 4 and 5 look towards self-regulation, accepting feedback and the value of renewable resources and services which go hand in hand with developing buildings which require these three things in order to function properly. Principle 6 requires, naturally, that sustainable projects produce no waste, which is linked to using all available resources.

For design specific projects, principle 7 states that one should design details from already existing natural patterns which have existed through previous experience. The integration of elements into projects , rather than trying to exclude them as referred to under principle 8, refers partially to the catching and storing of energy, but the fact that so much energy could be wasted trying to deviate externalities which could actually be included in the design of a project.

Principle 9 addresses the concept of localised projects and suggests that small and slow solutions are better managed due to their incremental approach. With smaller successful projects, it could be easier to replicate the successful dynamics, rather than trying to guess what works in which environment. Further to this idea of localisation, diversity can also benefit design, and principle 10 supports the previously mentioned concept of resilience, whereby a diverse space, community or city will be far more resilient.

Within the building scale, a diverse space or neighbourhood can utilise a number of different elements to create a more responsive environment. Principle 11 suggests using edges and the value of the marginal, stating that “The interface between things is where the most interesting events take place. These are often the most valuable, diverse and productive elements in the system” (Holmgren, 2002). The final principle which is vital in many other spheres, not only design, relates to creatively using and responding to change. The idea that adaptation and responsiveness of urban areas make up a portion of urban resilience, is paramount to trying to understand how to move forward with concepts such as green infrastructure and sustainable development practices.

From an aesthetic design perspective, two examples from Ken Smith’s Urban Projects (2006), The Museum of Modern Art, Roof Garden in New York, and the East River Ferry Landings in New York can show how complex the design process can be, as well as the

inclusion and exclusion of vegetation. The Museum of Modern Art is an ideal example which showcases an interpretive design, trying to imitate a camouflage pattern using artificial rocks, shrubs and pebbles (Smith, 2006, p. 58). This project exemplifies the idea of aesthetic purpose, purely designed and purpose built for its visual effect. The second example of the East River Ferry Landings introduces vegetation to an area trying to be pedestrianised. This project delves deeper into functionality and appropriate plant types for the project. As such, a 'riparian landscape container concept' was used, acknowledging that a specific type of vegetation needed to be used in order to mimic a natural river environment (Smith, 2006, p. 75). While the second example is not of a rooftop, it presents the awareness highlighted in the design principles regarding use, location and plant type.

2.13 Policy:

This introduction to the importance of policy is an integral part of moving green interventions forward. For the most part, green buildings have been encouraged by use of incentive programmes, such as tax incentives. The effort by France, is one example where specific guidelines and roof requirements are being incorporated into the building design process, which begins the process of regulating the specific types of interventions developers can use in order to improve energy rating performance. By taking this particular route of developing legislation, where developers need to comply via a set of plans, cities can have greater control and monitoring of effects these interventions actually have on a larger city scale, rather than just an individual building scale. Toronto, Canada implemented the Toronto Green Standard policy in 2009, which was a "two-tier set of environmental performance measures applied during the planning process to create more sustainable developments and help build a resilient city"(City of Toronto, 2016, NP). The City also implemented the Green Roof By-Law, which stated "requires green roofs on new commercial, institutional and residential development with a minimum Gross Floor Area of 2,000m²" (ibid). There is also a sliding scale for coverage required, depending on the Gross Floor Area, and it should also be noted that residential buildings less than 6 storeys or 20m in height are exempt from having a green roof. Furthermore, the 'green roof' designation includes "renewable energy, private terraces, and residential outdoor amenity space (to a maximum of 2m²/unit" (ibid).

Gross Floor Area (Size of Building)	Coverage of Available Roof Space (Size of Green Roof)
2,000 - 4,999 m2	20%
5,000-9,999 m2	30%
10,000-14,999 m2	40%
15,000-19,999 m2	50%
20,000 m2 or greater	60%

Table 2: Table of Coverage for Green Roofs (Source: City of Toronto, 2016, NP)

The development controls that govern land use typology are intricately woven into the urban fabric, taking a number of externalities into account such as socio-economic impacts, physical landscape and location, accessibility to both urban and social facilities and most importantly future strategic plans based on specific principles.

Currently, in Gauteng, and specifically Johannesburg, there are no zoning controls which guide or restrict urban gardening. The "Agricultural" zoning which is contained within the Town Planning schemes refer to the commercial aspect of farming, and is generally applied to the peri-urban areas outside of the urban boundary. The definition for agriculture as contained in the Johannesburg Town Planning Scheme, 1979, reads as follows: "Agricultural Purposes means purposes normally associated with or reasonably necessary in connection with the use of land and buildings for agricultural purposes and it includes only dwelling units necessary for and related to the bona fide agricultural use of the property" (Johannesburg 1979, Part 1, Clause 1, sub clause (iv), pg. 5). The definitions contained within the Scheme are typically generalised so as to allow interpretation to a reasonable level, so that they remain concise. While this is the case, within the zoning use table, "Agricultural" includes agricultural purposes and residential buildings. The inclusion of additional rights is typical of use zones, and quite often contain rights which the Municipality may grant with consent, typically not granted as a primary right for a use zone.

The policy for Johannesburg has defined an urban edge boundary line, where urban growth is promoted inside the boundary, and the protection of agricultural land is supported outside the boundary. The Regional Spatial Development Framework (RSDF) is the policy which developers use as a guide to see where the City of Johannesburg supports growth and development. The RSDF document is extensive in terms of what land-use rights will be granted, and within the greater Johannesburg region the majority of use zones revolve around residential, business, commercial, industrial and other such land use types consistent with cities. The protection of existing environmental areas such as rivers, wetlands and parks are governed by strict controls, however there is no specific policy which relates to a land use type such as urban agriculture. Within the city there are very few open spaces which have been designated as communal gardens, or agricultural spaces, as the majority of open space which would be traditionally used for agriculture, have been developed into an urban development.

Zoning as a tool is generally associated with the actual activity of urban agriculture, rather than the broader conceptual strategy of urban greening. This distinction is important to mention due to the location and type of agriculture assessed in varying case studies. Mukherji and Morales (2010) divide urban agriculture into "four categories based on two dimensions: the extent or dispersal of agricultural practices and the intensity of urban agricultural activities" (2010, p. 4). The first category specifies extensive and intensive agriculture, which is generally characterised by fully rural or peri-urban farms which have engaged with the standard practice of agriculture (Mukherji and Morales, 2010, p. 5). The second is less extensive but still intensive agriculture where examples given include "urban farms, farmers markets and composting operations" (ibid). The third type of urban agriculture is extensive but less intensive in nature and includes backyard and community gardens, but include limited livestock where users generally perform for subsistence or hobby purposes. The final category generally refers to the least extent in terms of land and intensity of urban agriculture characterised by small gardens at the back of dwellings or communal gardens in a small space, and generally restricts agricultural use to plants and excludes animals for health and nuisance purposes (Mukherji and Morales, 2010, p. 5). Referring back to the Johannesburg Town Planning Scheme, it can be seen how this categorisation would help in developing either a zoning use or consent use type zone, where

the inclusion of urban agriculture could be included into the standard use zones such as business, residential, or commercial.

The concept of including urban agriculture in the planning process speaks to the key purpose of planning, whereby a strategic framework can be designed, and a visual map can be created of land designated for this type of use (Mukherji and Morales, 2010, p. 3). This concept allows for the development of ground level tracts of land, rather than rooftops, and requires cities to have open spaces which can be set aside. Often the idea is to have community gardens which serve a neighbourhood, with a similar function to a local park. A policy example of this type is the Seattle Comprehensive Plan 2005, which states "at least one community garden for every 2,500 households in an urban village or neighbourhood" (Seattle Comprehensive Plan, Urban Village appendix B in (Mukherji and Morales, 2010, p. 4). There are currently examples of urban agriculture occurring at ground level in Johannesburg such as Marlboro, and plenty of backyard gardens within the urban boundary. Further out, there are more expansive models in areas such as Orange Farm and Northern Farms, however none of these have been implemented due to policy intervention, but rather as a socioeconomic project. While the inclusion of urban agriculture in the planning process is very specific, the idea which should be emphasised is the unique approach to planning for green infrastructure could be done in similar ways that of infrastructure services such as water, sewage, electricity, road upgrades and storm water attenuation. This applies on a large scale similar to how planning deals with the city via nodes and neighbourhoods, however the city is made of individual erven and buildings. If the focus on these individual buildings can have a bifocal lens, where each individual building can be designed or assessed on a micro level, but still maintain a macro focus on the interrelationships between these buildings, then there may be a niche in the design aspect of green infrastructure on or inside these buildings which would contribute to the greater green infrastructure of the city.

A proposal for introducing a zoning structure for urban agriculture, and specifically relating it to rooftop gardens in high intensity building developments such as commercial buildings and high density residential flats, is the idea of public versus private interests. Is a zoning requirement the only way to encourage the private sector and commercial developers to introduce green roofs as a public interest benefit (heat island effect, storm water retention,

air cleaning, creation of habitat)? Where previously, building owners were generally only concerned with their own building's performance due to rental income benefits and cost saving (energy savings, roof membrane protection and life extension, sound insulation, fire resistance, safe accessible green space). What the literature attempts to highlight is the fact that there are benefits for both public and private interests. Unfortunately the public benefits cannot be directly beneficial in terms of a monetary value, only if and when stormwater attenuation is considered, and this is a reasonably weak argument as discussed previously. Therefore the justification for zoning would be primarily based around formalising the urban agriculture interventions as a type of control, including them as a type of additional approval process such as stormwater attenuation designed by civil engineers, fenestration calculations done by architects and similar such approvals required at the plans approval stage of a building as discussed previously.

The SABS 0400-1990 document, which is the precursor to the existing SANS 10400-2010 document details its purpose succinctly. "This code sets out prescriptive provisions that are deemed to satisfy the technical aspects of the National Building Regulations" (SABS, 1990, p. 4). The document includes an alphabetised index which includes technical regulations for all aspects of the construction of a building, including roofs, drainage, stormwater disposal and structural design. With the updated version of the SANS 10400 there is a specific portion which is relevant to energy efficiency, namely Part X. This section deals with Environmental Sustainability and introduces Part XA which gives guidelines for Energy Usage in buildings (SABS, 2011, p. 3).

Compliance with Part XA requires details on the hot water supply, energy usage and building envelope, while specific design assumptions are articulated relating to occupancy, occupancy times, ventilation, heat gains, hot water supply compliance and maximum energy demand and usage. The document goes further to give building envelope requirements such as orientation, floor heating requirements, wall materials, Fenestration details and roof assembly details. The key figure used in all the details mentioned is the R-Value which is the thermal resistance of a component measured in $m^2 \cdot K/W$. When plans are submitted to the Municipality for assessment, a SANS 10400 XA compliance form has to be completed and attached, otherwise plans are not approved. This prescriptive measure assists in regulating the inclusion of energy efficient measure in all new buildings, as well as new additions and

alterations to existing buildings. This is an important example of policy which is implemented at the design phase of the building cycle, whether it be for new buildings, or amendments to an existing building. There is no policy for the moment which addresses existing building compliance other than an occupancy certificate, which is required upon transfer of ownership, and this may be a loophole in the attempt to make all urban buildings as energy efficient as possible.

2.14 Conclusion:

The various literature included are extensive and broad in their analysis of sustainable and energy efficient principles guiding urban development, and narrowing the focus down to urban agriculture. The expansion of the term 'urban agriculture' to include a larger set of practices allows the argument to show a historical relevance and development of including both aesthetic and consumable plants within the urban limits. The relation between urbanisation and increased demand on resources has been outlined, with the intention to unveil the need for self-sufficient urban environment, which does not require large energy inputs to satisfy the various needs of the urban population.

Green Urbanism is an approach which helped to identify 15 principles that show where interventions can be focused in order to reduce energy consumption, and develop a sustainable environment. It was found that there are three specific principles which are relevant to this research report, namely urban greening, green buildings and food supply which supported the initial argument. From these broad interventions, the urban landscape was noted to have changed radically over the past few decades, and that there was a constant flux in deciding what the ideal urban utopia should look like.

There was a short exploration into the ethical aspect of ecology situated within urban spaces, and a set of anthropocentric and non-anthropocentric alignments which could be seen to represent various parties within the urban development sphere. The identification of these assisted in figuring out what drives each type of perspective, whether it be economic benefits to suit the self, or community at large, or an ecological focus which put nature and ecology at the centre. The basic underpinnings of these perspectives illustrate why and how green infrastructure has become a vital part of the urban development framework. Green infrastructure, similar to sustainability, was found to be a voluminous in definition, with a hard and soft infrastructure being included. Notably, the location of green

roofs can be summarised by the rationale diagram which illustrated the intersecting spheres between green infrastructure, agriculture as a whole and landscaping.

One factor regarding green infrastructure is the numerous subsidiary benefits which could be associated with various interventions. While looking at the soft landscaping benefits of urban greening, it was noted that food security, storm water management, and heat reduction could all be resulting benefits. These benefits can be seen as more or less passive, as they are a result of vegetation which is planted, with no technological intervention for converting energy such as PV panels or wind turbines. These passive interventions were also shown to have specific and measured results if designed and implemented on rooftops, cooling the interior of buildings at an individual scale, and reducing the heat island effect at a larger scale. Certain case studies were identified, which showed a variation in materials, intensity and maintenance, ultimately leading to an analysis of how resilient urban areas are successfully influenced by these interventions. There was a clear cost benefit identified with the installation of rooftop gardens; however there was no definitive result for the preferred type of garden. It was also deduced that the majority of gardens could be designed for aesthetic pleasure, while maintain a fully functional outcome such as energy reduction. It should be noted too that productive rooftops were found to have a great deal more maintenance, and were often located in areas with little water access issues, or had a fully operational grey-water system which subsidised the water demand. This is relevant, as this report aims to find the most appropriate outcome for Johannesburg, a water scarce city. The design process was found to have specific steps which can identify the limitations such as water scarcity, location and purpose, and that this process could be influenced by policy and zoning applications. Similarly, the building process also has specific steps, one of which, development control, is never really promoted in the design process. Development controls can be used in such a way that interventions can be prescribed with a sliding scale for each individual project, allowing tailor made designs to take place. It can therefore be seen that if one were to start at the base, that being policy and development control, measures can be put in place allowing the development of green infrastructure interventions. If this prescriptive development control approach is actually beneficial at the building and city scales, what would be the most suitable path to bringing such development controls into principle and practice and even enforcement?

CHAPTER 3

3 - Research Methods

3.1 Introduction

This chapter presents the method of how to 'systematically solve the research problem' (Kothari, 2004) as well as the techniques employed in the methodology. Research has been defined as "a scientific and systematic search for pertinent information on a specific topic" (*ibid*, p. 1), with this particular topic being rooftop gardens and energy efficiency. This research report attempts to detail various procedures which guide the design process of a rooftop garden, while trying to pinpoint the relevancy of policy guidance relating to energy efficient measures which are included in the building process. The methods used in the methodology to incorporate the literature review and field research have been chosen in order to obtain a diverse range of facts and opinions relating to urban agriculture, architecture and landscape architecture. These three fields all interact; however each one is different in terms of subjective and objective approaches. Due to this variation in approach, the methods need to be varied in their approach, but maintain the qualitative aspect of research.

In terms of analytical and descriptive approaches, the information required for the design purpose uses the descriptive approach to survey professionals in order to ascertain comparisons and corollaries in their approach to design. Purposeful sampling was done for both the interviewees and sites selected for the study. With regard to the energy efficiency impacts of these design interventions, the analytical approach is more effective, as it uses facts and data already investigated in order "to make a critical evaluation of the material" (Kothari, 2004). This research tends towards the applied research approach, where the aim is to find a solution for the immediate problem of climate mitigation techniques and possible design interventions to assist them. The qualitative aspect of this research report aims to find out the underlying processes behind particular design approaches and the impact policy might have on these. A great deal of design and experience with landscaping and agriculture relies on the empirical value method where "proof is sought that certain variables affect other variables in some way" (Kothari, 2004).

3.2 Purpose of this Research

The purpose of this research is to further understand energy efficiency and sustainability in the built environment. The overarching themes of energy efficiency and sustainability are too broad to take all aspects into account, therefore this research report seeks to narrow the scope down to green infrastructure within urban areas. The scenario being portrayed is the inclusion of green roofs in the design process of buildings, and specifically investigating if policy development can assist this. In order to fully understand the benefits of green roofs, investigations into types of vegetation and benefits needs to be done. The types of vegetation also need to include both consumable and aesthetic plants, which leads to the concept of urban agriculture. The focus of this research cannot exclude any of these sub-categories if an accurate conclusion is to be drawn about green infrastructure benefits as a whole. Therefore, this research report seeks to question the design process of buildings, and the validity of including vegetation into rooftop designs, and whether this vegetation can have any ancillary benefits.

3.3 Procedure, Timeframe and Scope

The procedure of this research report began with a conceptual framework whereby the problem of food security and energy efficiency were identified as key concerns. Further investigation led to the idea that the development of rooftop gardens could assist with the energy efficient portion, using climate control, and the possible combination of urban agriculture being used to serve as an ideal vehicle in delivering the vegetation used on roofs. It was then identified that literature would be crucial in defining specific procedures and practices for both urban agriculture and rooftop gardening, and that an overall understanding of green infrastructure would be required. The literature directed the attention towards who the actual role-players were, in particular developments. It was then possible to identify who would need to be interviewed in order to gain site specific and regional specific information regarding building processes, landscaping, urban agriculture and policy development.

The timeframe has been limited to the programme timing of this course. It was envisaged that a full year would be required if a case study involving the growing of plants would be required, however, the information supplied by professionals in the agricultural and landscaping industry provided sufficient information, as the purpose of this report is not to

monitor growth, but possibly identify specific plant types best used in final designs which could influence policy development. With various professionals having been interviewed, further knowledge has been gained on specific sites where rooftop gardens and urban agriculture have been designed and implemented.

The scope of this research report focuses on a very small portion of green infrastructure, and is specific in its investigation of urban agriculture, in the broader sense, on top of buildings. There is a need to touch upon other factors such as internal greening, and urban agriculture which occurs on smaller plots of land on the ground, in order to gain an understanding of the challenges one might face growing plants, without the additional factor of the harder environment of a rooftop.

3.4 Research Strategy

The mixed-method research approach has a seemingly holistic tactic to investigate a number of avenues, and not focus on a single type of method for gathering and assessing information. Sarantakos (2005) investigates methods of data collection and sets out a six step process of how to conduct an evaluation study which will be the basis of this research report. The first step is to identify the topic and methodology to be employed (*ibid*, pg. 212). The subject of this particular research report is the opportunity of urban agriculture being included in the design process of buildings in Johannesburg. The topic looks at a number of sub categories in order to assimilate information that will be relevant to the research question. Of primary importance is the assessment of the value of urban agriculture and how it can assist in the case of energy efficient and sustainable city development. Scale and the type of agriculture are crucial to the development of rooftop gardens, although as seen in the literature, these can vary between cities and projects greatly. The second step requires the "Methodical construction of the topic" (Sarantakos, 2005, pg. 212), where variables such as location, users and plant type have been identified. Once these variables have been accounted for, the qualitative aspect of the research report is evident, when investigating the design aspect of buildings that have incorporated vegetation into their design. Steps 3 and 4 involve sampling procedures and data collection which address the fact that a potential of four case study areas being investigated (Sarantakos, 2005, pg. 213), namely the Joubert Park Collective Co-Op ("The Greenhouse"), Forum Homini Hotel, 70 Juta Street and the Discovery building in Sandton. It is therefore

necessary to take a purposeful sampling approach, where these specific areas will establish a general overview of how urban agriculture is developed. Within these case study areas, permission was requested in order to investigate the spaces, collect data, accurately record and analyse the data, interview certain participants, and finally depart the research site leaving a positive impression on both the area and respondents (Sarantakos, 2005, pg. 214). The final steps in this particular research strategy according to Sarantakos would be analysis, interpretation and reporting (ibid).

It was evident that a qualitative approach using case studies would be necessary, primarily because the data sets which are available for urban agriculture are not very large and their design and function are quite subject specific, rather than generally applicable. The use of interviews and case studies alone would not have provided alternative arguments to be presented, as they would portray what is happening in reality. It seemed important to broaden the scope of arguments, and with the lack of quantitative research available, literature was used to expand the research strategy. While the interpretation of design and interviewing will be subjective and left up to the interviewee's responses, there needs to be a controlled portion which deals specifically with the agriculture portion of research.

3.5 Research Design

The research purpose can be defined as exploratory and therefore a more flexible design is appropriate (Kothari, 2004). The research design identifies the means of obtaining information, the explanation of the way information will be gathered, the type of sample which will be researched and how the data will be collected, and the final point of data analysis. A good research design needs to have flexibility, allowing variances for who to interview, the sites to be investigated and appropriate conclusions to be drawn, even if they differ from the original hypothesis (Kothari, 2004). This study seeks to investigate a number of clarifying notions all relating to green infrastructure and energy efficiency. It therefore necessary allowed for a flexible approach when interviewing professionals and doing site inspections, as the theory and practice may be at odds with each other. This flexible approach can be seen in having a semi-structured questions, which act as a general guide for the interviewer. There was allowance for the interviewee to contribute knowledge which may affect the research question, but may not have been included in the questions. This also allowed for counter arguments to be heard regarding the concept of green buildings

and the greening of urban areas, establishing whether these investigated processes are active sustainability goals, or simply 'greenwashing'.

The variables which were allowed for can be defined as each professional interviewed, as well as the sites investigated for agriculture and design types. The opportunity to interview a broad variety of people including: architectural professionals involved in the design process of buildings; urban agriculture managers who actively grow plants and design green spaces within the city; landscape architects who combine the design element of architecture and the knowledge of botany to determine the best plants to include in a design; companies or directors who employ the design professionals and lay out the conceptual framework that the professionals use; and people who have been involved with the Green Star Rating system for the Green Building Council of South Africa (GBCSA). From all these perspectives, a great deal of information regarding the various steps for the design process and implementation of concepts could be gathered and reflected upon.

3.6 Meeting the Interviewees and Reflections

The interviewees were chosen primarily based on their profession and accessibility. There was a need for the professionals to have experience in their specific field, as well as a general understanding of how their profession might impact energy efficiency and sustainability, if at all. It was preferred if the interviewees were based in, or have experience in Johannesburg, as this was the study site, and general climate knowledge, urban structure and building processes underway would add value to the exploratory style interview. The questionnaire was chosen as a way to introduce the initial idea of growing consumable plants on a rooftop, with the refining of the topic left as a discussion point allowing the interviewee to both agree and disagree with concepts introduced. The questions were aimed towards all three primary professions of architecture, landscape architecture and urban agriculture, while trying to find specific answers about the locations, vegetation, maintenance and general process involved in landscaping and rooftop gardens. The interviewees' insight into the processes of not only urban agriculture, but general urban greening and energy efficiency and sustainability was included with the hope of creating a more holistic view of how a building can function as part of a community within the city, rather than an isolated block.

The selection of an architect who has embarked on a mission to incorporate as much energy efficient technologies and green infrastructure into his projects was considered important. This particular architect's academic work included a research report on Joubert Park, one of the first green spaces in Johannesburg and how it could provide new infrastructural linkages for urban culture. An urban planner with an urban agriculture background was considered in order to bring an interesting perspective to the greening of cities. This urbanist has experience dealing with public entities and providing both food and agricultural opportunities to both urban and rural communities. A landscape architect was included, with her focus on the improvement of the urban environment by using various landscaping techniques. She has a great deal of knowledge in both the design and implementation parts of the building process, as well as plant types. An urban farmer was found, who works first hand with three other women at two different locations developing a self-sustaining urban agriculture project in Joubert Park and Vereeniging. She has a great deal of knowledge regarding specific plans that are grown for medicinal purposes, as well as edible plants which the group sell directly to the public. In addition to plant agriculture, this interviewee also allowed the author access to the bee hives which the group uses to gather honey, as well as the biogas digester which is located at the Joubert Park facility. A Discovery facilities manager, and another architect at a Johannesburg practice were useful to give an overall view from the client's perspective. Both have been heavily involved with the new Discovery building situated at the corner of Rivonia Road and Katherine Street, Sandton. Their inclusion was aimed specifically for the fact that they wish to incorporate a rooftop garden which could provide the food for their on-site restaurant. A final selection was a registered professional with the GBCSA, who has been involved with various green building projects such as the new Sasol, Discovery and PricewaterhouseCoopers head offices. Her insight into both current building designs and the intended role of the GBCSA were requested in order to gain a holistic view of current green building processes and practice in South Africa, and specifically Johannesburg.

3.7 Site Selections and Visits

The locality for the site selection of this research report was based around Johannesburg, as a relatively new city established in 1886 (City of Johannesburg, 2016), and one of the fastest growing cities in the world (ibid). The specific sites chosen centred around the traditional

CBD of central Johannesburg, and the newly established Sandton CBD. The centre of Johannesburg has existing buildings which have historical value, however there is also a variety of high density residential and office space, allowing for an attempt to gain access to a varied sample type. Sandton is currently experiencing a development boom in the commercial office industry, with a number of new offices being developed within a one kilometre radius of the Sandton CBD. The thought was that by comparing existing buildings with less formal rooftop gardens, to the more formal office space with specific green designs, an accurate assessment of the design process and inclusion of rooftop gardens and building greening might be obtained.

The specific site in the CBD includes Joubert Park. Joubert Park was considered primarily because of the interventions which have been implemented along the sustainability lines, whereby the primary focus is to grow and maintain vegetation with the least amount of resource use. There are also design elements which recycle resources as foundations for planting beds, a bio-gas digester and rain water storage tanks, all contributing to the overall functioning of the project.

Image 5: The Joubert Park “Greenhouse”

The new Sasol offices in Sandton were chosen because the building was nearing completion and all gardens had already been designed and implemented. The design process could not be clarified, as there was a time constraint placed for the completion of the building.

However, renderings and a site visit allowed the visual interventions to be included in this report.

The new Discovery Site was chosen due to the fact that it was incomplete, and the information would be coming directly from the client. This would guide the perspective of the design goal, rather than the process, and ideally see to what extent the client would be involved in choosing the type of environment or their reliance on the professional team.

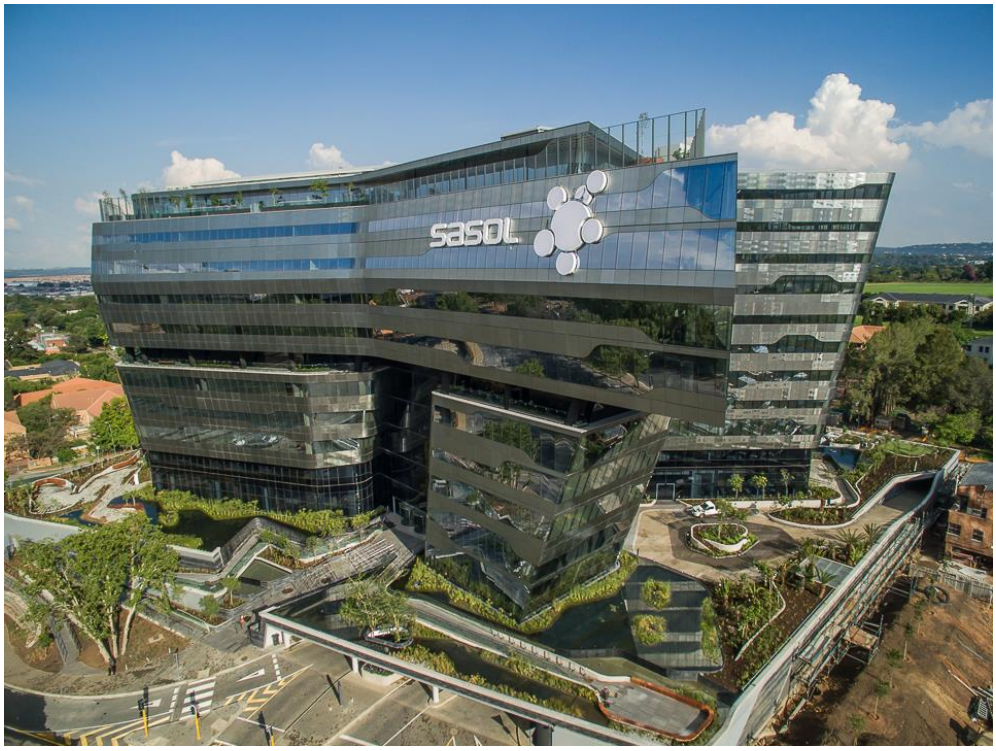

Image 6: Sasol Head Office (Source: Horak & Geustyn, 2017)

Forum Homini was a suggestion by the landscape architect due to her firm's work on the project. The site is located on the urban periphery of Johannesburg, however the design principles were considered to be crucial for identifying structural considerations as well as fully indigenous and water-wise vegetation.

Image 7: Forum Homini (Source: Forum Homini Hotel; Accessed 12 December 2016)

3.8 Themes from Interviews

The general themes from the interviews varied depending on the professional who was interviewed. However the key points revolved around the initial design process of either a specific intervention used in a project or the general principles established by a particular firm. Flora type, water considerations, and cost were tangible themes which featured heavily, as these usually had the greatest impact on how comprehensive an intervention was. Further concepts which were also introduced included the incorporation of green roofs into RDP houses, the farm to table idea, the GBCSA framework used by professionals, indigenous planting versus food security and finally both local and international projects used as archetypes.

3.9 Data Collection

A large portion of design data has come from architectural and planning journals, and books which highlight successful projects underway internationally. The comparison of the theoretical underpinnings guiding urban agriculture have been made between local and international examples. However the information regarding local plants can be incorporated into local designs and projects, avoiding the phenomena of reproducing global ideas which may not be relevant to a local context. The use of a secondary data sources has been used wherever possible, as collecting vegetation data would have been extremely time consuming and possibly detract from the primary purpose of this research report. It was

possible to gain this secondary data via interviews with urban agriculture professionals who deal with a variety of plants and specific purposes for their use.

The site selections, as discussed previously, were decided upon for specific reasons relating to location, access and background. The data collected from each site visit show the different approaches employed by users and designers. However, all sites show a social aspect which was not fully anticipated at the onset of this research report. These social aspects will be touched upon in greater detail later in the report.

3.10 Ethical Concerns

The ethical considerations were relatively limited and related to the interview process, questionnaires and permission to use a subject site in this research report. The users or professionals of the case study projects were approached and given a short questionnaire, listed in Appendix A, with predetermined questions so as to establish a brief understanding of the project and make sure they were over the age of 18, in order to give their consent for an interview. From this a semi structured interview followed, with a focus on the design and functioning of the case study area. The case study which required a more careful ethical approach was the urban garden in the inner Johannesburg CBD, as it is currently being used as a community development tool. It was important to note in this report that the main research topic would avoid encroaching on social and political agendas, as this would most likely have overreached the intended research concept. Ethical considerations were fairly limited regarding the direct influence of urban agriculture on the building design process, however, cognisance towards those being interviewed and how the result could possibly affect policy development regarding the South African National Standard (SANS 10400) was given. Qualitative interviews are more subjective in nature, and as such reporting exactly what a person says was crucial so that the author's personal subjectivity could not influence or alter the interviewing data.

3.11 Limitations

This study focuses on urban agriculture, which is generally accepted as the growing of edible produce. However, this research report seeks to broaden that term to include the general growing of plants for both aesthetic and consumption purposes. This broadening of the definition was done to avoid the limitation of too narrow of a definition being either gardening, which would generally be accepted for private purposes, or farming, which

would be for commercial purposes. The attempt was to have a broad definition for the growth and maintenance of all plant types for energy efficient purposes, which could essentially be incorporated into a policy document and used as a land use typology.

The time limitation regarding the growing of plants, and an attempted real-time time line was not possible due to the limited period of this study. There was a possibility of waiting for a production season to have a full cycle in order to gather accurate data regarding the establishment of a plant, and possible harvest of food products on a given portion of land. This was avoided by looking into the records of the projects and intensive interviews with the users who provided further information. Timing coincidently occurred at the start of the planting season, and initiation of gardens in subject sites, allowing a good opportunity to see the start of the growing cycle.

Studies on urban agriculture being implemented in Johannesburg specifically proved to be quite limited. There was a great deal of urban agriculture literature from other countries which could assist in this regard and it will be necessary to gauge the type of environment that these other examples come from. The purpose of doing this would be to have similar environments, such as water scarcity and hot climates, as comparing to more temperate climates would have a negative outcome on research results. There was a lot of local knowledge, which was discovered from the interviews, and a niche industry seems to be developing in the form of organic urban agricultural community based projects.

Limitations of access were encountered with certain buildings, as security concerns and private property laws were correctly adhered to. The author attempted a number of times to gain access and information from the 70 Juta Street rooftop garden project, however, these attempts ended up being unsuccessful and eventually abandoned for the purpose of this report. A great deal of this research report revolves around the policy work and actual design elements of certain rooftops, but not the question of public versus private space, and accessibility to various areas. While this should not detract from this particular research report, it is worth noting that accessibility is a further topic for consideration when looking at urban agriculture.

3.12 Conclusion

The mixed methods approach to this research report allowed for a range of inputs to be analysed. The literature provided the detailed foundation which informed the general analytical response to the research questions. In terms of relevance, the descriptive approach relating to interviews conducted with professionals within the built and agricultural professions seemed to gather the most appropriate local knowledge, while confirming certain aspects of the literature. It should also be noted that certain interventions were countered by the local professionals, indicating that the mixed approach allowed for the most accurate conclusions to be drawn. The limitations of this report were constrained to time, although, most of the respondents and site areas provided useful feedback. What may be useful in the future is to find a larger sample of rooftop sites, with the specific goal of testing the cooling effects of the interior and exterior environments. The research design regarding tacit knowledge found that the more diverse the interview group, the more relevant the information gathered, due to the complexities of each profession and their association with each other.

CHAPTER 4

4 - Discussion of Findings

4.1 Introduction

The literature cited in Chapter 2 attempted to give a broad overview of the how the concept of green infrastructure is developing, narrowing down the interventions to green roofs and how they may benefit urban areas. The inclusion of town planning policy examples also directs the argument towards how various development control interventions are prescribed. It can be seen how rapid urbanisation has changed the urban landscape, and the four perspectives of egocentric, homocentric, biocentric and ecocentric being represented by building owners, tenants, specific green interventions and planning professionals respectively. These associations give clarity to which professionals are involved with their specific interests in mind, and by incorporating the trivalent design concept, a balanced design process can be adhered to, where all perspectives have an input. The interviews highlighted the varied opinion of each professional, with some opinions shedding light on practical responses to conceptual principles which may have contextual downfalls.

From the literature review, specific professionals were identified and interviewed, as mentioned under Chapter 3. This was done to confirm certain procedures and processes, as well as in depth views of site design, stumbling blocks for policy, decision makers and general views for energy efficiency and sustainability concepts. The general themes through this chapter are policy and practice for landscaping, architecture and urban agriculture, physical design intervention concepts, flora identification, design process, spaces and places and the final theme of knowledge. The themes were defined in such a way that the literature and interviews engaged to provide an overall analysis of urban agriculture and rooftop gardens. The lack of accessible sites in Johannesburg required that principles for strictly rooftop garden examples needed to be taken from the case studies listed under Chapter 2.

The assimilation of knowledge between the theory based literature and the experience based interviews, attempts to clarify and ascertain if and how green roofs could be included

in policy development for the City of Johannesburg. The increasing interest in both urban landscaping and urban agriculture is evident from the interviews conducted, as well as taking note of articles in the general media. It is further hoped that this chapter can formalise that interest into a definite and identifiable need, allowing a succinct and accurate conclusion to be drawn regarding not only policy development, but also rooftop design principles that may be employed.

4.2 Spaces and Places:

There is a clear move towards including green infrastructure within developments, whether they are residential or business. The portfolios which many architectural firms are presenting to the public as conceptual ideas have a clear inclusion of vegetation in their design. It is important to also note that there are a number of cities which have started to include green infrastructure in their policy, allowing both renewable energy structures such as PV panels as well as rooftop gardens as an option for inclusion. By doing so, policy is engaging directly with the development of urban areas, providing a much needed endorsement of alternative technologies and interventions, which exist, but are yet to be fully embraced. The case studies from London are indicative of the style and type of rooftop gardens for highly urbanised cities. The spaces chosen allow for a variation in users, however the majority of the examples are of retrofitting projects.

In terms of the location within the city of Johannesburg, where urban agriculture for produce takes place, there is a general trend to seek open spaces that the public frequent as pedestrians. Using Joubert Park and Discovery as examples there are two principles which govern this, namely selling produce directly to the public, and public access to restaurants which use the produce grown. The urban farmer (2016) is clear in indicating that the Joubert Park collective benefits from the informal street vendors who buy in bulk from them, and then resell to the general public. There is also the opportunity for the public to purchase products directly from the Joubert Park collective, however, due to the limited number of staff, there is not always a guarantee that someone will be available to harvest and hand over the vegetables. The Joubert Park collective further indicates the delineation between primary and secondary goods from this issue, as the staff would focus more time on the skilled portion of producing ointments, moisturizers and other such products, rather than selling the primary produce.

The urbanist (2016) also tended towards open space by developing suburban gardens, and having a large tract of land on the outskirts of the city providing the individual plants used in these projects. The idea is to implement these ground based gardens on rooftops within urban areas, due to the large coverage offices and high density buildings take up. There are a number of individual examples, where private initiatives have taken over various roofs within the Hillbrow, Johannesburg Central and Newtown areas. These initiatives change the location of the gardens from a reasonably limited amount of open spaces within Johannesburg, and raise them up to the skyline, where there is, in a sense, much greater block space. While this space may eventually become limited, at present there is little to no use of roofs in the city. The question becomes an issue of access, and how to manage these rooftop spaces. The landscape architect (2016) mentions that older buildings might have an issue with heritage permission, however also points out that older buildings will have a reasonably set structural integrity, unless a large amount of money is set aside for reinforcing the building. The issue with this from a landscape architect's point of view is that soil depth plays a large role in determining the type of plants that will be used in rooftop gardens, with shallow soil depth limiting flora to succulents and grasses. Larger plants such as trees require a greater depth, and as such their incorporation would be more successful in new buildings which can take their projected load into account.

The facilities manager at Discovery (2016) suggests that the rooftop gardens would struggle if there was full reliance on external people to manage the space. However, if a communal project for the inhabitants of the building, there may be less of a security concern. Similar to how developers pay contributions to the municipality when a new building is zoned and built, inhabitants of various buildings could either contribute financially or with labour intensive input. The point made is that while developers generally pay contributions into a general fund which could be used at any location deemed necessary by the municipality and not necessarily benefiting that development, the inhabitants of a single building will see their efforts being put to proper use, as the communal space would be their rooftop, and not some other building or space.

The landscape architect and the urbanist also refer to the manipulation of an environment, where a microclimate might naturally occur due to a change in the local ecosystem, or the environment is purposefully changed in order to create a particular type of habitat. This

applies directly to interior gardens, which require additional light or water, such as hydroponic systems, or internal atrium gardens which can manipulate the internal environment through vegetation or water misting, and create a considerably different climate. This begs the question of what the priority of the building is, due to the cost of providing artificial light and additional water may significantly outweigh the cooling, aesthetic or production benefit of the garden.

4.3 Design Processes and Principles

Within the literature, the trivalent design summary of ecology, community and design having equal focus is the ideal design process. However, as mentioned, the heavy emphasis on the ecology aspect of urban development may lead to an unbalanced design approach where a greater focus on environmental issues supersedes community or design aspects. The landscape architect's suggestion of using a matrix to determine which scenario should be followed can assist in determining how important community, design and ecology are for a given client. From the interviews it became noticeable that every professional has a certain view of which principles are more important: with landscape architects and urban farmers focusing mainly on vegetation and ecological aspects of a space; architects focusing on the function and design of a single building; town planners focusing on the buildings in relation to the urban fabric as a whole; and corporate clients who view marketability and social accountability as a key focus. The conceptual underpinning of urban agriculture attempts to deal with all three of the trivalent cornerstones, with aesthetically pleasing garden designs which communities have a hand in either harvesting or developing that are ecologically sustainable and assist by means of sustainability and energy efficient doctrine. The landscape architect does state that her approach towards this issue is that aesthetics should always follow function, making sure that the landscape is ecologically sound, and no invasive or destructive species are introduced.

A design principle which should be considered vital was highlighted by the urbanist when he stated that one of his core principles was to implement companion planting, whereby plants flowering and bearing fruit at different times of the year, as well as when vegetables will be ready to harvest, create a diverse garden. This diversity, similar to an urban space, creates resilience, due to a number of species existing in a given space. The variation between ornamental and produce producing plants provides an aesthetically pleasing environment,

however the absolute benefit is the fact that the resilience will lead to a longer lifespan of the garden. The landscape architect agrees with the increased diversity of gardens, but more from the physical layout and including a mixture of hard and soft landscapes in order to deal with water collection. More water is collected on hard surfaces, with the softer surfaces acting as a type of sponge, absorbing the water. The mixture of hard and soft surfaces allows rain water to be directed to selected areas, allowing part of the water collected to be used for plants and the remainder to be diverted to collection tanks which tie into a grey-water system.

The notion of buildings being included in the urban fabric was repetitively brought up from a number of different positions. The framing of Discovery as a thoroughfare to Sandton City required that the ground floor be completely pedestrianised and open to the public. There was a feeling of social responsibility that the building should not be an individual monolith, which keeps the general public out, but rather a vital part of the public environment. While this is commendable, the nature of the surrounding buildings does not necessarily comply with the same principle, which brings up the framing for block developments. The landscape architect indicated that the rooftop gardens offsetting the heat island effect would not necessarily work if it was one rooftop out of a full city. However, if a conglomerate of roofs were to be used, the effect would be greater. Therefore, there needs to be due consideration of the surrounding environment, and a general design principle of the city. This argument ties into the policy development concept, where each building would have some sort of plan or acknowledgement of an intervention, which would allow municipal town planners to have an overall vision of where these interventions were placed. If these interventions are tied into the GIS system of the Municipality, it would create a visual representation, or map of the green infrastructure layout of the City, similar to how the water, sewer, power and even roads are laid out for various engineering departments.

The Discovery architect follows the above-mentioned principle with the idea that the City of Johannesburg is in desperate need of a design and landscaping department with in the development and building control section. The engagement with Council at a design level is similar to master planning, however, when relating to aspects of landscaping, it can be argued that it is rather infrastructure planning. The hard landscaping interventions such as benches, curbs and street lights all contribute to the general public environment, which the

municipality is responsible for. However there is a move by private developers to take on the aesthetic treatment of public pavements to ensure the external environment of their building is kept to a high standard.

Within the design process, the green architect asserts that there should be high value placed on the psychological aspects of a development or building space. He believes that it is an absolute asset to have pause spaces and similar areas where people can collect as a group and interact. The green architect further states that architecture is 'so much more than just an expression of art, it's got to do with how a person feels in your space" (2016). The addition of landscaping such as rooftop gardens may provide certain physical benefits such as passive cooling and stormwater attenuation, but there is a definite psychological benefit at both an individual and social level, where individuals experience nature for mental wellbeing, but there is a communal space provided for interacting. These benefits cannot be directly translated into policies, as emotionally subjective opinions may differ and change, making them irrelevant when considering policy changes or additions. It therefore becomes a design principle which may be included in a company's ethos, similar to incorporating indigenous plants. The psychological benefits of aesthetic design become valued only as a secondary consequence to purposes such as rental rates, energy efficient standards or occupancy rates, leaving the concept to be done on a voluntary basis.

The urbanist discusses a project done in the inner city by a municipal department, where rooftop gardens were installed for residents or tenants to grow and maintain food products. The urbanist suggests that this attempt was not really structured, and was more an amateur attempt at food security, with a further developmental idea of the gardens providing a surplus which could be marketed and sold for income. One of the reasons for including food security as a sub-theme in this research report, is the fact that there is a large push by the municipality to use creative concepts such as rooftop gardens to encourage and fulfil their own mandate of job and food security. The problem, confirmed by the landscape architect and the urbanist, is that the quantities required and the space available are disproportional, and that the informal design and implementation mean that there is no well-established model to work off of. The external climactic factors which the gardens need to fight against, restrict mass implementation of these types of gardens, with the added stress of no set plan to deal with various climactic incidents such as drought or flooding. It should also be stated

that informal designs are not to be discouraged at all, as these can often bring creative solutions. However, in certain situations, formal design interventions can give clear guidance. This guidance is beneficial in circumstances where a clear mandate has been set, such as carbon offsetting or energy efficient standards, which should be included in the building design process. It is therefore understandable how broad this subject actually is, not only involving green infrastructure, but social responsibility and economic development.

4.4 Design Interventions

The specific design interventions employed by various professionals differs depending on the purpose of the garden. The interventions mentioned below are all employed to reduce the carbon footprint of a particular building, recycle waste and other materials, or promote a sustainable principle identified such as food security. The discussion of climate resilience is relevant when assessing the type of interventions, as the fundamental justification can be categorised as either an adaptive or mitigating model. From the theoretical investigation, the difference can be seen as either a policy based intervention which changes the behaviour of an urban population, compared with mitigating technologies which rather change how much energy is consumed, rather than the actual behaviour. These interventions add a realistic view of what is actually happening in practice, adding to the idealistic interventions identified in the literature. The landscape architect considers the fact that the effects of having a garden on the rooftop may become more important than producing food on the rooftop and that there may even be a preference to install other interventions such as PV panels, as they will have a direct impact on electricity consumption and cost. This assigning of value or importance to various interventions will guide the type of intervention chosen. However, the focus for making these decisions is still on the internal environment, and energy used within the building, rather than any external benefits which might come as a consequence.

The control over the design seems to lie with the tenant, as the majority of interviewees responded positively to controlling their space. The urban farmer indicates that the Joubert Park Collective is entirely controlled by her team, and is not regulated by the owner. The facilities manager and the Discovery architect stated that Discovery are the lessee of the proposed new development, and they had majority control over their design. However this is not the norm, with the owner, architect and developer usually deciding on design

interventions and principles. In the case with Discovery, it was made easier by the fact that there was a single tenant, and that the lease was long term, therefore made sense to allow them to have some sort of control over their environment. The landscape architect states that "a small space that is designed to be a quality space for people has a far greater impact on their lives than a large park" (2016) and that the small rooftop spaces should rather cater as private places of relief for the building users, rather than restricted produce area.

One of the questions posed to the interviewees was whether internal and external designs were preferred. There was not a definitive answer as factors such as climate, water and convenience all played a role in what the end product's achievement was supposed to be. The landscape architect and the urbanist both indicated that the climate of South Africa in general, and specifically in Johannesburg, was considered to be quite harsh in that there were high temperature fluctuations, as well as increasingly erratic rainfall. Therefore outdoor designs needed to take this into account as these factors could not be controlled. The green architect's view is that internal environments are more mechanical, especially at a commercial scale and need to be managed, however external gardens are open to the elements and more unmanaged. The urban farmer's preference was for an outdoor design as there was less management once a plant had been established and the natural environmental processes maintain the plants for the most part. Internal designs require a great deal more consideration, as the internal environment needs to satisfy two standards, that of the occupants and then that of the desired vegetation. Constant maintenance is required in order to ensure plants are regularly watered and trimmed so as not to interfere with the internal building amenities. Internal designs have the benefit of not being at the external environment's mercy when it comes to heat and lack of water, however, a consistent water source is required which would either come from storage tanks if the building has a grey-water system, or municipal water. The Discovery building's solution to the internal versus external issue is to deal with these issues by handling the most adverse conditions such as heat with shade cloths. Simply put, if the external environment is favoured in a design, there will need to be certain measures in place to mitigate against the harsh and unpredictable external environment. This leads to the hydroponics concept, which was also investigated by Discovery, however this is not always an acceptable solution for some as it is not viewed as an 'organic' process using soil, but rather water

supplemented with concentrated chemical nutrients. In terms of further interventions to assist with internal cooling, the landscape architect proposes that vegetation should be included vertically on the facades, as heat enters the building from a number of positions, not only from the roof. She further states that heat from paved areas at street level will rise, and therefore be absorbed horizontally sooner, suggesting that not only will there be heat gains directly from the sun, but also thermal radiation heat from the ground. The inclusion of vertical gardens is included in the green architect's analysis of successful passive cooling efforts. However, his preference would be an interior garden, possibly taking up the majority of certain floors, creating large internal pause spaces throughout the building.

The Joubert Park Collective employs a simple design using existing beds within "The Greenhouse" structure, and raised beds using discarded tyres. The sunken beds are generally used for the creeping flora such as pumpkins, however depending on demand of other vegetables, this can be changed accordingly. The majority of the sunken beds already existed when the current team of urban farmers started the initiative at the end of 2015. The tyres are used to add further growing space with the benefit of being mobile, as well as allowing greater control of the soil content. The standard design is to stack two tyres, as one is too shallow for growth and three is unnecessarily deep, with spinach, potatoes and beetroot being the ideal plants grown in these.

Image 8 and 9: Tyre planters and permanent raised beds at Joubert Park

This facility uses municipal water, however there is a 5000L storage tank which can provide water for about a month. The drawback of the storage tank is that water needs to be transported by buckets for watering, while the municipal water can be used with hoses. The use of mulch is also highlighted to save water by reducing evaporation. The Biogas digester is an initiative which was undertaken to provide cooking gas for manufacturing the products sold for income. The digester takes up a small space of approximately 10mx5mx2m and there is little to no odour given off. The digester requires an initial 20L of cow dung and 20L of water to start the process with specific enzymes which emit the gas. Once the process is underway the digester needs to be fed daily with organic waste such as the unused food grown.

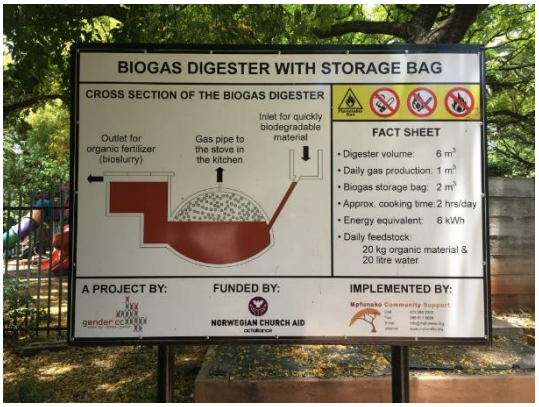

Image 10, 11 and 12: The water storage tank, Biogas digester process, Biogas Digester (Joubert Park)

Image 13 and 14: Cooker using gas from the digester, various products sold for income (Joubert Park)

The Discovery facilities manager indicated that the rationale to develop the Discovery site in a specific way was to promote the 'Healthy lifestyle initiative', which the company promotes by nutrition and activity. The roof was seen as a key area to incorporate activity areas such as playing courts, landscaped gardens as well as a productive food garden. The food garden idea was brought about to supply the on-site restaurant which was also part of the healthy lifestyle concept. The size of the garden was planned at approximately 300m² with a blended watering system that would use stored rain water, as well as municipal water, if the rainwater tanks ran dry. The stormwater system was designed in such a way that all rooftop stormwater drains into basement number four, where storage tanks are located. These storage tanks tie into both the Katherine Street stormwater management system, as well as the building's greywater system. The Discovery architect indicated that the architects approached a landscape designing firm in order to develop the finer details of the gardens, both for the landscape aesthetic garden as well as the productive food garden. Further to the specific design principles, as mentioned previously the bottom level of Discovery was left public so there was a thoroughfare which people could use to access various parts of the Sandton node.

The landscape architect cited Forum Homini, an hotel close to the Cradle of Humankind, which was designed to be incorporated into the surrounding landscape. The landscape architect identifies that the predominant vegetation is grassland, therefore the roof

structures were designed specifically to hold a certain weight that could withstand the proposed grasses to be planted. Lightweight soils were incorporated into these rooftop gardens to provide additional relief to minimise the load, allowing a greater focus on the vegetation rather than the actual soil. Additionally the incorporation of a rooftop garden design was to provide insulation for the buildings so that heat gain and loss were minimised. The landscape architect refers back to a point regarding the harsh climate of South Africa being a key reason why rooftop gardens would not be preferable, saying internal atriums would possibly be better suited, however, she further states that new buildings do have the opportunity to cater for structural additions which can deal with adverse climactic conditions, allowing the development of rooftop gardens. In terms of water use, the landscape architect confirms that municipal water is generally used to establish the plants on her projects for approximately a year, after which the plants have established themselves and can be self-sustaining on the natural weather system of the area. The use of drip irrigation systems, which keep the water line close to the roots of the plants, with the added benefit of mulch, conserves water by reducing evaporation.

Image 15 and 16: Forum Homini thermal layer roofs (Laylin, 2011)

The urbanist's experience with developing agricultural land is useful when trying to gauge the scale of urban gardens, as well as the productive capacity. Over a period of three to four years, the urbanist and his team did seventy five installations of vegetable gardens in urban areas, and before that he spent two years working with rural communities attempting

to provide a means to food and water security. The scale therefore varies from individual gardens of approximately 150m² to full agricultural farms of around 900ha. These smaller urban gardens sought to provide an aesthetically pleasing solution to the standard vegetable garden and indigenous landscape. The gardens included perennial vegetables like picking greens, herbs, fruits and fruit trees. Beehives were incorporated into some houses and others had chickens. One of the interventions was the conversion of a swimming pool into a freshwater filtration system, which acted in a similar way to a wetland. In order to maintain a local supply chain of plants, the urbanist made use of a plot of land on the urban periphery, in Honeydew, approximately forty five minutes outside of Johannesburg. There was a fairly big composting operation on site, a small nursery to propagate various plants, and about a hectare of permanent beds used to grow the plants which were to be planted in the designated gardens.

The targeting of middle to high income households was chosen due to the fact that they would be able to fund the various technologies which aimed to take them completely off grid in both energy and food production. The interventions for the larger scale agricultural farm land focussed a great deal more on diversifying the value chain, so not focussing on simply maize products, but localising production of a range of produce which suite the site's characteristics. One project also saw the development of a training centre which focused on a permaculture design system which attempted to investigate how animals would interact with each other as well as with various plants so that a more holistic type of agriculture could be established. There was a residential house incorporated into this specific project which implemented a greywater system, again with the attempt to recycle as much of the water as possible so that water loss could be kept to a minimum due to water scarcity.

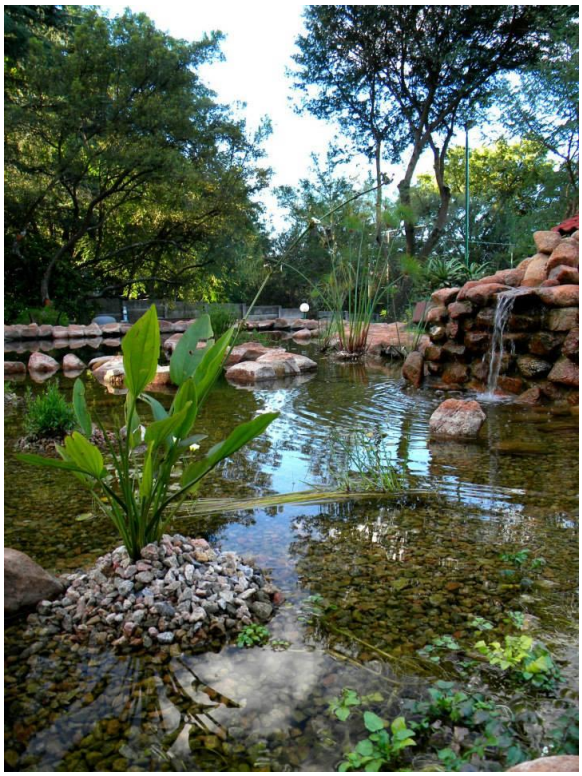

Image 17 and 18: The urbanist's water conversion before and after (Te Brake, 2017)

The green architect gave an example of a school in the northern suburbs of Johannesburg which introduced water-wise gardens or xeriscapes which were implemented to reduce water consumption and maintenance. It was seen as the best value to maintain an aesthetically acceptable landscape appeasing the parents to the school who prefer a well-manicured appearance of the gardens. There was also the introduction of small vegetable gardens in specific areas, directed at changing some of the invasive tree species which had been on the school property for a long period. These vegetable gardens were thought to provide a better use of space, providing an optional food choice for the staff and children, and even going as far as linking with underprivileged schools to provide food and skills development for growing vegetables. In addition to normal soil gardens, the green architect had come across a private hydroponic development which was being used to supply one household's fruit and vegetables. He describes the system as essentially a closed system with a continuous supply of water and nutrients, minimizing any waste of water and plant nutrients, seemingly the most efficient way of growing plants on an individual household basis.

The green architect also introduced a point about regional specialisation in terms of specific vegetation being used. He cited China as a country that has regional specialisation with its agriculture, where certain areas can only grow specific plants, and therefore attempt to

localise agriculture reducing energy spent on growing plants outside of their ideal habitat, as well as expending energy transporting that vegetation great distances. This example focuses more on the ethics of crop cost, such that if a crop has a greater demand and therefore a greater cost, this may be favoured over a crop that is more appropriate. Similarly, if plants incorporated into urban gardens, and landscapes, there is no real prescription for a plant type, and a landscaper or architect may feel that a particular plant is more valued, over an indigenous species. This may create a bigger problem than simply having no vegetation due to invasiveness by consuming water or poisoning a localised environment. The urbanist's take on the decisions guiding vegetation type, and specifically relating to commercial farming, is that there is a focus on market demand, and a particular crop may be supplemented and subsidised when it comes to input, in order to ensure that those particular crops are grown and harvested successfully to fulfil the market demand. "This input intensive way of growing plants is usually associated with high water, seed, fertilizer and pesticide costs to ensure a large volume which can be shipped either locally or internationally" (The urbanist, 2016). This can be translated at a smaller scale to urban agriculture and even green infrastructure, where a market demand for certain interventions could lead to concepts like a green building rental premium. The costs associated can also be broken down into two categories as discussed by the urbanist, namely financial and environmental. The financial costs will be more immediate, and linked to marketing and green building premiums, both for rental and purchasing. These financial costs are also taken seriously because they are more immediate and visible to the general public, however the environmental costs are long term and often only seen years or decades later. Using the idea of a localised supply chain, a comparison can be drawn between understanding exactly what went into growing seasonal products locally, and shipping in a product all year from an unknown destination, not knowing if due consideration has been paid to the local environment and climate restrictions.

Referring to the strategies for climate resilience and the approaches for adaptation versus mitigation listed under paragraph 2.9, there is a definite separation between the approaches mentioned by the interviewees. The merits of adapting to a changing environment may benefit those able to afford various technological advancements, or even behavioural changes, however there may be various factors limiting adaption for others.

This is not only limited to the human population, but the animal and plant kingdom. Mitigation then promotes the stability of the external environment, allowing for a greater number to benefit, however still requiring an active change to a given environment. The interviews highlighted some of concepts under the adaptation and mitigation headings, but there seems to be little acknowledgement of the overlapping sector such as green infrastructure. Specifying the design interventions as adaptation, mitigation or some sort of combination of the two would assist in the type of policy one could use, as well as where in municipalities' structures regulation could take place. Mitigating factors seem to fit in with building control, while adaptation may be better suited at a national or provincial level involving social programmes.

4.5 Flora Identification

The urban farmer and the urbanist gave insight into the type of products grown in urban areas, as well as the supply chain that may be followed if food producing plants are used. The inclusion of flora identification in this research report serves to identify two purposes, the first to substantiate the idea that food producing plants can be grown in urban areas, and secondly, further justification for the inclusion of food producing agriculture into urban policy. By relating what is happening in urban areas to the conceptual framework identified in Lehmann's Green Urbanism, specifically biodiversity and local food supply chains, as well as linking this the food sovereignty concept and the millennium development goals of food security and environmental sustainability, a brief list of plant types could be listed to give bearing on the design interventions used. This may be preferable to prescribing a set of flora types, which limit diversity and could have a more restrictive impact on design interventions. Flora identification also assists with figuring out just how much flora is actually indigenous or exotic, as there does not seem to be any prescription but rather verbal communication that a ratio of 80:20 for indigenous to exotic plants according to the urbanist. Plant identification is crucial not only for simply finding out the indigenous component, but further to support the design implications of rooftop gardens if one were to use the leaf area index and foliage height guidelines in Kumar and Kaushik (2004) shown in Chapter 2.

The urban farmer states that if herbs and other such plants are to be grown on the roof, they need to be very hardy and withstand harsh climates. She suggests that aloes and other

such succulents are better suited to rooftops, as they don't require a lot of water, and once the initial establishment phase has passed, they are self-sustaining. This is echoed by the landscape architect, the urbanist and the green architect, who all state that the rooftop climate is extremely harsh and specific plants would be better suited there. Regarding the general climactic conditions experienced in South Africa, it was also advised by all three that a water wise garden is preferable for any landscaping intervention, as water is a crucial conservation commodity in the country. The food producing plants used by the urban farmer revolved primarily around demand and included spinach, rhubarb and beetroot in the standard tyre beds and pumpkins in the sunken beds. There were also trial beds of tomatoes, chillies and peppers; however these were being monitored closely to see if the input was too intensive in comparison with the other plants. The plants grown for further refinement included camphor, fennel, nasturtium and stinging nettle, with all products being processed further on site to produce soap and moisturisers.

Image 19 and 20: The rooftop garden at Joubert Park highlighting a waterwise garden

It is interesting to note that there are also plants grown which deal with rodents, such as Plectranthus, but not a great deal of companion planting done for aesthetic purposes. By a similar comparison with the urbanist's urban agriculture projects, annual and perennial vegetables such as herbs were planted, and stone fruit trees such as peaches, nectarines and plums, specifically catering to the type of climate experienced in Johannesburg. At the nursery which his company invested in to try and shorten the supply chain of plants, there were perennial vegetables such as peppers, chillies, gooseberries, strawberries which were

either used in the garden projects undertaken, or sold in the greengrocer attached to the farm to table establishment. The urbanist also indicates that companion planting was preferred, through which there were productive plants with fillers in-between, such as indigenous grasses and flowers. This companion planting also relates specifically to the design concept of creating a more diverse and therefore more resilient garden, but also maintaining an aesthetically pleasing presence. The green architect reiterates the importance of indigenous planting in any type of development and states that by reintroducing wetlands and ecosystems which may have been eradicated due to urbanisation, it is possible to gain additional points for a green star rated development. Clearly the choice of flora is vital when considering the type of rooftop garden intervention, and therefore creates the need to include flora type in the governing document similar to that of the Toronto and Paris green roof policy documents.

The landscape architect suggests that evergreen trees should be used on the ground floor of buildings and pavements as they lose little foliage throughout the year. The root system should also be non-aggressive so that the building and pavement structures are not compromised. A drawback with these evergreen trees is that during the winter months, it might be preferable to have less foliage allowing the sun to heat localised environments. Typically, the landscape architect suggests trees such as *Celtis Africana* (White Stinkwood) or *Kigelia Africana* (Sausage Tree), which she says do not have an aggressive root system, and can provide enough shade in the summer. Again, this is an indication of site specific circumstances which need to be considered, suggesting that each flora choice and intervention will need to be specifically suited to an individual project. Therefore if a policy intervention requiring the planting of vegetation, or inclusion of green infrastructure such as green roofs is implemented, it would need to allow for variance in the interventions. The use of a matrix to identify a possible limited number of scenarios which take the building's age, budget constraints, location and use into account, could be more beneficial and engaging than a set blanket policy. These scenarios could include a sliding scale for interventions, similar to that of the Toronto rooftop garden policy, where the required size of an intervention would be adjusted according to the size of the development.

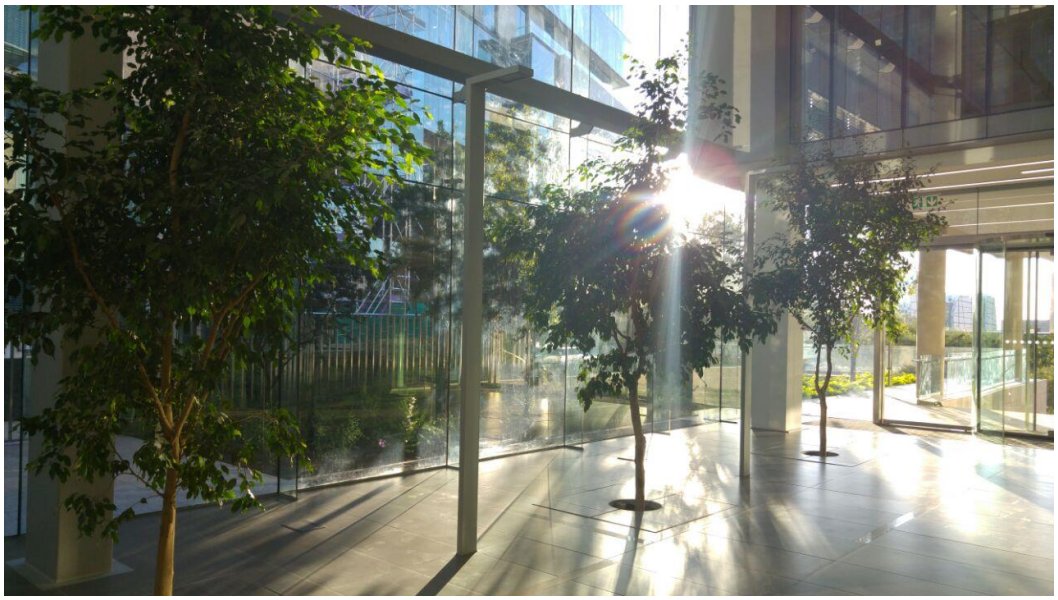

Image 21: Internal atrium trees highlighting the need for non-aggressive root systems (Bruni, 2016)

The final justification for including plant type in this research report is to address the issue of micro-climates that can be specifically designed to cater for various plants, even if they are not technically indigenous to a particular localised climate. Both the landscape architect and the urbanist mention the importance of micro-climate considerations, however from different ends of the spectrum. The landscape architect suggests that one of the reasons for a six to twelve month maintenance period is to investigate whether an altered landscape has created a micro-climate and if the initial flora is suited to such a change if it occurs. The urbanist's approach considers whether there is indeed a micro-climate present already, and then suiting the flora to that. It was also clarified that the opportunity also exists to create a micro-climate specific to a certain ecosystem if the idea was to reintroduce an ecosystem which had been damaged or altered by development.

4.6 Cost Benefit Analysis:

The cost benefit of green roofs was briefly touched upon in Chapter 2, where Carter and Keeler's (2008) net present value over a given period for specific sites was cited. One of the strongest themes coming from the interviews related directly to the cost of trying to implement some type of agriculture, both on a roof structure as well as a ground based garden. The Carter and Keeler comparison takes the full roof development into account, and compares the roof structure as a stand-alone entity incorporating all issues such as

structural integrity and waterproofing. The examples cited in this research report have two vastly different approaches, the first being recycling of products for base planters, and the second, the full incorporation of a garden into the structural design.

The first approach often uses tyres and wooden pallets as a base structure which sits on top of the roof, and does not alter or interfere with the waterproofing or structure of the roof, as the net weight is generally insignificant due to the small scale size of the planters. The second approach which was specified in the Discovery interview, was incorporating a small garden into the actual design of the roof, taking structural and safety considerations into account. The first approach uses existing products at little to no cost, and relies on the user's creativity to deal with design. This approach also allows for greater flexibility and control of soil depth and content, but lacks the literature to support energy efficiency benefits, as most literature refers to fully incorporated green roofs. The second approach cited only specified approximately 300m² out of a total roof size of 12 000m². This rooftop had a great deal of space designed for other uses such as playing courts, pause spaces and a smaller landscaped area. The design of this particular garden incorporated both structural and safety measures with just the balustrade amounting to just under half of the total cost of approximately R1.7 million. The building steering committee for Discovery have therefore delayed the implementation of this particular design until a better solution can be introduced, as the cost was seen as a bit excessive for something that had not been tested before.

The landscape architect (2016) indicates that one of the major constraints faced by landscape architects is the lack of budget. "There's always a budget and we are always considered at the end of the budget so there is not a lot of money for us to work with. It's frustrating for us because we believe that we can create and add value to a project and there is often not a lot of money for us to work with" (The landscape architect, 2016). Further to this point is the fact that other building considerations are more important, such as structural integrity, and other physical attributes, which a developer would rather invest their initial capital into, as opposed to the aesthetic development of a landscaped garden. The landscape architect also identifies context as a key factor when addressing the type of landscaping for a project. Within the context of South Africa food scarcity and water scarcity are considered a great deal more important than the aesthetics of a project. The

idea is not that aesthetics is irrelevant, but rather that the order of problems to be solved will start with the most important problem, that being food security and then water security, with the aesthetic design being a luxury. This argument lends itself to the idea of plant typology and whether they are considered indigenous or not. This specifically relates to the type of food products which are grown, and their quantity in order to satisfy a specified population's need. An example could be that certain types of maize would be more suitable in various parts of the country, however the important factor is not so much where the maize is grown, as micro climates can alter and seasonal changes can affect areas, but rather that the maize is being grown and done so while conserving as much water as possible.

A difficult cost-benefit to predict is the social or psychological impact which the green architect refers to, as there is no measure for this other than word of mouth. The landscape architect agrees that there is no accurate measure, however suggests that if an environment conducive to a better work ethic and user satisfaction is designed either on the roof or internally, it should be implemented. She further states that a ground floor garden would most likely have a greater impact, because there are generally more users entering, exiting and using this space, than a rooftop. The urbanist's understanding is that whether the green star rating idea works or not, this does not really change the fact that psychologically, internal or landscaped green spaces provide a place of reprieve and generally uplift the mood within a space. He also states that such interventions, whether green star or not, are generally not the interventions of the Municipality at the moment, and therefore done as a marketing tool, rather than complying with a legal framework.

4.7 Policy and Practice

Table 1 (Chapter 1) lists a few examples of policies which have been implemented at local and national level in order to guide and control green infrastructure, energy efficiency, food security and water conservation. It can be seen that the majority of control occurs when new building permissions are applied for, with little focus on retrofitting buildings, unless new alterations for changing the structure are required. There seems to be a gap in the general built environment which requires retrofitting of older buildings so that they become compliant with updated building control requirements. This introduces an argument about the stage at which to introduce policies, and where they may be most effective.

The three stages where policy could intervene are at the town planning stage, the design stage and post development stage. These three stages can be seen as the most crucial points for decision making and where changes to the building's purpose can be made. The prescription of rooftop green infrastructure seems to be necessary, due to additional work and the related costs for including the design of this infrastructure, as well as the physical construction. The green architect indicates that if an optional design element is required, which would send the budget of a project over by twenty or thirty percent, the majority of businesses would not opt for it, as they would try to save costs wherever they could. Discovery showed the same issue, with a seemingly innocuous inclusion of a vegetable garden on their rooftop structure, however the total cost of implementation for a small area became excessive and the design was put on the backburner. It is evident that not only could prescribing assist with helping implement green infrastructure, but it could also hinder it by raising the general cost of developing to such a degree that development would actually be hindered due to non-compliance. This relates directly to the cost-benefit of not only the actual infrastructure being used, but the related professionals such as structural engineers, landscape architects and possibly even botanist specialists. There would therefore need to be clear delineations, as done by the Toronto Town Council, where a sliding scale depicting the amount of green infrastructure required for a certain amount of coverage or floor area.

The first stage in a development is usually the town planning stage, which manages the rights for a particular property, allowing general land use, height, floor to area ratios and any additional general requirements needed to amend the town planning scheme. These rights seldom indicate the type of vegetation and design interventions required, as this is generally left up to an architect or qualified design person. The purpose of the town planning stage is to give an overall vision or box that an owner or developer can work inside, often trying to take the surrounding environment into account so that land uses which interact such as high density residential and retail or office can be in close proximity. Competing land uses can be seen as those which have little association such as industrial and residential, where adverse effects may be experienced due to a specified use having harmful or adverse emissions. The example of Toronto illustrates how the incorporation of

a general policy, stating the coverage required for an intervention, but leaving the actual design up to the owner, developer or architect.

The design phase usually occurs shortly after the planning phase as the limitations have been identified and a general development concept can be isolated. Once the general purpose of the development has been identified, the specific design principles can be characterised through a design process carried out by a professional design team. This team is quite specific about the end product, and as the landscape architect states, one needs to know what the client wants right at the start so that the design and conceptualisation are correct from the outset. This often benefits new developments as there is a clean slate to work with, and retrofitting older buildings can lead to various complications such as heritage issues and structural integrity (Landscape architect, 2016). This design phase usually includes the architectural development, which requires various approvals. One of these approvals, as mentioned previously, is the SANS 10400 compliance, which the Discovery architect explains has a large number of addendums ranging from A to Z, with the XA portion being highlighted under the literature review of this report. The Discovery architect further indicates that there is also a SANS 204 compliance, which has not been prescribed yet, however is available for use by professionals to gauge their green star rating. He indicates further that the compliance with the SANS 204, which obtains an R-value for the energy efficiency rating of a building, equates to a four star green star rating, and therefore is useful as a guideline for architects and developers. The SANS 10400 and 203 may be the most useful stage to implement a policy intervention for rooftop interventions and urban agriculture. The technical aspects for calculating values for heat gain and radiation would be appropriate under Part XA, while it may be better suited for the type of rooftop intervention to fall under land use planning and development. It should also be noted that the SANS 10400 document suggests that a review of the regulations should occur at 5 year intervals, in order to maintain the correct standard of materials and practices (SABS, 1990, p. 4). While this SANS document has an updated version of 2010/11, the town planning schemes used in Johannesburg vary between 1976 and 1980. Both Tshwane and Ekurhuleni, the neighbouring municipalities have consolidated town planning schemes dated 2008 and 2014 respectively, indicating that an updated consolidated scheme should be investigated for the City of Johannesburg.

The post-development stage could be considered retrofitting of an existing building, but also includes interventions which developers or owners do towards the end of the construction phase. As the landscape architect described, landscape architects can be consulted post construction in order to fix and maintain landscapes which were not originally part of the design framework. If a policy were in place whereby compliance was necessary, there would need to be forethought into what aspects need to be included in a building right from the outset. Reactionary concepts such as providing landscaping, reducing carbon footprints and attempting to reduce energy consumption are not always the most effective, as certain limitations will be inherent with structural capability and available space and technologies. The benefit of incorporating various interventions from the design phase is that they can be fully incorporated into a building's structure and design, avoiding issues mentioned by the landscape architect such as heritage compliance, structural integrity and the overall maintenance of a building. Again, the case studies cited in London show how post-development or retrofitting buildings with green roofs is possible, however there are often predetermined limitations.

The GBCSA is specifically mentioned by the urbanist, the green architect and the landscape architect, each with their own opinion of how the organisation affects their particular profession. The GBCSA professional became an accredited professional in 2013, and states that since then "there are now a number of accreditations and educational programmes for professionals in both face-to-face and online formats" (GBCSA professional, 2016). The GBCSA has implemented two systems which attempt to assist with the green building developments in South Africa. Firstly, they have competent professionals who specialise in new buildings, existing buildings and interiors, who become accredited with the organisation through a series of lectures and an exam (GBCSA, 2016). The GBCSA professional clarifies that the exam is not mandatory, however if a professional does not write the exam, they will not be registered, even though they may have the understanding of how to use the various tools supplied by the GBCSA. If the registered professionals are listed on the database, people may contact them and they can then assist in seeking interventions to make the subject building 'greener'. However they still remain in their primary profession, with this certification merely an added benefit to understanding how a green building functions. The GBCSA professional shares that often there is "fragmentation

between developer decisions, tenant decisions and other professionals involved, with designs constantly changing" (GBCSA professional, 2016). The second tool used is the actual accreditation tool which lists a number of criteria with allotted points for compliance with each intervention. The initial step for a building to be certified is for submission of supporting documents and contracts along with a certification fee. Once all the relevant drawings, calculations and documents are submitted, there are two rounds of submissions and assessments before a certification rating can be issued. The building is given a rating with the GBCSA, who state that the benefits include "positive associations", "a competitive advantage" and "an increased awareness of your contribution to sustainability" (GBCSA, 2016). Therefore the benefits seem limited as a marketing tool, but with the hopeful intention to gain some type of credit through the municipality. The inclusion of spaces such as Sasol, Discovery and Joubert Park points to the idea that tenant demand can be a key driver in a building's development, and The GBCSA professional expresses the fact that owners and developers will therefore have incentives to provide green buildings with a higher market value due to the association with the Green Star Rating.

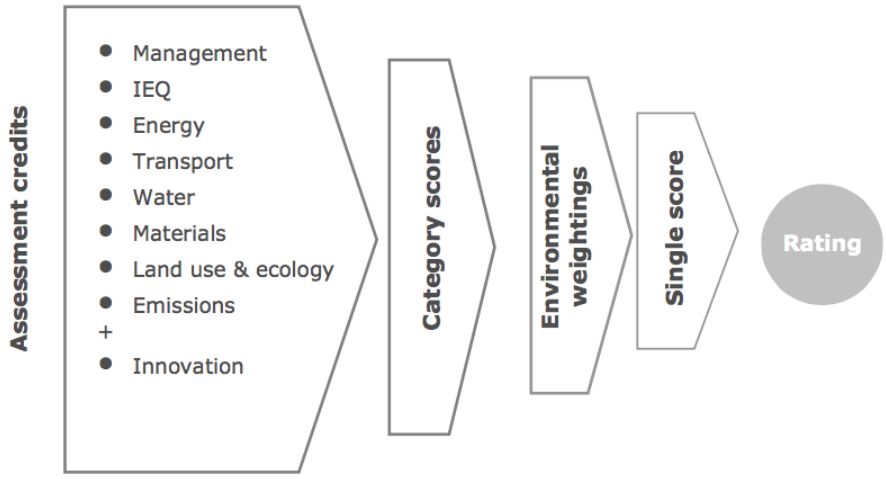

Diagram 8: Assessment criteria leading to Green Star rating (GBCSA, 2015)

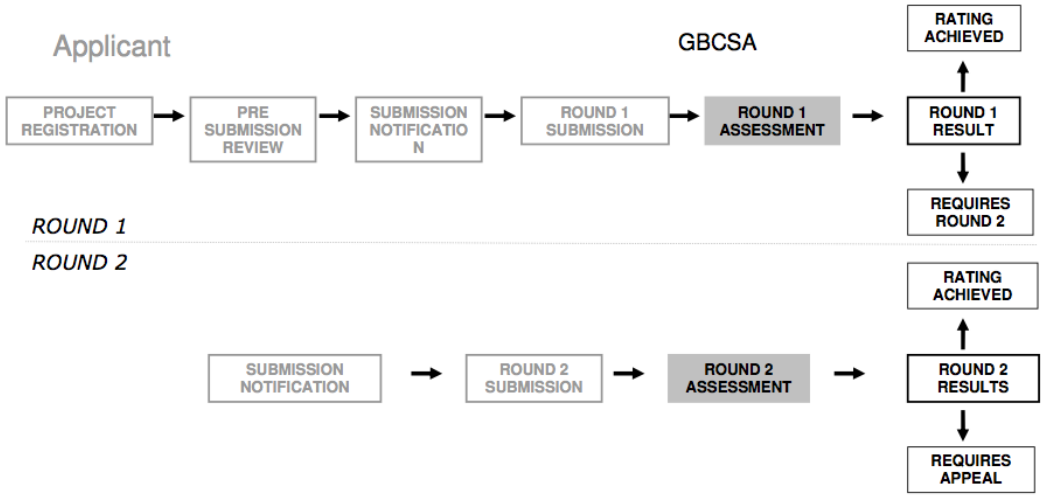

Diagram 9: The two round process to achieve a Green Star Rating (GBCSA, 2015)

Overall Score	Rating	Outcome
10-19	One Star	Not eligible for formal certification
20-29	Two Star	Not eligible for formal certification
30-44	Three Star	Not eligible for formal certification
45-59	Four Star	Eligible for Four Star Certified Rating that recognises/rewards 'Best Practice'
60-74	Five Star	Eligible for Five Star Certified Rating that recognises/rewards 'South Africa Excellence'
75+	Six Star	Eligible for Six Star Certified Rating that recognises/rewards 'World Leadership'

Diagram 10: Scoring and rating card for Green Star Rating (GBCSA, 2015)

The green architect states that one of the other considerations by the GBCSA is how buildings accommodate small enterprise, where there is a different weighting of points for providing spaces for various traders or businesses. The principle of incorporating this into buildings allows forethought into the design, where specific spaces can and possibly should be allotted to diversifying the use of buildings. Applying this idea allows for interventions, such as rooftop gardening being used as a diversified operation, to be justified in urban developments. The urbanist's concern is that the tools provided by the GBCSA are supposed to be used for offsetting carbon footprints and reducing energy consumption, but they seem to be used solely for a marketing tool as mentioned previously. The outcome of this is not entirely negative if there is an actual offset, as envisioned. This relates to the

garden use at Discovery, where the rooftop garden is used by the restaurant, but possibly maintained by an external NGO or urban farmer who requires either a space to grow vegetables or earn an income. While the consequences of providing job or food security are not the focus of this research, there is a clear benefit to including such principles into the design process, rather than trying to retroactively catch up with the needs of an urban area. The GBCSA professional agrees that the Green Star Rating tool is primarily used for promotional value of a building, giving the owner the certain prestige status which would attract various tenants. She also mentions that the while the environmental benefits are one of the drivers, the industry is financially driven, and therefore depending on the professional or company involved in the rating process, there will be a variable focus on environmental considerations versus financial considerations.

The urbanist cites the Johannesburg Metropolitan Open Space System (JMOSS) which was drafted in 2002. This policy document attempts to create an environmental management strategy for the City of Johannesburg which can be used as a guide for developing and using open spaces. The document states that there are seven uses for open spaces as listed by the Department of Environmental Affairs and Tourism. These are: providing recreation opportunities; conserving natural resources; being ecologically productive; providing opportunities for environmental education; providing concrete opportunity for urban agriculture; being a viable economic entity; and enhancing the City's appearance (JMOSS, 2002, p. 8). The inclusion of urban agriculture in this document, and the idea that there should be food production and medicinal plants grown in public open space suggests that there is a goal to include this type of concept in policy. There does seem to be a void in how to actually implement the concept and whose responsibility it is to maintain and harvest the products grown. What the policy does do, is set out a great deal of criteria defining the various ways that open space could be used "in a continual path to sustainable development" (JMOSS, 2002, p. 72). It is quite general and vague about actual interventions, and lacks the site specific details which could be laid out in a more localised urban development framework (UDF). Table 2, under Chapter 1 of this study highlights where both the prescriptive and guideline policies are applicable in terms of their scale. It can be seen that there is a limited number of prescriptive policies, which may be beneficial

to avoid confusion in a reasonably bureaucratic system of compliance. This also requires less enforcement due to fewer prescriptive frameworks needing to be adhered to.

A brief investigation into the type of control used for policy enforcement touches on whether an incentivised route should be taken or the idea of moral suasion. Reference to the fact that all developments take heed of their economic viability must be made. By establishing this fact, the conclusion follows that one way to promote a particular policy which has a lack of traction is to provide some sort of incentive. Economic incentives such as the carbon credits mentioned previously, as well as tax incentives are often used to entice the corporate sector. Another popular method is for corporations to have a firm stance on their marketing campaign, which can see concepts such as corporate social responsibilities. These are less defined compared with economic incentives, as they usually rely on a corporate's mission statement or operating principles. Moral suasion can be seen as an attempt to coerce the private sector activity "via governmental exhortation in directions not already defined or dictated by existing statute law. It is, in a sense, the extreme case of 'rule of men' as opposed to 'rule of law'" (Romans, 1966, p. 1221). Finally, there is the punitive approach, where non-compliance may result in a fine, or refusal of proposed rights. These various approaches each have their own benefits and downfalls, however these will not be explored in this research report, as it falls outside of the intended scope.

4.8 Knowledge

An aspect which came out of the interviews, was the vast amount of knowledge which each interviewee demonstrated. This cumulative knowledge is increasingly being divided into specialised professions who focus solely on particular aspects such as design, landscaping or development control. The green architect is a strong believer that the progression of society and knowledge in general is the reason why there is such a concern for the natural environment, and that it is not just a case of green-washing. Countries such as Norway and Netherlands have been implementing green infrastructure interventions for a number of years, with communities fully embracing the change and reducing their carbon footprints. There could be an idea that these interventions are a fad, and that there will be less focus on it in ten to fifteen years' time, but the interventions proposed can only benefit society, as there are no adverse effects from being environmentally conscious. The concluding remark

from the green architect is “if we carry on and in ten years it all falls apart, what have we actually lost? Nature cannot be a fad, or rather, nature is our oldest fad”.

The landscape architect is clear regarding the limitations of various professionals, acknowledging that each one has a general idea of what the other does regarding architects, landscape architects, developers and town planners. She states that as a landscape architect she understands all the systems which may need to be considered, such as restoring a wetland or ecosystem, however she will appoint a wetland specialist who has a greater knowledge on that specific intervention. Therefore the knowledge depth that is required to holistically assess and complete a project can be reasonably vast considering there are ecological, social, economic, structural and legal aspects all having some type of bearing on a project. Further to this, the GBCSA professional suggests that the industry is relatively new and as such has found that a number of professionals who attend to the Green Star Rating process lack this in-depth knowledge specifically relating to the building function as a whole. The types of interventions are also important to consider, as there are various interventions which should be identified for their inputs and outcomes. This knowledge is vital when different technologies such as concentrated solar power systems, biogas generators and wind turbines are introduced. Each of these requires a different input, and specialise in specific environments allowing a broader range of green infrastructure to be developed.

4.9 Conclusion

The interviews conducted presented an interesting perspective on the ideas investigated in Chapter Two. It can be seen that practice can differ from theory, and the reality of the real world application of theories having unintended consequences. What is interesting to note is that the fundamental principles will still remain the same, and it becomes an implementation issue, which can be adjusted according to the localised context. Questions from Mukherji and Morales (2010) specifically regarding policy change can be seen coming through in the themes from the interviews. Examples include: What are the possible urban agriculture activities in our city? What can be allowed in a widespread way with little controversy? What can be allowed, but controlled? What can be allowed, but only in some places? Are there some places where specific activities should be particularly encouraged? Who are the likely participants and how can positive relationships be fostered?

There is a clear mandate from the JMOSS policy to include a broad range of urban agriculture within the city. However, the urban farmer, the urbanist and the landscape architect give evidence of what will be successful in terms of the types of plants which can grow, and further stating that within that group there may be a limited amount of vegetation which can be grown and harvested successfully. Regarding the widespread application of urban greening, all seven interviewees agree that there can be direct benefits of various degrees, and that if the decision is to introduce soft urban infrastructure and the climactic conditions are conducive to growth, most buildings should have a dedicated landscaped portion. The question of control can relate specifically to how to best encourage these interventions, with the green architect being clear about prescriptive means, as voluntary approaches will see little success due to financial implications that come with added design processes and costs. The decision of location is another aspect which needs to be considered on an individual basis, and preferably early on in the design process so that there is not a last minute rush to simply place random greenery inside a building, but rather have a set plan and outcome for including urban agriculture in a development. The landscape architect details that the participants in the design process include a broad range of professionals including architects, engineers and landscapers. The complexities of who becomes involved post-development becomes more evident when considering who maintains the vegetation, and what the intended purpose is. If there is a productive outcome aiming to supply food, individuals who will either receive or distribute the food usually have preference in involvement. However, if the site is located on a rooftop of a private building, there may be a dedicated team who have no association with the food, other than maintaining it. If the outcome is simply an aesthetic garden, there will most likely be an external maintenance team. The users of this garden would then become the questionable subject, with the example of Discovery having a fully public ground floor, but a private rooftop. Access to the roof, where the subject vegetable garden would take place, would only be able to be accessed by a maintenance team and employees, while the ground floor can be enjoyed by the general public. This in itself is not a suggestion for opening up the roof or closing the ground floor to the public, but rather a comment on how the urban green space may be used, viewed and maintained.

The urbanist and the urban farmer both indicated that certain activities can be encouraged in a variety of spaces and there simply needs to be greater awareness created to the opportunities and delineation towards who the participants are. This extends not only to public parks as the general trend seems to be, but also to private and semi-private spaces which should be managed with the outcome of achieving a few green urbanist principles, which attempt to deal with urban development holistically. It should be cautioned that adopting a green urbanist ideal may be idealist and naïve, as there is little focus on the economic development of the city under these principles, with the focus remaining primarily on the social and environmental spheres. Incorporating the trivalent design concept, and suggesting the three spheres be economic, social and environmental as linked to the viability of a particular urban agriculture project, it might be argued that having such a heavy focus on two out of the three spheres will leave the economic development sector of the city lacking, and ultimately an unbalanced approach will be adopted.

Further to the economic development concept, it is clear that the financial considerations play a key role in both funding a project, as well as justifying the inclusion of certain interventions. The landscape architect clearly states that budgetary constraints often limit the interventions, and the inclusion of her profession at the start of a project could allow for better planning. The urbanist's input regarding funding targeted middle to high income households, as they were able to fund the various technological interventions. Similarly, corporate funding of projects could give the green infrastructure concept a boost. There seems to be interest in the green roof and urban agriculture concept from corporates, with many newer developments having intensive landscaping at various levels. Furthermore, the scale of these interventions is large, which the landscape architect suggests will have the best impact. If the block development concept could be used for designing green space, and a master overview could be implemented by a municipal design team, there would be a great deal of benefits seen from both an internal and external environment point of view. This can be seen as a manipulation of environments, or creation of micro-climates, which would have an offsetting result.

Comparing the benefits of some of the case study results mentioned in the literature with the practical suggestions made by the interviewees shows a clear and undeniable reason for including urban agriculture into the design process. The suggestion of creating a scenario

matrix, coupled with a set guideline or ratio of the scale similar to the Toronto design guideline, allows a reasonable conclusion to be drawn regarding the research question.

CHAPTER 5

5 - Conclusions and Recommendations

5.1 Consolidation of Theory and Practice

This study has shown how broad sustainability, energy efficiency and the related green infrastructure frameworks are through the literature section. Given that the increasing urbanisation trend is expected to continue into the future, the need for alternative and radical interventions in order to cope with the increased demand on natural resources will keep intensifying. How the city interacts with the surrounding sub-urban and rural environments should be carefully analysed and understood, due to the majority of resources being produced in these areas, and later consumed or used in some form within the urban environment. This report at building and city scale focused on the green infrastructure aspect of sustainability and energy efficiency, noting that agriculture is one of the most important factors in modern society due to food security becoming strained.

The rationale for the study indicated the importance of trying to incorporate a greater focus of green elements within or on buildings, and the city in general. It was necessary to focus on the term “urban agriculture”, and expand the term to not only include food production as associated with agriculture, but also aesthetic elements such as aesthetic gardening and landscaping. The literature suggested that one of the least utilised spaces in a building was the rooftop, and when combined with the large scale of cities, revealed the enormous area which could be developed. There has been clear support for rooftop gardens from various professionals, both productive and aesthetic, however there seems to be a slow response towards implementation. The benefit of urban agriculture in general, if included in the urban environment, can be valuable to both social development and sustainable green principles. This research report does not seek to analyse funding models specifically or define the social or economic benefits, even though these may have an impact on the implementation of urban agriculture projects. The key research outcome is an attempt to define where in the building design cycle these types of interventions could be introduced, and the best way to do so.

The study finds that policy will be a large factor in driving green infrastructure and urban agriculture projects from an unregulated pastime to a well-developed and structured urban development control principle. Design specific principles would need to be individualised, as rooftop agriculture would differ significantly from garden and plot based agriculture, where there has been a fair amount of focus in a number of other cities. As evident from the study areas and interview responses, Johannesburg does have examples of urban agriculture in general, with a few rooftop gardens being developed and marketed as social projects as discovered by the various interviews conducted. There has also been a large push to incorporate landscaping in and around buildings, more for aesthetic purposes rather than green infrastructure. The literature does cite a number of rooftops which were fully covered, showing the majority of benefits coming in the form of insulation and heat absorption. The difference between some of the literature examples, and the projects cited by the interviewees, can be seen in the design layout, where most of the rooftop gardens in Johannesburg use pots, tyres or similar base planters, rather than developing the whole rooftop based on a purposely designed and constructed roof element.

The prescriptive approach of bringing rooftop gardens and urban agriculture into the urban environment seems to have the strongest argument for it. The SANS 10400 A to Z schedule seems to be the ideal place to implement it along with the SANS 204 for energy efficiency. The example set by the Toronto municipality for introducing a bylaw indicating a set size of green roof compared with the gross floor area of the building, as well as the focus being new commercial, institutional and residential buildings, shows how to introduce the concept. The interviews further confirm that even with a prescribed policy or by-law, the inclusion of a green infrastructure design early on in the design process is crucial in order to fully integrate a selected outcome.

A short comment regarding the economic perspective of this research mentioned previously is directed at the necessary question of who will be the primary driver for these interventions. With the additional inclusion of added infrastructure, there will be an associated increase in design and building cost. Until such time as a credit system can be implemented (assuming that the result of having a green star rated building is the chance to market a better environment) funding of such interventions will be a limitation of sorts. A likely outcome would be the involvement of corporates, where roof space can be set aside

and possibly offset certain municipal rates, similar to offsetting contributions for infrastructure if developers build their own infrastructure independent of the municipality. Once there is a fundamental base practice laid down, the initial high costs of developing various green interventions may reduce over time. There is also a clear directive needed for municipalities and similar regional departments to have clear mandates and associated programme plans relating to the urban environment and its use of resources. This can be seen not only in energy consumption, but as shown in this report, food security and urban development.

Regarding the type of interventions favoured by owner, user and municipality, it will be necessary to identify what the rooftop will be used for before any development takes place. There should be a differentiation between the type of intervention, namely if it will be an aesthetic passive rooftop garden, an active producing alternative energy interventions such as PV panels, wind turbines or food producing rooftop garden. This differentiation would best be suited to occur at the land use and zoning stage, where the overall need and desirability could be assessed. Once the type of intervention is established, the technical aspects can then be included in the SANS 10400 Part XA section, where compliance will need to occur prior to the approval of building plans and construction. This, along with a similar ratio used by the Toronto Town Council, whereby specific floor areas are required to develop a certain amount of rooftop space for green roofs will be the best scenario for a prescribed intervention. As noted by both the green architect and the urbanist, voluntary implementation for such interventions will most likely fail, as there will not be active involvement in trying to apply the best intervention, but rather simply the minimum requirements for a functional building. If a prescribed intervention is favoured, the normative approach is then to have a minimum standard, which can be rationally defined, and from there the expectation is then to improve upon the minimum, similar to how technological advancements continually challenge the minimum standards.

5.2 Reflections

The initial starting point for this research report seemed limited, with little obvious data to follow up on. Having narrowed down the scope through various means, it was soon discovered that the depth of knowledge was vast. Similarly, the types of interventions initially envisioned for a reasonably simple concept such as growing food, or landscaping a

certain roof became a great deal more complex when factors such as climate, structural integrity and maintenance were considered. The process followed highlighted the need for delving into literature so that a basic understanding of green building interventions could be understood, along with various forms of urban agriculture. Attempting to bring the concepts of agriculture and landscaping together under one term also seemed necessary, as the rationale was not limited to only productive agriculture, or aesthetic landscaping, but both.

The time limit on the report allowed a brief outline into a number of contributing factors of rooftop gardening and urban agriculture. There is a great deal of detail which this report can still go into regarding each profession, design principle and location. Therefore it might have been useful to narrow the scope even further in order to gain more detail. The interview component of this report was vital in bringing a number of perspectives together, not only in how the real world application can be successful or not, but where theoretical underpinnings may need work. This can be related to education, but more importantly policy development which relies on practical solutions transcribed into theoretical policies. The ramifications of introducing policy could be far further reaching than simply introducing an energy efficient concept to urban development. Considerations such as who will benefit from the policies, and who might be disadvantaged may only be fully realised further down the line than the initial conceptual stage of policy development. As mentioned, the cost of designing and implementing rooftop gardens, and even green infrastructure, is one particular disadvantage to emerging professionals and developers who would need to cater for an extra financial cost, as well as extending the development time line due to additional development compliance. In addition to the decision makers and developers, there is the question of enforcement. Considering that the Municipality is required to enforce development control regulations already, there may be additional strain placed on them to further monitor and enforce green infrastructure development relating to green roofs.

Regarding interviewees, there was an attempt to interview a senior town planner, as well as a building plan inspector from the City of Johannesburg. Availability and time constraints did not allow for these interviews to take place. It would have been beneficial to include the points of view from these two interviewees specifically, as they would have a good sense of

the limitations and opportunities the City are faced with in terms of assessment and regulations of the building process.

5.3 Avenues for Future Research

This study attempted to intervene in existing policy for the benefit of rooftop gardens and urban agriculture. Subsequently, there seems to be an intervention gap regarding prescriptive and guiding frameworks for green infrastructure. There is opportunity to investigate the larger theme of green infrastructure, and delineate what constitutes functional green infrastructure, which may be considered just as important as infrastructure such as roads, water and electricity. There also seems to be a gap in the supporting frameworks from the private sector, with the green star rating seemingly being the only private sector initiative. Investigations into why there is a lack of initiative may lead to accountability and enforcement themes. There is also a great deal of work to be done regarding the actual ramifications of attempting to implement such a policy or even attempting to change the existing policy to incorporate additional parameters. There would be a number of positive and negative spin offs, economically, socially and environmentally, requiring understanding, so that prescriptive and enforcement measures do not counteract the purpose of trying to improve the urban environment.

5.4 Summary and Conclusion

Relating all these themes back to rooftop gardens and the implementation into the design process, it should be argued that policy intervention is required. Using the rooftop space for productive purposes such as generating power, or growing food have clear benefits, there are two different spheres in which policy could assist. As stated under point 2.13, the inclusion of an additional regulation in the SANS 10400 XA portion would ensure technical design standards needing to be complied with. It is important to ensure that before this, there is a step in the planning and development control sphere, where a land use typology is created whereby the inclusion of a rooftop intervention, either passive or active are included in the development rights of all new commercial, high density residential and industrial uses. By doing so, the owner or developer of land may choose the type of intervention they prefer, however, the choice is limited to those which benefit either sustainable practices or energy efficient models.

The landscape architect's assertion that the driver for any principle will be the most important social constraint of a community, society or country, indicating that in South Africa food security and water scarcity rank a great deal higher than the aesthetic design of cities. Incorporating the green architect's point that unless prescribed intervention occurs, there will not a shift towards green infrastructure developments in general, and definitely not at a fast enough rate that will ease the already strained general infrastructure. The interventions researched in this report try to intervene in the two major issues which are faced not only by Johannesburg, but a greater global community too. The concept of using the city's largest unused surface area to address energy efficiency with passive cooling, stormwater management and heat island reduction is simply an offset tool. The inclusion of a productive rooftop facility either by generating electricity with PV panels and wind turbines, or as investigated in this report, produce food, changes the intervention from a passive offset tool, to an active and functional tool worthy of inclusion in the City's policy. There is a general social responsibility which was mentioned by one of the interviewees, insofar as if a company or person is capable of assisting in any way, most often action will be taken to do so.

Regarding policy development, it is also clear that there are various mandates which need to be fulfilled. The landscape architect and the urbanist both indicate that there is a hierarchy of needs which both the private and public sector focus on. While there may be a mandate for environmental preservation through energy efficient buildings and sustainable practices, social mandates may override these with issues such as poverty alleviation, food security and employment creation. The private sector attempts to introduce and maintain a sense of corporate social responsibility, however, as suggested by the green architect, unless there is a direct prescription for certain interventions, the majority of people would prefer to save costs and minimise time and effort.

5.5 Recommendations

It is recommended further research into the various types of uses for a rooftop is done, so that an overall plan for energy efficient buildings and sustainable cities can be developed. A revision of the Town Planning Schemes and Building Regulations should be done in the near future, so that updated development controls can be introduced. The use of a garden benefits a more passive approach, with PV panels adding to the active power generation

model. Therefore, site specific investigations should be initiated to find out the benefits of each approach, so that a matrix can be developed with a set of outcomes, and their associated interventions. It may also be pertinent to revisit a number of case studies cited in this report, in order to assess if they are still active and successful.

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LIST OF INTERVIEWEES

Green Architect based in Johannesburg. (12 October 2016).

Urbanist based in Johannesburg. (22 October 2016).

Landscape Architect based in Johannesburg. (6 November 2016).

Urban Farmer at Joubert Park. (17 November 2016).

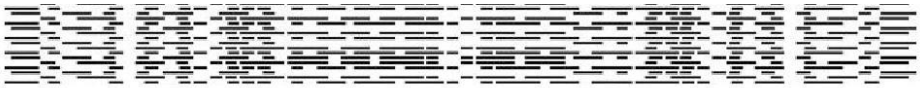
Group Facilities Manager at Discovery. (14 December 2016).

Architect for Discovery. (14 December 2016).

GBCSA accredited professional. (22 January 2016).

APPENDICES

Appendix A – Interview Questions



SCHOOL of ARCHITECTURE PLANNING

PARTICIPANT SURVEY

An Exploration into Urban Agriculture and Rooftop Gardens in Johannesburg

Please answer the following questions with as much detail as possible, if there are any further issues or suggestions not addressed in this questionnaire, please add these in at the General Comments section.

1. Are you actively involved in urban agriculture or rooftop gardening?

2. Do you own or rent the space where urban agriculture or rooftop gardening takes place?

3. Building type: Commercial/Industrial/Residential/Business/Educational/Other

4. How much input did you have in the design and layout of the garden?

5. In terms of internal and external design, which is preferential and why?

6. What type of plants are grown in the garden?

7. Are there any permissions or permits which are required to grow plants in this location?

8. What type of water source do you use to irrigate the garden?

9. How many people are actively involved in the garden?

10. How close do the users live from the garden?

11. What do you do with the produce once it is harvested (if produce is grown)? ie: (sell or subsistence)

12. If no produce is grown, what is the primary use of the garden?

13. What are the current constraints you experience with such a garden? Could these be alleviated by a different location or support from an external source?

14. Do you believe that urban agriculture adds value to the building and surrounding area and reasoning behind your answer?

15. Have you heard of passive climate cooling?

16. Is there interest in both an aesthetic garden designed for visual effects, as well as a garden which can produce edible goods?

Are there any general comments regarding rooftop gardens or urban agriculture?

[redacted]

SCHOOL OF ARCHITECTURE AND PLANNING
HUMAN RESERCH ETHICS COMMITTEE

SCHOOL OF ARCHITECTURE PLANNING

CLEARANCE CERTIFICATE
PROTOCOL NUMBER: SOAP108/12/07/2016

PROJECT TITLE:	An Exploration into Urban Agriculture and Rooftop Gardens in Johannesburg
INVESTIGATOR/S:	Nicholas Ansell (Student No. 0406913N)
SCHOOL:	Architecture and Planning
DEGREE PROGRAMME:	MArch in Sustainable and Energy Efficient Cities (March SEEC)
DATE CONSIDERED:	06 October 2016
DECISION OF THE COMMITTEE:	APPROVED
EXPIRY DATE:	06 October 2017

CHAIRPERSON
(Professor Daniel Irurah)

DATE: 10.10.2016

cc: Supervisor/s: Brian Boshoff

DECLARATION OF INVESTIGATORS

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to endure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Signature **Date** 24 October 2016.

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