203512907
Clive Greenstone

Rooftop gardens and the greening of cities - a case study of UKZN

ROOFTOP GARDENS AND THE GREENING OF CITIES – A CASE STUDY OF UNIVERSITY OF KWAZULU - NATAL

Submitted in partial fulfillment of the requirements for the degree of Master of Town and Regional Planning in the School of Architecture, Housing and Planning, University of Kwazulu – Natal, Durban

BY CLIVE GREENSTONE

23 NOVEMBER 2009

DECLARATION

Submitted in fulfillment / partial fulfillment of the requirements for the degree of Master of Town and Regional Planning, in the Graduate Programme in School of Architecture, Planning and Housing, University of Kwazulu – Natal, South Africa.

I declare that this dissertation is my own unaided work. All citations, references and borrowed ideas have been duly acknowledged. I confirm that an external editor was not used and that my Supervisor was informed of the identity and details of my editor. It is being submitted for the degree of Master of Town and Regional Planning in the Faculty of Humanities, Development and Social Science, University of Kwazulu- Natal, South Africa. None of the present work has been submitted previously for any degree or examination in any other University.

_____

Student name

_____

Date

_____

Editor

ABSTRACT

Owing to the concern about the serious factors influencing global warming and climatic change, the process of sustainable landscape construction as well as ecologically friendly developments needs to be addressed. In particular, the questions to ask is are we nearer to accepting sustainable growth advantages in South Africa, primarily the greater eThekwini Municipal Area? In this research paper an analysis of both a theoretical and practical approach to conventional understandings relating to development practices and issues that encompass greening of cities and the notion of rooftop gardens will be assessed. In so doing it will investigate the discourse surrounding urban ecology and sustainable landscape developments and how both processes incorporate the topic of rooftop gardening, urban agriculture and peopleôs attitudes towards nature in the city, which regrettably from a South African perspective has very little comprehensive literature written about it. The research will give clarity and hopefully show that there is sufficient evidence to demonstrate that rooftop gardens form an intricate part of urban ecology. In addition to this that they can provide general environmental, associated aesthetic and health benefits for cities and their inhabitants. Hopefully in culmination this research study will promote a greater insight into rooftop gardens benefits for city management systems.

Acknowledgements

My sincere thanks go out to:

- To my beautiful mother your calm energy and warmth will always be with me.
- To my amazing partner Kira and our son Lorkin, thank you for all your support, help and belief in me.
- My entire family both blood and extended, for being you, and allowing me to be eccentric in every direction.
- To Romain Francis a genuine friend who helped labour through compost and aphids.
- Dr. Harald Witt for continually inspiring the environmentalist in me and for always practicing what he preaches, respect.
- To Prof. Peter Robinson my supervisor, who always took the time and effort to guide me through this interesting topic, and for the great conversations that always occur when we meet, thank you
- To my co-supervisor Ms. Molapo who really went out of her way to offer me valuable assistance in the final stages of this work, thank you
- To those that continue to push the boundaries of urban development even when conservative doors slam in their face.
- As Albert Einstein once said, ñBrilliant ideas often receive violent opposition from mediocre mindsò.

CONTENTS

CHAPTER ONE – ORIGINS

1.1. Introduction 1

1.2 Background and outline of research topic 2

1.3 Research problem and objectives 3

1.4 Research objectives 5

1.5 Key research questions 5

1.6 Research exploration route 6

1.7 Structure of dissertation 6

CHAPTER TWO – METHODOLOGY

2.1 Introduction 8

2.2 Secondary research 8

2.3 Surveys with three target groups 8

2.4 Interviews with ecological design specialists 10

2.5 Pilot case study 11

2.6 Technical component 14

2.6.1 Trays/ containers 15

2.6.2 Thermometers 15

2.6.3 Measuring buckets 17

2.6.4 Plant material 18

2.6.5 Research summary 19

CHAPTER THREE- ROOFTOP GARDENS SOCIAL AND ECOLOGICAL CONTEXT

3.1 Introduction 21

3.2 Literature review 21

3.2.1 Urban design and role of nature in cities 22

3.2.2 Sustainable cities and eco cities 23

3.2.3 Nature and its effects on human behavior 25

3.3 Climate change and global warming 27

3.4 Urban Ecology 29

3.5 Sustainable Development 30

3.6 Built Environment 31

3.6.1 Urban Design 32

3.6.2 Urban Planning 33

3.7 Rooftop Gardens 34

3.8 Urban Agriculture and Food Security 35

3.9 Technical issues 37

3.9.1 Heat Island Effect 37

3.9.2 Storm water management 38

3.9.3 Benefits and types of rooftop gardens 39

3.9.4 Container or modular rooftop gardens 40

3.10 Conclusion 42

BIBLIOGRAPHY **71**

APPENDICES **79**

Appendix 1: Questionnaire **79**

Appendix 2: Professionals interviewed **81**

Appendix 3: Interview Sheets for Geoff Nichols (24 April 2008) **82**

Appendix 4: Interview sheet for Derek Van Heerden (25 April 2008) **84**

Appendix 5: Interview sheet for Jessica Rich (6 June 2008) **86**

LIST OF FIGURES

Figure 2.1 Measuring bucket set up under planted tray 17

Figure 2.2 Measuring bucket set up unplanted tray 18

Figure 4.1 Rooftop garden systems 42

LIST OF PHOTOGRAPHS

Image 2.1 Top view of pilot study area 12

Image 2.2 Pilot study area 13

Image 2.3 Pilot study planted trays 13

Image 2.4 Food crop pilot study area 14

Image 2.5 Thermometer placements 16

LIST OF TABLES

Table 2.1 Plants used in the pilot study 19

Table 4.1 Understandings of Rooftop gardens 44

Table 4.2 Rainfall run-offs 47

Table 4.3 Heat Islands and climate conditions within cities 50

Table 4.4 Aesthetic roles of Rooftop gardens and urban greening 55

Table 4.5 Advantages and disadvantages of different rooftop garden systems 62

LIST OF CHARTS

Chart 4.1 Water retention rate 48

Chart 4.2 Water run-off rate 49

Chart 4.3 Temperature readings over 6 day period 51

LIST OF ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
ARV's	Antiretroviral
CBD	Central Business District
DVH	Derek Van Heerden
GN	Geoff Nichols
GRPP	Green Roof Pilot Project
HIV	Human Immunodeficiency Virus
IDP	Integrated Development Plan
JR	Jessica Rich
KZN	Kwazulu Natal
MTB	Memorial Tower Building
SD	Sustainable Development
UKZN	University of Kwazulu Natal
WCED	World Commission on Environment and Development

CHAPTER ONE - ORIGINS

1.1 Introduction

"Energy-efficient land use planning is critical if we are to build now to accommodate the future." Mike Sutcliffe, eThekwini City Manager, Urban Green File (2006:49).

This research paper investigates the concepts of rooftop gardens; the relationship it has to urban ecology, the benefits and constraints of implementing them; and future prospects of this type of urban intervention within a South African context. The rationale for the research is embedded in the positioning and functionality of nature in current and future urban developments. In all areas nature plays a significant role in the urban ecology of city environments, including the rooftops of buildings. Now more than ever before, further investigation is being called for into issues such as the relationship between nature and the growing concern around climate changes; the role of nature in urbanization and densification of cities; the associated influence that the built environment has on the climates of cities, and on citizens. To what extent have urban development projects taken into account the concerns relating to the environment and global warming? What effects have various acts, protocols, and policies, which have been promoted by the different spheres of government in South Africa and, particularly, within the eThekwini Municipality, had on the urban environment?

In the majority of cities around the world, and Durban being no exception, rooftops comprise of thousands of hectares of unused space. These vertical unused spaces could be transformed into resourceful areas. They can be used to mitigate some of the problems associated with cities and global warming and climate change such as the urban heat island effect; impervious

surfaces and their relationship with storm water drainage; and at the same time promote biodiversity. They can increase food security and urban agriculture, and they can be used to transform the visual and spatial quality of urban, commercial and industrial landscapes.

The process of construction and planting rooftop gardens could, arguably, be a partial solution to these problems. However, the conservative mindsets among professionals, officials and citizens, coupled with techniques used to date, have plagued positive execution of rooftop gardens in South African cities. Prior research and literature have proved the benefit of rooftop gardens in many cities throughout the world,[1] but none in South Africa. This study offers evidence, from a South African perspective, on the benefits of rooftop gardens, as well as insights into the mindsets and attitudes towards nature, greening and rooftop gardens.

1.2 Background and outline of research topic

The city of Durbanôs drive towards mitigating global warming and the need to create "sustainable cities" that provides enough food, shelter, basic services and jobs for all urban residents for now and in the future, will be a great challenge for the next millennium. To solve these problems creatively, cities and citizens will need to rethink the use of available space and begin to question how ñempty spaceò can become ñresourceful spaceò.

This research will provide insight into the viability of certain types of green roof systems within the eThekwini built environment. This form of retrofication[2] has significance for the

[1] Cities like Montreal, Singapore, Toronto, Chicago, and others.
[2] The addition of new technology or features to existing buildings in order to make them more efficient and to reduce their environmental impacts.www.london.gov.uk/mayor/strategies/sds/further-alts/docs/glossary.rtf

sustainable health of urban environments as well as the future role of cities in mitigating issues around climate change and global warming. This contemporary role of cities will require creativity by municipal governments and citizens especially with regard to how cities can help citizens address global warming and their needs of food, shelter and employment; and how urban environmental problems can be solved.

It is my submission that the study of rooftop gardens is woven into the theoretical frameworks of urban ecology, the built environment, urban agriculture and eco-cities. It must be mentioned that the literature around, and the implementation of, rooftop gardens in South Africa is virtually non ï existent. Furthermore the theories and frameworks pertaining to the research project are inter-related. For example, rooftop gardens encompass the ideologies around the green cities movement, as well as issues around urban ecology, urbanization, aesthetics, citizenôs mindsets, behaviors, perceptions and the need for rethinking the use of vertical space. All these form synergies as cities and the urban environment begin to spread and consume excessive amounts of horizontal space[3].

1.3 Research problem and objectives

The result of increased urbanization[4] and the serious factors influencing global warming and climatic change, the process of eco cities and the role of nature as well as ecologically friendly developments need to be investigated further. The approach to understanding this exploration was considered within in the conceptual framework of urban ecology, urban design and the metabolism of cities. Are the possibilities of eco cities, inclusive of rooftop

[3] A process that compact cities pragmatists are trying to address.
4 Infrastructure backlogs, limited access to arable land, overcrowding and increased development at the expense of the natural environment are some of the primary resultants of increased urbanization.

gardens, being utilized or planned for in a proactive response to the various issues around the built environment urban planning and climate change issues? These issues include the planning and role of vertical space with regard to urban agriculture; cultivating food on top of rooftops thus supporting a growing urban populace; and the overall affects that the built environment have on the climate of cities and its inhabitants. Examples include issues around human psyche, human health and how the urban environment is perceived by society. However in hindsight a far greater analysis will be required in order to obtain sufficient evidence to determine the ergonomic characteristics that are at play in urban-human relationships.

Rooftop greening is currently happening in Durban[5] on such a small scale, as to be almost non-existent in comparison to cities around the world, such as Singapore, Chicago, Toronto, Tokyo, Linz, Montréal and a host of others (Ayalon, 2006:5) . In addition to this, the containerized rooftop garden technique is a completely new concept in South Africa. As a result of South African cities falling behind in this form urban transformation, it has proved challenging to provide an analysis of rooftop gardens within a South African context. What has been of significance is how this form of urban intervention is inherently linked to urban ecology and eco- city concepts. This proved valuable when addressing the validation of international and domestic claims adhered to rooftop gardens and nature in the built environment.

[5] Hawaan forest gated community has one rooftop garden. There are two buildings on Musgrave road that have small rooftop gardens; the Greyville racecourse has an extensive window box initiative. Supposedly the Point development has a building that might have one installed. Otherwise as mentioned earlier a handful of private property owners have installed very small conventional rooftop gardens mixed in with a few potted plants.

1.4 Research objectives

The objectives of this research are therefore to:

- Situate theories around the role of rooftop gardens and rooftop agriculture in the context of mitigating climate change relating to heat island effects, storm water runoff, and food security;
- To examine the degree to which containerized roof gardens can aid in the reduction of temperature levels, reduce storm water runoff, benefit the biodiversity scope of eThekwini, and lastly, promote healthy mindsets of the inhabitants of the city of Durban;
- To test the above questions through research surveys and interviews as well as the construction of a pilot containerized rooftop garden on top of the Memorial Tower Building (MTB) roof at University of Kwazulu Natal (UKZN).

The challenge for future research will be a more in depth investigation into the physiological benefit of rooftop gardens from an aesthetic perspective. This is beyond the scope of this dissertation.

1.5 Key research questions

The research questions that will help achieve these objectives are:

a) What are the benefits to rooftop greening?
b) What are the understandings of the benefits and constraints of rooftop gardens?
c) How can rooftop greening address urban environmental, agricultural and food security issues?

d) What are the barriers (policies and perceptions) preventing the expansion of rooftop greening in Durban?
e) In what ways do rooftop gardens increase biodiversity? For example does it offer a haven for insects, birds and other fauna?

Additional research questions relate to technical issues such as the water run-off of the pilot area (linked to rainfall and storm water velocity in millimeters); the effects of using an area of containers compared to an area of just flat roof with no containers; measuring the heat (Degrees Celsius) of the immediate area above the containers and temperatures underneath containers- as opposed to the area with no containers.

1.6 Methodology

The investigation into the research adopted various processes. The methodological approach and research design incorporated exploratory, explanatory investigations as well as primary, secondary and technical research investigations that employed both qualitative and quantitative techniques. Chapter two offers a more detailed discussion of these procedures.

1.7 Structure of Dissertation

Chapter Two discusses the research exploration route, design and the investigation methods used in some detail.

Chapter Three outlines the theoretical and conceptual framework of this research and the interrelationships and philosophies surrounding the notions of rooftop gardens. It takes into

account both theoretical and technical perspectives; and it outlines the ways in which the South African governmentôs legislation, agendas and protocols affect rooftop gardens and urban ecology.

Chapter Four presents the research results of the project and addresses the understandings, perceptions, benefits and constraints surrounding of rooftop gardens. It identifies a range of benefits and constraints to more extensive development of rooftop gardens in South Africa.

Chapter Five incorporates the final conclusions of the study together with recommendations for further research of rooftop gardens and city greening. It addresses the questions raised from this study, and makes reference to eThekwini municipalityôs current green roof pilot project, which materialized as a result of this dissertation.

CHAPTER TWO – METHODOLOGY

2.1 Introduction

The exploration route for this research incorporated a number of both qualitative and quantitative techniques. This chapter outlines the methods used for assembling secondary information (2.2); primary research which incorporated surveys with three target groups (2.3); in depth interviews with specialists in the field (2.4); the site selected for the case study (2.5); and finally technical aspects (2.6).

2.2 Secondary research

There were three components to the secondary research. First was a literature review using books and journals about rooftop gardens, urban ecology, sustainable landscape development, urban planning, architecture and eco city dimensions. The second involved a scanning of internet sources which were particularly useful in filling the gaps in other literature on green rooftop gardens, and technical aspects, for example modular and container systems. The third secondary source was documentation associated to municipal frameworks and national government acts. They were used as a base for comparison to address whether the relevant polices around sustainable urban developments were actually followed, or merely rhetoric.

2.3 Surveys with three target groups

Surveys were undertaken in order to gain insight into the understandings of eco cities, urban ecology and of rooftop gardens in particular as well as associated government policies. The

surveys aimed to determine if they had any preconceived ideas around rooftop gardens and to assess peopleôs mindsets and attitudes with regard to installing rooftop gardens.

The target groups selected were:

- A sample of 27 scholars from grade eleven and twelve classes at Glenwood High school. This sample group was chosen firstly, because of accessibility and secondly from an explorative directive as to whether high school students have already reached a level of awareness and intellect and have preconceived ideas of rooftop gardens and on issues around vertical green space.

- A sample of 225 UKZN students attending courses in the Human Science Faculty. Namely, in Town and Regional Planning; Geography and Environmental Science; Economic History & Development Studies; Sociology; Political Science; History and Internet Studies students. This sample group was chosen because of two elements. Firstly, the accessibility to the researcher and secondly UKZN Human Science students were assumed to have the ability to provide educated and progressive responses to the questionnaires.

- Nine professional consultants from urban development disciplines currently working in Kwazulu- Natal. These professionals from urban development backgrounds were selected on account of their general understandings of built environment issues.

The sample sizes were not planned at these relevant sizes, but rather were a result of the researcherôs accessibility to the various target groups and the resources made available to him, at the time of research.

The same questionnaires were used for all groups. It consisted of 15 questions (see Appendix 1). The questions were formatted through an inverted funnel layout. The inverted funnel technique poses specific questions and personal issues in order to encourage clear unbiased responses (Sarantakos, 1993:161). This funnel technique allowed the researcher to obtain non -influenced answers relating to perceptions of rooftop gardens. The data collected through the questionnaires was analyzed in order to determine mindsets and understandings of urban ecology and the use of green spaces in an urban environment.

The methods of sampling were as follows:

- 27 High School going scholars ï Questionnaire sheets were given to one teacher who taught history, to both grade 11 and 12 classes at Glenwood. He requested all the learners to complete the questionnaire which they did. Only one was unusable.

- 225 UKZN students ï This part of the research used a purposive, stratified sampling technique. As in the case of the scholars, questionnaires were given to the respective lecturers who invited students across all three undergraduate years and one post-graduate class to participate. The outcome was thus a convenience sample within the strata selected.

- 9 Built environment professionals - This group from Town Planning and Architectural backgrounds, was randomly selected on account of their general understanding of built environment issues.

2.4 Interviews with ecological design specialists

Three in depth interviews were administered to interviewees who were specifically selected because of their specialisation regarding ecological design and current experience in applying

these approaches in Durban. They represented three primary disciplines that are needed to support rooftop gardens.

- Urban ecology and landscape design Geoff Nichols (GN) is an ecologist and urban landscape specialist, who pioneered a roof garden project at Hawaan Forest in Durban. He has been and still is, involved with various municipal, provincial, national flora and fauna projects. In addition to this he has received numerous conservation awards for outstanding service and input into the environmental field (see interview question sheet, Appendix 3).

- Derek van Heerden (DVH) is an Architect from East Coast Architects, a progressive firm that practices green architecture. He has been involved with numerous projects promoting greener ethics towards the construction and the development of the built environment (see interview question sheet, Appendix 4).

- Environmental Policy formulation and implementation Jessica Rich (JR) is Manager of Policy Coordination and Implementation for eThekwini Municipality Environmental Management Department (see interview question sheet, Appendix 5).

2.5 Pilot case study

The pilot case study was used to test and support the various international claims about the advantages of roof gardens. Thus a systematically planned and executed pilot study was put into operation on top of the MTB on the Howard College Campus of the UKZN in 2008 (see Image 2.1). The rooftop chosen was one of the outdoor roof terrace areas of the MTB. It was then an unused, barren area (except for air-conditioning units) (see Image 2.2). Moreover it

must be noted that the pilot site was a miniature version (one square metre) of what a more extensive coverage of rooftop gardens would potentially achieve. One area of the roof was filled with four containers making up a square metre and an adjacent area left empty. This was done in order to record the heat of the virgin, blank roof, (see Image 2.3). The pilot study also set out to determine if it was possible to grow food crops on rooftops, (see Image 2.4).

The pilot area is depicted in blue in Image 2.2 and it measures approximately +/- 1m wide by +/- 3m long. The roof top area is formed by reinforced concrete with a torch on grey waterproof finish. Each storey below the roof top area is constructed in an identical way. According to the Universityôs Structural Engineering Department, the roof of MTB was more than adequate to carry the various containers. The containers have an individual maximum weight ranging between 20kg and 90kg.

Image 2.1: Top View of Pilot study area

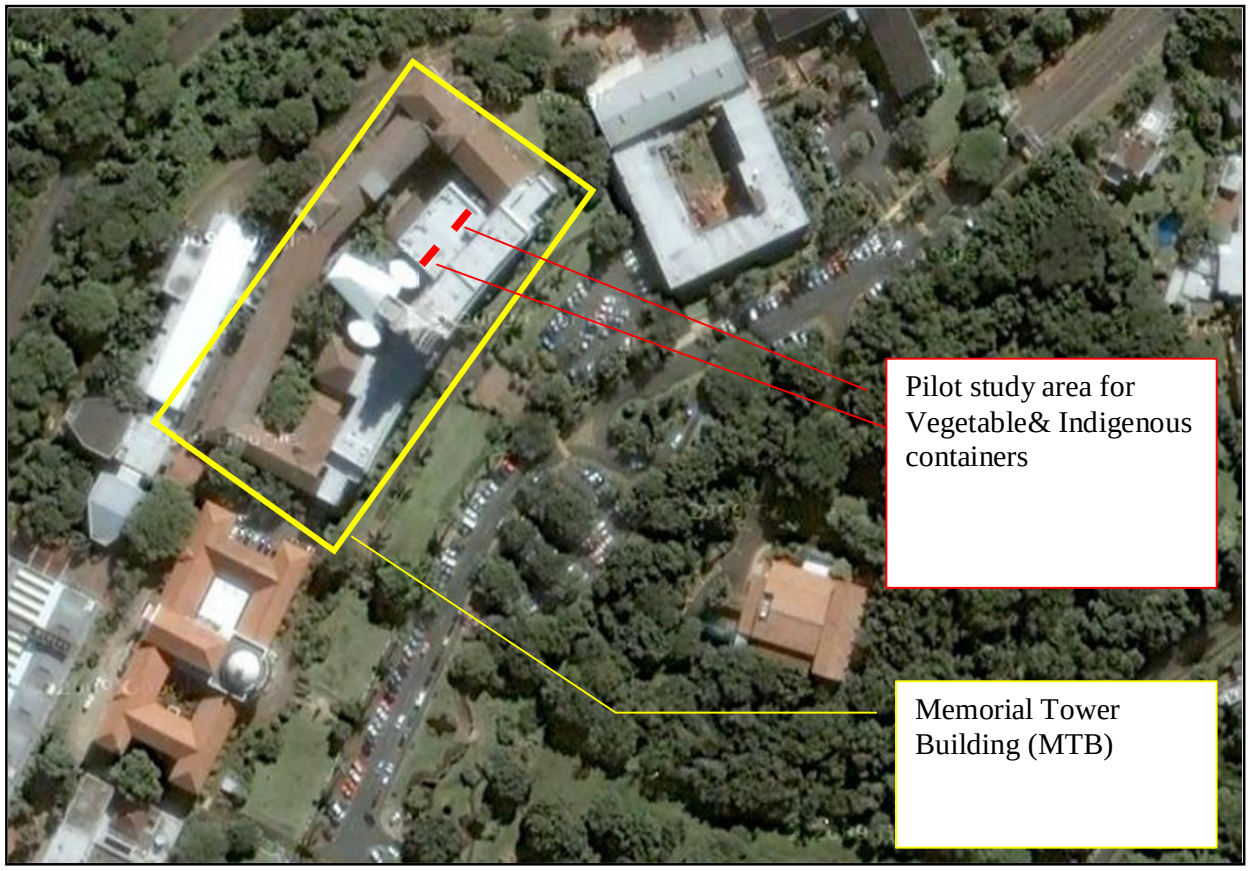


Image 2.2: Pilot study area

Image 2.3: Pilot study planted trays

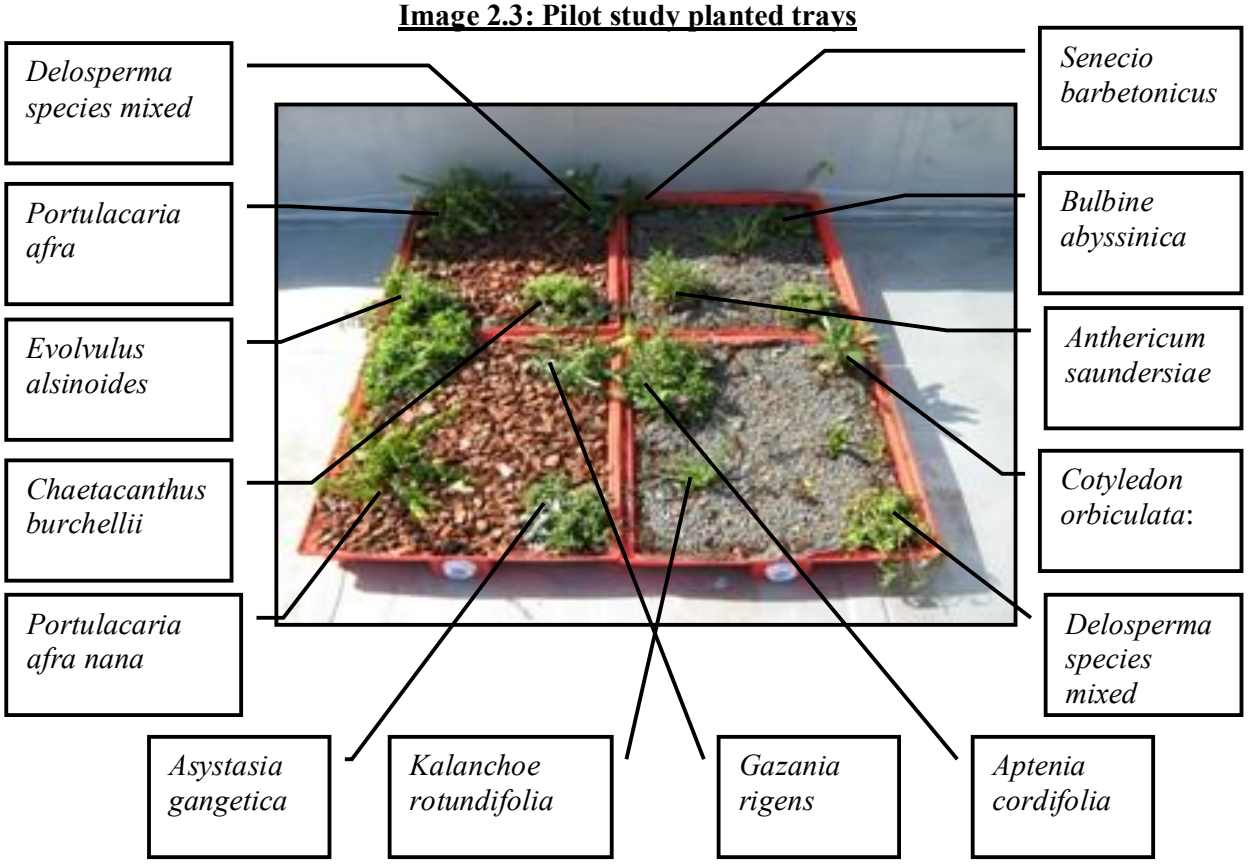


Image 2.4: Food crop pilot study area

2.6 Technical components

This part of the research incorporated scientific observation and technical implementation. It was essential in offering practical support for the various international theories revolving around the benefits and processes of implementing roof top gardens. It must be stated that this research is still ongoing in the form of a pilot project being administered at the eThekwini Municipality City Engineers building. The instrumentation used in the UKZN pilot included trays, drums, thermometers and measuring buckets. Another technical component relates to plant types.

2.6.1 Trays

Four trays were used in the simulation study of rooftop gardens.

Length: 670 mm

Width: 600 mm

Height: 70 mm

These four trays were used in the research for temperature variances and water retention rates.

Drums

Fifteen containers were used to grow and observe the results for vegetable and other edible crops.

Height: 420mm

Diameter: 30mm

2.6.2 Thermometers

Three basic thermometers were used on the pilot site. Each of the thermometers was placed in specific points on the pilot site in order to record the temperature readings over a six day period. The temperature was logged at 9 am and 13 pm during these six days (see Image 2.5 and Chart 4.3). In addition to this, Appendix 1 shows the results of a more comprehensive investigation into temperature variances. The results are from an eThekwini Municipality pilot project currently operating that was influenced by the outcomes found from this dissertation.

Image 2.5: Thermometer placements

Thermometer on top of the blank roof:

The placement of this thermometer allowed for a general reading of what temperatures the blank roof would reach over a six day period.

Thermometer on top of the planted tray: The reason for this placement was to observe the difference in temperature on top of the tray even though plant cover was not fully matured yet. The growing medium would show a fluctuation in surface temperature in comparison to the blank roof.

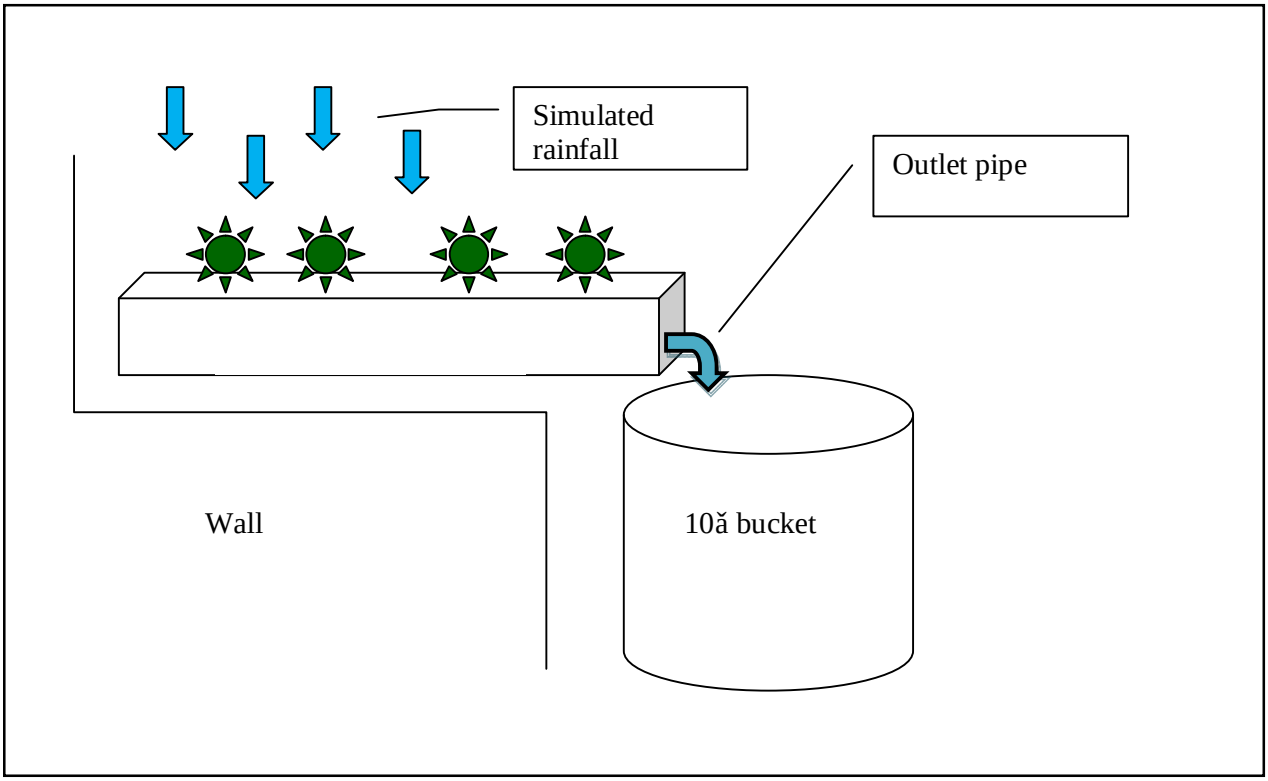
Thermometer under the planted roof tray: the Different temperatures was recorded under and on top of the planted trays

2.6.3 Measuring buckets

Two 10ă measuring buckets were used in the pilot study. Each bucket was placed in designated positions shown in Figure 2.1 and Figure 2.2.

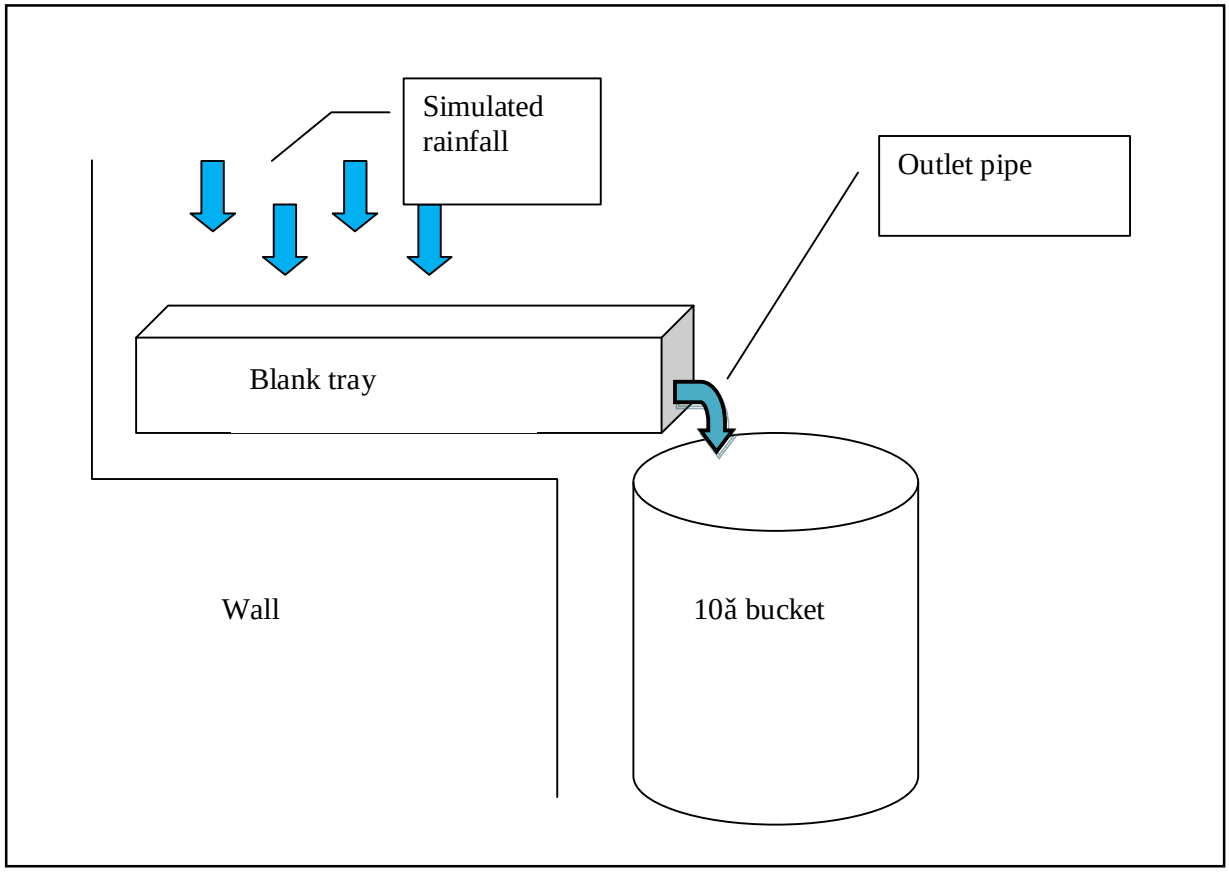
1x 10ă bucket: was placed under the planted up tray and water was used to simulate rainfall. The rationale behind this approach was to provide evidence that the planted tray would absorb a percentage of the water. This amount would be recorded until it reached saturation point, subsequently it would then flow out however this rate of flow would also be affected as the rainfall velocity would be slowed as the run off made its way through growing medium and plants to the drainage points.

Figure 2.1: Measuring bucket set up planted tray



1x 10ă bucket: was placed under a blank tray (unplanted used to simulate an area of blank roof the same dimensions as a portion of planted roof). This was used to investigate the run off rate of a blank roof, to record the run-off flow per minute of the rooftop (see Chart 4.1 and Chart 4.2).

Figure 2.2: Measuring bucket set up unplanted tray



2.6.4 Plant material

Both indigenous and various vegetable crop were selected. The criteria were based upon what type of plants would be able to survive the harsh conditions of a barren rooftop. Urban roofscapes are extremely hot, lifeless places of bituminous surfaces, violent temperature contrasts, bitter winds and an antipathy to water. Table 2.1 lists the indigenous plants selected for the pilot study and the associated vegetable types.

TABLE 2.1: Plants used in the pilot study

Indigenous rooftop garden plants selected ***(scientific name)***	**Vegetable/ edible plants selected** ***(common name)***
Aptenia cordifolia: Prostrate or semi-scrambling, succulent herb	Egg plant
Anthericum saundersiae: 700mm in groups, on coastal forest floor and grassland	Tomato
Asystasia gangetica: Spreading herb, in woodland and forest	Peppers
Bulbine abyssinica: Robust perennial in clumps, very variable	Rocket
Chaetacanthus burchellii: Shrublet, in grasslands, woody rootstock	Lettuce
Cotyledon orbiculata: Evergreen, succulent shrublet, reclining to sub erect	Nasturtiums
Delosperma species mixed: A succulent groundcover with small white flowers in summer.	Sweet potatoes
Evolvulus alsinoides: Perennial herb, in grassland and woodlands	Corn
Gazania rigens: Creeping perennial herb	Spinach
Kalanchoe rotundifolia: Perennial, sparsely branched, erect or straggling succulent herb	Basil
Plectranthus spicatus: Perennial succulent, spreading to scrambling, in dry woodland rocky places	Radish
Portulacaria afra: : A low growing succulent perennial shrub	Beetroot
Portulacaria afra nana: A low growing succulent perennial shrub	Cucumber
Senecio barbetonicus: Much branched, scrambling, succulent shrub.	Runner beans
	Dwarf paw paw

Reference: Pooley, 2005.

2.6.5 Research summary

The research methodology proved successful. However better equipment for measuring the rainfall would have proved beneficial. In addition to the above a more widely stratified sample selection would have been extremely beneficial when assessing human mindsets and understandings. Such a sample would incorporate students and academics views in each faculty and discipline and more interviewees would have been included from engineering and other faculties. More interviews with civil engineers and storm water drainage practitioners would have been of value. With regards to the pilot study on top of the Memorial Tower Building, additional planted containers (for example 30 containers) would have been an advantage, as it would have provided a better approach for aesthetic analysis regarding

peopleôs perceptions on the planted rooftop. Furthermore owing to the lack of funding for the research, the researcher had to rely on accessibility regarding questionnaires and volunteers during implementation, recording and tabulating data.

CHAPTER THREE - ROOFTOP GARDENS SOCIAL AND ECOLOGICAL CONTEXT

3.1 Introduction

This chapter provides the theoretical and conceptual framework for the research as well as the synergies and understandings associated with rooftop gardens. In addition to this, it briefly outlines South African governmentôs legislation, agendas and protocols that potentially affect rooftop gardens and urban ecology. A literature review revealed the need for two forms of contextualization. Firstly, a more theoretical framework based largely on international examples, examined within the context of urban ecology, ecoï cities, sustainable development and urban design. Secondly, a more technical explanation offers an analysis of the workings and benefits of rooftop gardens. Despite the dearth of formal literature around rooftop gardens in South Africa, the research process uncovered a growing body of material on rooftop gardens in popular magazine publications[6].

3.2 Literature review

Several influences make up the concept of urban ecology therefore the literature review was divided into discrete categories. However, the linkages between these and the overlaps should not be overlooked. This literature review draws together a wide range of dimensions in a lattice, to provide a conceptual framework for the research.

[6] Sunday Tribune 31 October 2002, Men Health Magazines 2008, SA Gardeners Magazine 2008, National Geographic May 2009.

3.2.1 Urban design and role of nature in cities

There is a vast literature linking urban design and role of nature in cities. For example Classical theorist, Frederick Olmstead[7] understood the synergies of urban planning and urban design systems and addressed the need for nature in urban environments. Rooftop gardens are a contemporary appreciation of this vision. Givoni (1985) addresses green buildings and the bioclimatic control of buildings, based on eco friendly construction techniques, the notion of eco ï cities and sustainable urban design, arguing that buildings should be designed with the immediate natural environment taken into account.

Hough (1995) addresses the view of architecture from an urban design perspective embracing the natural processes that need to be incorporated into urban spaces and designs of cities. An example of this is the use of forgotten urban spaces such as the rooftops of buildings. Thompson and Sorvig (2000) offer understandings of the need for a more holistic and sustainable landscape construction process. This alludes to the role of landscape and urban planning especially with regards to how sustainable landscape construction can be envisioned in a vertical form such as rooftop gardens. McDonough, for example, (2005) engages with the overall construction of urban landscapes, inclusive of rooftop gardens, the various types, techniques and loading capacities associated to them. This proved useful when realizing the numerous constraints attached to rooftop gardens. Furthermore the introduction of sustainable techniques can help reduce problems arising from global warming and opportunity costs when constructing buildings in different habitats and climates.

[7] Born In 1822 and in 1883 Olmsted established what is considered to be the first full-time landscape architecture firm in Brookline, Massachusetts Was prominent in promoting and planning recreational parks across the country. Egalitarian approach to public parks all citizens should benefit and believed that the common green space must always be equally accessible to all citizens (Sutton S.B, 1971).

3.2.2 Sustainable cities and eco cities

Contemporary authors such as Satterthwaite (1999), Wheeler & Beetley (2004) address the sustainable development of cities by engaging with urban geography, planning and environmental studies. This body of research addresses urban planning and the sustainable use of space, by promoting the concept of growing both flora and food crop on the rooftops of cities. Nicholson- Lord (1987), Girardet[8] (1992), Roseland (1997) and Register (2006), offer additional analysis of urban ecology through an ecoï city perspective that takes into account the role of nature and greening the city.

The eco-city vision links ecological sustainability with social justice and the pursuit of sustainable livelihoods. This dissertation interacts with the eco-city debate through rooftop garden initiatives, in the drive for mitigating effects of unsustainable development in the urban-built environment. It further supports urban agriculture, urban greening projects and community gardens on top of residential units. In support of this, Register (2006:32) argues that on a planetary scale we are excavating vast patches of natural habitats, which increasingly degrade natural systems. Currently resource extraction takes place at a faster rate than natureôs capacity to renew it. Furthermore wastes are disposed of into natural systems at a faster rate than natural systems can absorb. The increasingly accepted view is that ecosystem manipulation must not be done at the expense of human beings and nature. These destructive developments, according to the above theorists, have extremely negative effects. For example the continued destruction of natural systems results in major transformation of the planetôs atmosphere and city developmental infrastructure. Hence the abilities of cities to perform and establish efficient and sustainable management processes are jeopardized.

[8] Girardet developed the Gaia Atlas of Cities, which encourages new directions for sustainable urban living.

All these processes are features which eco-cities try and mitigate, by promoting courses of action revolving around a ñcircular metabolismò[9] (Girardet, 1992:22), as opposed to conventional cities which function on ñlinear metabolism.ò According to Spirn (cited in Wheeler et al, 2004:114) traditional urban development has set the city against nature, and nature against the city, whereas both form part of the same system. However if both are addressed from an eco-systems approach, the relationships they share are similar. One cannot remove an element from either system without replacing it or compensating, so as not to disrupt the balance. Rooftop gardens offer solutions to the degradation of green areas where natural space is cleared for new buildings. One is able to órepláceô the natural system lost on the ground by replanting it on top of the roof. In addition to this it supports an increased awareness of the local environment through effective focus on ecologically sustainable issues (Roseland, 1997:3). The role of rooftop gardens and nature in the city falls under the concept of an eco-city directive.

All these approaches have been labeled progressive but lack the foundation of being part of a broader policy and implementation framework. For example, in a local context the eThekwini municipality has various frameworks and policies on environmental issues and planning, however they are not specific enough. Section (4.3.2) of this dissertation briefly discusses principles of local Agenda 21 and the National Environmental Management Act (NEMA). It considers whether sustainable initiatives such as rooftop gardens have been incorporated into urban development frameworks and environmental management systems. These principles and frameworks were investigated to decipher whether a city like Durban could adopt certain elements of an eco-city approach, and what the constraints might be, including human

[9] Where all activities are constructed in a manner that resources are either re-used or re-cycled and cities management mechanisms are performed in an ecological and sustainable way (in-put = out-put)

mindsets and attitude around eco-cities and a more holistic form of urban planning and urban ecology. Unfortunately the noble intentions cited in the rhetoric about sustainable eco-cities are often not implemented in policies and projects.

3.2.3 Nature and its effects on human behavior

The literature regarding the effects of nature on human beings is very broad. It engages with concepts of behavior and human psychology. In the attempt to address and analyze cultural and urban ecological concepts (public perceptions about nature and rooftop gardens) authors such as Nasar (1988), Thayer (1994) and Porteous (1977), provide a biophiliac[10] study pertaining to cultural - urban ecological analysis, inclusive of human behavior. This theory is adapted further and suggests that children who have abundant exposure to nature tend to be more biophilic. Wilson suggests that as children get older they lose touch with nature. This is a result of various socially conditioned processes. For example they value television, computers and video games above trees, insects and birds. In addition to this Wilson (1984) states that when people deplete and degrade the natural environment, most particularly their meaningful and satisfying experience of it, they diminish their potential for emotional and intellectual capacity.

Balling & Falk (cited in White, 1994:144) and Thomas (2003) support the above statements and explore the maternal bond that humans have with nature influenced from an evolutionary

[10] Biophiliaò describes humanity's intrinsic fascination with life and life-like processes. A growing body of research shows that building environments that connect people to nature are more supportive of human emotional well being and cognitive performance than environments lacking these features. Whether nature's presence comes from daylight, fresh air, indoor plants, or landscape views, there is growing evidence of positive impacts on building occupants in a wide variety of settings, from offices to hospitals and community spaces. In biophilic spaces, patients recover more quickly, students learn better, retail sales are higher, workplace productivity goes up, and absenteeism goes down. Sometimes the differences are up to 15 or 20% (www.worldtrans.org).

perspective. According to Balling & Falk (cited in White, 1994:144) people have an affiliation with scattered trees and uniform ground cover because it resembles African Savannahs - the epoch of human existence. There is evidence that the mere presence of natural areas, trees and established landscapes can influence human psyche. People who drive, live and work in tree-lined streets are less prone to violent behaviour (Thomas, 2003:35). Furthermore colour therapy specialists state that in the colour spectrum, green is the neutral colour, perceived as an analeptic for exhaustion and stress (Thomas, 2003:35). Urban trees and forests provide both contrast and relief from highly built up cities and environments. Consequently it has a strong relaxing effect on people (Dwyer et al cited in White, 1994:138). The above theorists input were beneficial in drawing on the relationships that humans have with nature and vice versa. It further highlighted the need for incorporating nature into every corner of the built environment.

With regard to urban planning, contemporary urban formations and growth must strive to understand the contributions and effects human developments have on the environment (Hough 1984:24). Supplementary to this, citizens need to adopt a more responsible approach to their lifestyles and urban development in order to maintain the health of their cities. However this would require continuous levels of exposure of humans to the gradations involved in greener ecological environments. Rooftop gardens could fill this position. In hindsight limited attention has been given to the effects that physical form and structure have on human societies[11]. These inherent acuities can compose of different arrangements involved within the built environment, but of primary concern are the roles that trees and various floras play in the city environment.

11 According to Jessica Rich, ñé its ergonomics and I donôt think environmental aesthetics have been investigated at all from a policy perspective.ò

For example, because of the three dimensional construction of cities, many views could be enhanced with the addition of roof gardens. This is because bare rooftops can be seen from higher vantage points on the hills and from other buildings. The surveys undertaken for this research provided insight into the attitudes of the sample groups regarding rooftops as an effective tool for greening of cities. One of the primary foundations for establishing sustainable urban developments, eco cities and rooftop gardens is the will of the public (human mindsets, see chapter four) and it was rewarding to see the enthusiasm towards promoting green spaces within Durban.

As mentioned above, the emotional effects of greener cities and natural zones are extremely beneficial to the psychological state of its inhabitants, a huge benefit for the citizens of the city, which in turn affects the economy of the region. In summary all of the above arguments promote a greener city and the role that nature plays in promoting a healthier urban environment. This argument was anchored by Register (2006), Roseland (1997), Laurie (1979), Nicholson- Lord (1987) and others.

3.3 Climate change and Global warming

Global climate change is the increase in the average temperature of the earthôs atmosphere that causes change in both local and international climate patterns inclusive of sea level fluctuations. The term global warming is often used interchangeably with climate change because the average temperature of the earth is increasing (eThekwini Municipality Environmental Management department Climate Change report 2007). It must be mentioned that climate change will affect different parts of the world in different ways. For example the Gulf Stream current that transports warm water from the equator, keeps England warmer in

the winter than other countries, which are further north. Ocean warming as a result of global warming, may decrease or halt the Gulf Stream current thus cause Englandôs winters to become even colder. South Africa is not exempt from these global issues as climate change will not only result in increased temperature and rising sea levels, but will also alter rainfall patterns and seasons across the country. Accompanying these patterns are the various problems (eThekwini Municipality Environmental Management department Climate Change report 2007) relating to:

- **Human health** This is due to heat stress, which is a problem for the very young and old, and those who work outdoors. Furthermore changes in the distribution of disease bearing organisms that will have considerable effect on people, domestic animals and crops.
- **Water availability** Due to decreases in the recharge of dams that supply the city of Durban namely Inanda and Midmar as well as an increase in evaporation from the increase in temperatures, water availability is a looming problem.
- **Soil** Due to more intense rainfall there are increased problems of erosion and flooding.
- **Biodiversity** Loss of biodiversity and ecosystems occur due to the reduction of climate sensitive indigenous species, erosion, floods, sea level rise and increase growth in invasive alien species.
- **Infrastructure** Damage to infrastructure occurs because of storm water velocity, rainfall intensity and increase in tidal activity.

Rooftop gardens are able to mitigate some of the above mentioned issues to a certain extent. It is my observation that through rooftop gardens firstly, the efficiency of buildings will

improve thus decreasing the amount of coal burned in electricity production. Secondly, by planting rooftops with indigenous plant species biodiversity and ecosystem activity is likely to increase. Moreover by restoring ecosystems on rooftops, carbon dioxide is removed from the atmosphere by plants as they absorb carbon dioxide and use the carbon for their structural growth. Section (3.9.3) and Chapter four of this dissertation discuss further benefits of rooftop gardens.

3.4 Urban Ecology

The question of whether the human built environment can co-exist with the natural world is an important one. The urban environment is in a state of constant flux. Inhabitants of cities worldwide increasingly find themselves losing touch with nature as they move from rural hinterland areas that have an abundance of nature, to cities that compete for space with nature. People generally want wildlife in urban areas and suburban areas, even if they are unsure about some of the potential conflicts. ñHaving nature around us in urban environments is an indication that nature still prospers in the places where we dwell. It is a sign that our habitat still retains some of its ecological integrityò (Shaw et al, 2004:8).

The theory of urban ecology and urban ecological integrity are the umbrella framework for this dissertation. It encompasses conservation values, biodiversity and ecological resilience. Urban ecology is linked to the concept of ecology and it deals with the interaction of plants, animals and humans with each other and with their environment in urban or urbanizing settings. Furthermore cities are both the producers of environmental impacts through the consumption of resources and generation of wastes as well as forming an intricate part of a larger ecosystem (Register, 2006:1). This concept of production and generation of wastes

epitomizes the link between the city and the natural world as habitat fragmentation, pollution and noise make contemporary cities hostile to the natural environment.

However rooftop greening can create healthy, functioning habitats on rooftops as opposed to being primarily lifeless places of bituminous surfaces. As mentioned above, the value of rooftop greening forms part of the understandings of eco- cities, urban agriculture and their connection to the theory of urban ecology. This was confirmed by the secondary sources assessed; and it became evident that the concepts of urban ecology, ecoï cities, sustainable development and urban design are inherently interrelated. Contemporary authors such as Nicholson-Lord (1987), Girardet[12] (1992), Roseland (1997), Wheeler and Beatley[13] (2004) and Register (2006), offer additional analysis of urban ecology addressing it through an ecoï city dimension and taking into account the role of nature and greening of the city. The eco-city vision links ecological sustainability with social justice and the pursuit of sustainable livelihoods.

3.5 Sustainable Development

The concept of sustainable development was made the flavour of the 20th century by the chairman of the World Commission on Environment and Development (WCED). Sustainable Development is the innovative and distinctive process whereby simultaneous relationships maintain the balance between economic growth, meeting social needs and conserving environmental quality (Purvis & Grainger, 2004:33). Sustainable development is closely associated with Agenda 21. Agenda 21 is the programme of action for sustainable development that was adopted by the General Assembly of the United Nations following the

[12] Girardet developed the Gaia Atlas of Cities, which encourages a new direction for sustainable urban living.
[13] Wheeler & Beatley provide an alternative or appropriate approach to sustainable urban ecology. For example the inclusion of communities in urban planning. Green building, green architecture and innovative practices and techniques for sustainable development.

Earth Summit in Rio de Janeiro in 1992. It was constructed to place emphasis on the need to unpack the process of sustainable development, one that incorporated the social, economic dimensions of development and concerns for the natural environment (http://www.johannesburgsummit.org). Thus with strategic and creative planning solutions from both municipal governments and citizens, the urban environmental question offers a vision of a healthier and more sustainable urban space. To do this, city spaces need to be re-conceptualised, restructured and examined to identify how existing empty spaces can become resourceful spaces.

One way of enacting this transformation is through the use of empty rooftops. Rooftops can become areas of innovation through rooftop gardening techniques. Large, flat and empty rooftops are abundant throughout the eThekwini city, on institutional, private, residential, industrial, municipal and commercial buildings. As revealed in earlier paragraphs, the eThekwini municipality has various frameworks and policies however they are not specific enough with regards to innovative techniques associated with greening. Thus concepts like rooftop gardens are not yet seen as a solution and part of existing or even future policy developments. This became evident when the surveys and interviews with professional consultants and the manager of eThekwini policy development were analyzed.

3.6 Built Environment

The built environment is primarily part of the physical surroundings which are human constructed or at least organized by humans. Examples include buildings, roads, bridges and other forms that make up the urban fabric (Reekie, 1972:1). Urban design and urban planning are two of the ingredients that shape part the built environment.

3.6.1 Urban Design

Functionality, structure and appearance are the cornerstone of urban design philosophy. Together these three categories create the physical form of cities. Urban design engages with elements that administer physical direction to urban growth. Conservation and progressive change and how cities are designed and the buildings within them are influenced by urban design. Contemporary urban designs strive to understand the contributions and effects human developments have on the environment (Hough 1984:24). In order to achieve this, citizens need to adopt a more responsible approach to their lifestyles and urban development in order to maintain the health of their cities. The success of this outcome is dependent on greater integration of both human responsibility and ecological practices. Whether these preparations are enforced or seen as a conscious necessity for better standards of living are debatable.

Many years ago Reekie reported that solar radiation ceases in the evening and temperature in the urban peripheries and rural areas decreases. However in urban areas, temperature stays constant due to the released heat stored in the fabric of buildings and by the increased domestic and industrial heating and lighting (1972:110). Rooftop gardens form part of this concept in that vertical space needs to be addressed when engaging with urban design and natural space in cities. Thus rooftop gardens can have a strong influence on the design of cities in the future, especially as urbanization increases[14].

[14] By the year 2010, 73% of all South Africans will be urban dwellers (www.deltaenviro.org.za). Rooftop gardens may play an intricate part in offsetting the numerous effects of increased urbanization. For example, greater open space for nature, biodiversity, growing crops on rooftops and harvesting rainwater off roof gardens to name a few.

The way urban developers, planners and designers re-use existing vertical spaces will help strengthen the possibilities for cities to create more responsible ways of developing urban and built environments.

3.6.2 Urban Planning

Classical theorist, Frederick Olmstead[15] understood these systems within urban ecological dimensions and addressed the need for nature in urban environments (Wilson, 1989:9). Olmstead is famous for designing many well-known urban parks, such as Central Park and Prospect Park in New York City. Olmstead designed using his own term, to ócivilizeô the city, by building parks that simulated nature (Sutton, 1971:11). Working in the late 1800s Olmstead was seen as somewhat of a óvisionaryô. He predicted the rate of urbanization and how it would affect the role that nature, public space and parks would need to play in a built-up environment[16].

In addition to creating city parks in many cities around the country, Olmstead also conceived entire urban planning systems that envisioned park networks and interconnecting parkways (tree lined streets), which connected certain cities to green spaces. Rooftop gardens represent a new trend in urban planning; integrating lost natural processes into human made structures, a technology for working with nature instead of replacing it (McDonough, 2005:21) as well as offering progressive, innovative practices of increasing green spaces in cities. This dissertation aims to extend Olmsteadôs understanding and need for increased nature in cities

[15] (Urban landscape designer - City beautiful movement) Born In 1822 and in 1883 Olmsted established what is considered to be the first full-time landscape architecture firm in Brooklyn, Massachusetts. He was prominent in promoting and planning recreational parks across the country. Egalitarian approach to public parks all citizens should benefit and believed that the common green space must always be equally accessible to all citizens (Sutton S.B 1971).

[16] http://magma.nationalgeographic.com/ngm/0503/feature2/fulltext.html

by examining how rooftop gardens and vertical parks could be envisioned connecting natural continuity above the ground. Urban planning needs to create and raise awareness of the link between the city and the natural world. Rooftop Gardens could be that link encouraging the once vacant space on top of buildings to be retrofitted and utilized as parks and biodiversity areas above the city centre.

3.7 Rooftop Gardens

Throughout history humans have constructed landscapes, gardens, parks and even buildings aiming to enrich their bond to the earth.[17] Historically, rooftop gardening is not a new form of landscaping, as elements of its design date from the ancient Hanging Gardens of Babylon to the modern[18] aesthetics of ecologically friendly designs (Thompson & Sorvig, 2000:1).

Integrating nature into metropolitan frameworks has always been a very valuable construct for people and for the environment. The original inspiration for contemporary ógreen roofsô came from Iceland, where sod (grass) roofs and walls have been used for hundreds of years. Furthermore, from a human health perspective, it has been shown that roof gardens in and on top of hospitals[19] have an immediate effect on human well-being. Hospital roof gardens create an atmosphere of transition from despair to hope and reliance as well as promoting an opportunity for exercise, and an appreciation of fauna and flora that is attracted to the

[17] Classical theorists such as Frederick Olmstead[17] (Urban landscape designer - City beautiful movement) and others addressed the need for nature in urban environments. More contemporary authors; David Nicholson-Lord (1987), Mark Roseland (1997), Richard Register (2006) and offer an eco ï city dimension and the role of nature in cities- greening the city perspective

[18] Examples of modern rooftop gardens are ACROS Fukuoka in Japan and the Chicago City Hall building (McDonough, 2005)

[19] See Davis, 2002:15, healing the Whole Person: a post occupancy evaluation of the rooftop therapy park at Fort Sanders Regional Medical Center, Knoxville, Tennessee.

gardens. In addition to hospital roof gardens, correctional facilities have utilized roof gardens and vegetable gardens within in their compounds[20].

3.8 Urban Agriculture and Food Security

Urban agriculture is by no means a new phenomenon yet the exponential growth of cities and how they are constructed has left little or no space for arable productive land to be used for urban agriculture. The modern city has become unable to sustain itself without resulting in waste and environmental damage. Girardet (1992:23), states that it is obvious that the fate of the planet depends on the future of cities. In abstract, cities are zones characterized by a form of ñlinear metabolismò whereby inputs are not equal to the outputs. A route aggravated by the symbiotic relationship between increased inefficient resource consumption and waste disposal. In order to forestall further destruction of the earth's life-support systems, cities must be transformed, retrofitted in order to support healthier lifestyles paralleled with a reduction of ecological impacts.

As mentioned above the movement of people from farms and rural areas into urban centres has resulted in numerous pressures. One of these pressures is the ability of urban inhabitants to grow and produce local food crops whether for subsistence or profit[21] in urbanized settings. Urban agricultural practitioners play major roles with regards to the future of urban planning and how cities can mitigate against environmental damage. For example by placing the production of crops closer to the cities both transportation costs and the amounts of pollution involved in transportation can be minimised. Furthermore with the increase of food

[20] The administration of city prison "Kresty", which has 10 000 prisoners, expressed an interest in gardening. This notoriously overcrowded prison created roof top (and ground level) gardens to feed the inmates and to provide a creative outlet for their energy (www.cityfarmer.org/russiastp.html).

[21] It was estimated that urban farms will represent 33% of world food production by 2005 (Allen & You, 2002:64).

costs, urban agriculture can help support and maintain population health, local economies and community development[22].

The concern regarding how operational networks[23] affect the relationships between environmental economic and social sustainability is ongoing and embedded in sustainable development debates. Population growth, climate change and environmental degradation have, and still are causing severe challenges to world food security. This research mentions the concept of urban food security, which according to Swift & Hamilton cited in Devereux & Maxwell (2001: 75), was widely ignored, mainly because there was a global assumption in terms of food security that towns and cities were usually better off than the rural hinterlands. Urban poverty immediately translates into food insecurity, with the predominate characteristic of urban food insecurity being the relationship between changes in food prices and urban dwellers wages.

This is further exacerbated by unemployment and low wages in the informal economy which hamper poor householdsô ability to earn enough income to guarantee food security (Swift & Hamilton cited in Devereux & Maxwell, 2001: 75). Urban households may avoid some of the costs of buying food by setting up community gardens or rooftop gardens. The rooftops offer various advantages, one being that it is restricted area, thus offering less opportunity for vandalism. Residents in buildings are easier to collaborate with. Due to proximity and whatôs more, transfers of produce between residential blocks become potential avenues for urban food market dynamics. In Yaoundé, Cameroon for example 35 percent of urban

[22] See Price and Meitzner (1996:Chapter 17) Above Ground Gardens

23 The international and national movement and trade-offs of goods from basic to materialistic. Practically every national government intervenes in markets for goods and services that invariably distort international commerce. The result is that these policies harm most of the world poorest people (Anderson cited in Lomborg, 2004: 541).

residents are farmers. In Maputo, Mozambique 37 percent of households produce their own food (Swift & Hamilton cited in Devereux & Maxwell (2001: 76).

3.9 Technical issues

In attempting to assess international claims regarding the benefits of rooftop gardens and nature in the city, research was undertaken to explore the technical and practical applications of rooftop gardens.

3.9.1 Heat Island Effect

The heat island effect is a product of citiesô hard concrete, brick, stone, and blacktop surfaces, which absorb and retain heat (Nowak, 2004:11). According to Girardet (1992:28) in developed countries between 5 and 10 kilowatts of energy are used day and night for each individual. Cities trap and store the sunôs heat in paved surfaces, roof tiles, protective water membranes on flat roofs, asphalt, concrete and tar surfaces, which subsequently release it back into the surrounding environment. Known as the Heat Island effect, this human made occurrence exacerbates the phenomenon of microclimates. In addition cities are central points for the increased consumption of energy. For example all modes of transportation, electrical and mechanical appliances, such as air-conditioners, fridges, personal computers, ovens, toasters, light bulbs, and a whole host of other consumer products all give off heat. Furthermore, cities give off pollutants such as waste gases and other particles such as Carbon dioxide (CO^2) and Nitrogen oxides (N0x) as a result of combustion of fossil fuels. All these gases and waste dust form a blanket layer above cities trapping heat and fueling urban heat island effects.

Heating of buildings and air-conditioning in KwaZulu-Natal (KZN) occurs all year round. All this energy is ultimately released to the urban air (Givoni, 1998:244) and the urban air temperature is usually higher than the temperature of the surrounding open country. The urban heat island effect explains the six to eight degree heat increase in cities as compared to the surrounding countrysideøs. It is my observation that current developments in Durban have not only allowed for the continuation of conventional building practices at the expense of people and the environment but has also ensured that its developerøs guidelines are riddled with practices and developments that further damage the environment. The heat island effect is a cause for concern and international examples of rooftop gardens have been shown to minimize the amount of heat radiated off the built environment. Research at the US Lawrence Berkeley National laboratory and elsewhere has shown that the use of city vegetation can substantially reduce the urban heat island effect (Wong et al, 2003 and Taylor, 2007). By placing thermometers in three areas of the rooftop, the pilot study (see section 2.6.2 and Image 2.5) was able to demonstrate the results of heat reduction over a six day period (see Chart 4.3).

3.9.2 Storm water management

Storm water management is another important variable in contemporary urban development. Natural vegetation is often removed to make way for pavements, roads, buildings and storm water drains. What is apparent is the increased destruction of civil infrastructure due to the increase of impervious surfaces as it results in storm water and rainfall run-off being channeled at increased volumes and speeds towards existing urban control points. This is because the construction of buildings and storm water drains has destroyed the natural environments ability to reduce the run-off and increase evapo- transpiration. Appropriate storm water management is a method of limiting these negative impacts and according to the

South African guidelines for human settlement planning and design (2000), the goals of storm water management should support the philosophy of lessening the impact of storm water flow through and off developed areas. Storm water should rather be considered a resource and rooftop gardens provide an appropriate solution to sustainable storm water management and attenuation.

3.9.3 Benefits and types of rooftop gardens

Several authors Thompson & Sorvig (2000); Nowak (2004); St Lawrence (1996), Ayalon (2006), Oberndorfer et al (2007)[24] as well various international green roof companiesô internet sites[25], comment on the range of positive impacts of rooftop gardens. The benefits of rooftop gardens may be summarized as follows:

- Rooftop gardens are able to attenuate storm water run ï off.
- The plants on rooftop gardens are able to absorb air pollutants and dust.
- Rooftop gardens help reduce the urban heat island effect.
- Rooftop gardens provide a habitat for wildlife.
- Rooftop gardens are an attractive form of open space.
- Rooftop gardens can promote various health benefits for human, mentioned earlier.
- Rooftop gardens can reduce both civil infrastructure costs and building costs. For example storm water drainage and energy reduction in buildings insulations with regards to heating and cooling.
- Rooftop gardens can support urban agriculture and promote local food security.

[24] Oberndorfer et al,(2007) Bioscience, Vol 57,No. 10, wwwbiosciencemag.org

[25] http://www.alternatives.ca/article1165.html, www.eltgreenroofs.com, http://www.temple.edu/env-stud/seniorsem/section5, www.greengridroofs.com & www.livingroofs.org.

Theoretically, any roof surface can be greened; even sloped or curved roofs can support a layer of sod or wildflowers. There are different construction and design processes for rooftop gardens. For example there are intensive, extensive and container or modular rooftop gardens. The extensive rooftop gardens (see Figure 4.1) are characterized by minimum soil depth and are not designed for human traffic except for annual maintenance checks. Intensive rooftop gardens on the other hand are designed for human flow, which allows for humans to walk on the rooftop gardens where they can be used as parks or recreational space. From an urban agricultural concept of growing crops, the modular or container system has proved beneficial.

3.9.4 Container or modular rooftop gardens

Container gardening[26] or modular systems are not a new form of gardening and date back to famous examples namely, the creation of the Babylonian gardens with earthenware containers filled with soil. There are numerous records of gardening in pots in China, India, Egypt, Assyria, Greece, and Rome[27]. Container gardeningôs popularity grew in southern California in the 1950s, and its techniques and implementation have progressed considerably incorporating a whole pageant of designs and methodologies[28]. Furthermore where the roofôs construction has been too weak to support green roofs, modular container systems have proved to be a successful solution to this structural issue.[29] Roof container gardens consist of ornamental plants and can hold almost any kind of green roof plant and food plant, depending on the container size. Container gardening can help subsidise nutrition and as is a highly

[26] Roof container gardens consist of ornamental plants and can hold almost any kind of food plant depending on the container size. Container gardening has many uses; primarily it can help subsidize nutrition as it is a highly flexible form of gardening that is especially effective for urban settings, because it avoids problems associated to soil qualities and accessibility (Nowak, 2004:20).

[27] http://www.container-gardens.com/Container-gardens-pot.htm

[28] www.containergardeningtips.com

[29] www.safegaurdeurope.com

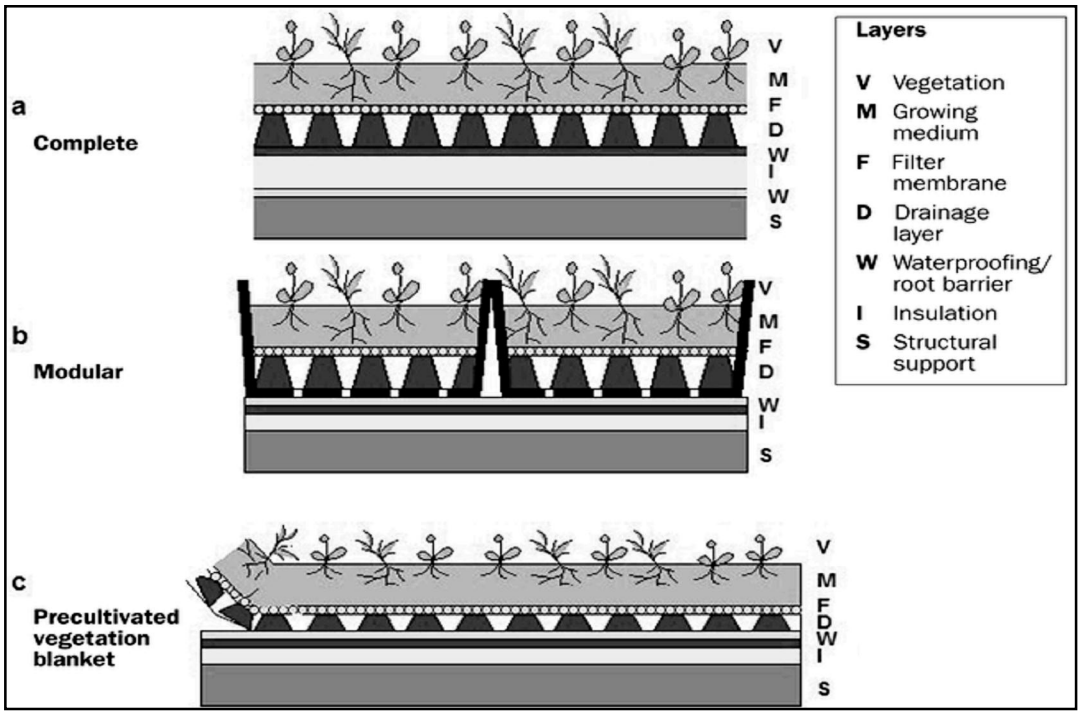
flexible form of gardening that is especially effective for urban settings. For example, containers would be beneficial in the following areas:

High rise residential buildings: these either have no space for food cultivation, however on the rooftops and balconies container gardens will be useful.

Low cost housing developments: the soil surrounding the houses is either very compacted or has been disturbed or nutritionally damaged by construction processes.

School courtyards: these spaces are usually concrete or covered in asphalt, an ideal area to grow food in containers.

Figure 4.1: Rooftop garden systems



(a) Complete systems: each component, including the roof membrane, is installed as an integral part of the roof. (b) Modular systems: vegetation trays cultivated ex situ *are installed above the existing roofing system. (c) Pre-cultivated vegetation blankets: growing medium, plants, drainage mats, and root barriers are rolled onto the existing roofing* (www.biosciencemag.org).

This dissertation focused on roof gardens using a modular system for analysis. As previously mentioned this is a portable system that is much lighter in weight thus minimizing structural restraints, offering instant aesthetics on barren rooftop spaces. Furthermore maintenance becomes easier, as it requires only the container to be moved or replaced upon repair of existing roof membrane.

3.10 Conclusion

The investigation into the social and ecological understandings of rooftop gardens has exposed more advantages for this type of urban intervention than disadvantages. The

accelerated pace of contemporary urban developments has and still does affect the natural environment considerably, with various implications for human health and wellbeing. The process of gathering data and testing hypothesis resulted in multifaceted exploration route. It incorporated a combination of research design, research methodology and practical experimentation, the results of which are discussed in the next chapter.

CHAPTER FOUR - TYPES OF ROOFTOP GARDENS, THEIR BENEFITS AND CONSTRAINTS ON FURTHER DEVELOPMENTS

4.1 Introduction

This chapter addresses the understandings, perceptions, benefits and constraints surrounding of rooftop gardens primarily from a South African perspective. It identifies a range of benefits (4.2) and then goes on to discuss factors that presently constrain more extensive development of rooftop gardens (4.3). Following this are some of the technicalities of rooftop gardens (4.4) and the various limitations of the research (4.5).

The research revealed that a high level of understanding of rooftop gardens (see Table 4.1). It was not unexpected to find that all the professionals were aware of the concept of rooftop gardens. This supports the notion that rooftop gardens are already within the mindsets of the targeted individuals and provides evidence of potential acceptance of rooftop gardens in to the realm of contemporary urban development.

TABLE 4.1: Understandings of Rooftop gardens

SURVEY GROUPS	YES	NO
Number of high school scholars that knew what rooftop gardens were	74%	26%
Number of Human Science students that knew what rooftop gardens were	61%	39%
Number of professional urban development consultants that knew what rooftop gardens were	100%	0%

Source: Survey, 2008

4.2 Benefits

4.2.1 Biodiversity

What is biodiversity? According to eThekwiniôs Environmental Management Department the term biodiversity refers ñto the variety of life on earth, and includes all the species and ecosystems that are found in any region. Biodiversity also includes the genetic differences within and between speciesò (2009). Biodiversity is supported by the eThekwini Municipality and is ratified within its Integrated Development Plan (IDP) as well as their Local Agenda 21 program.[30] The allocation of the various benefits that biodiversity offers eThekwini Municipalityôs citizens was categorized into four key perspectives.

- Direct benefits: the use of everyday resources, such as, drinking water, plant growth, and utilization as materials for food, fuel and construction materials.

- Indirect benefits: These encompass the non consumptive use of resources, cost saving, that financially benefits urban residents indirectly. Examples are estuaries, wetlands which reduce flooding, and other plants such tall trees that provide shelter.

- Optional benefits: Some resources are able to be preserved and protected to provide both economic and social benefits. Examples include the discovery or protection of the medicinal quality of plants, the conservation of a pristine coastline, mountain range or gorge.

[30] See Section II, Chapter 15 of Agenda 21, Sustaining Biological Biodiversity.

- Existence benefits: The aesthetic and green psychological value of the existence of un-spoilt landscapes has been proven to give people a feeling of wellbeing (Kaplan 2001; 507; Durban Biodiversity Report, 2007:8).

One of the key advantages of rooftop gardens is their ability to be used as an effective design tool for improving biodiversity. This is supported by, Thompson & Sorvig who claim that diverse species of Falcons have been recorded nesting on top of rooftop gardens (2000:113). According to Nichols (2008), if one uses a diverse choice of plants on top of a roof it will attract a greater variety of insects. Even certain birds such as the Priniaôs and warblers will come and breed on top of roofs thus promoting rooftop gardens as extensive urban habitats for a variety of fauna.

Rooftop gardens contribute to biodiversity by being able to supply different quantities, types of environmental goods and services[31] embedded in the above four categories of biodiversity. Rooftop gardens can provide an effective form of urban intervention in each of the above mentioned benefits. Moreover the results of the surveys show that 55 % of the scholars, 79% of students and 88% of professionals responded that rooftop gardens would support biodiversity.

[31] Goods and services is a tool which The OECD defined the environmental goods and service EGS industry as follows: ñThe environmental goods and services industry consists of activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use (OECD, 1999)ò (www.egsf.org.za).
In broad terms the EGS sector covers traditional sub-sectors such as the supply of drinking water, wastewater treatment and solid waste management as well as new and emerging sub-sectors that include environmentally preferred or ócleanerô technologies and renewable energy supply (http://www.enviropaedia.com).

CHAPTER FOUR – TYPES OF ROOFTOP GARDENS, THEIR BENEFITS AND CONSTRAINTS ON FURTHER DEVELOPMENTS

4.1 Introduction 44

4.2 Benefits 45

4.2.1 Biodiversity 45

4.2.2 Storm water management 47

4.2.3 Heat Island reduction 50

4.2.4 Food security 52

4.2.5 Aesthetics 54

4.3 Constraints 56

4.3.1 Human mindsets 57

4.3.2 Policies for rooftop gardens 57

4.3.3 eThekwini Municipality and its role in urban greening 60

4.4 Technical issues: containers and direct applications on rooftops 62

4.5 Limitations of the research project and lessons for future applications 63

4.6. Conclusions 63

CHAPTER FIVE – CONCLUSION AND RECOMMENDATIONS FOR FURTHER RESEARCH

5.1 Introduction 65

5.2 Review of research objectives and questions 65

5.3 Considerations regarding further research of rooftop gardens in South Africa 66

5.4 Local opportunities for greater use of rooftop gardens 67

4.2.2 Storm water management

A particular problem with land development is the change in rate and amount of run-off that enters city infrastructure, urban streams and waterways. Urban areas are dominated by hard, non porous surfaces that contribute to heavy run-off. This increases the burden on existing storm water management facilities and infrastructures. Rooftop gardens are ideal for urban storm water management because they make use of existing roof space and prevent run-off at the source (Oberndorfer et al, 2007:827). The sample groups primarily agreed with the statements of how rooftop gardens can be used as an effective tool for storm water management (see Table 4.2 below for summary of the surveyed groupsô responses).

Table 4.2: Rainfall run-off

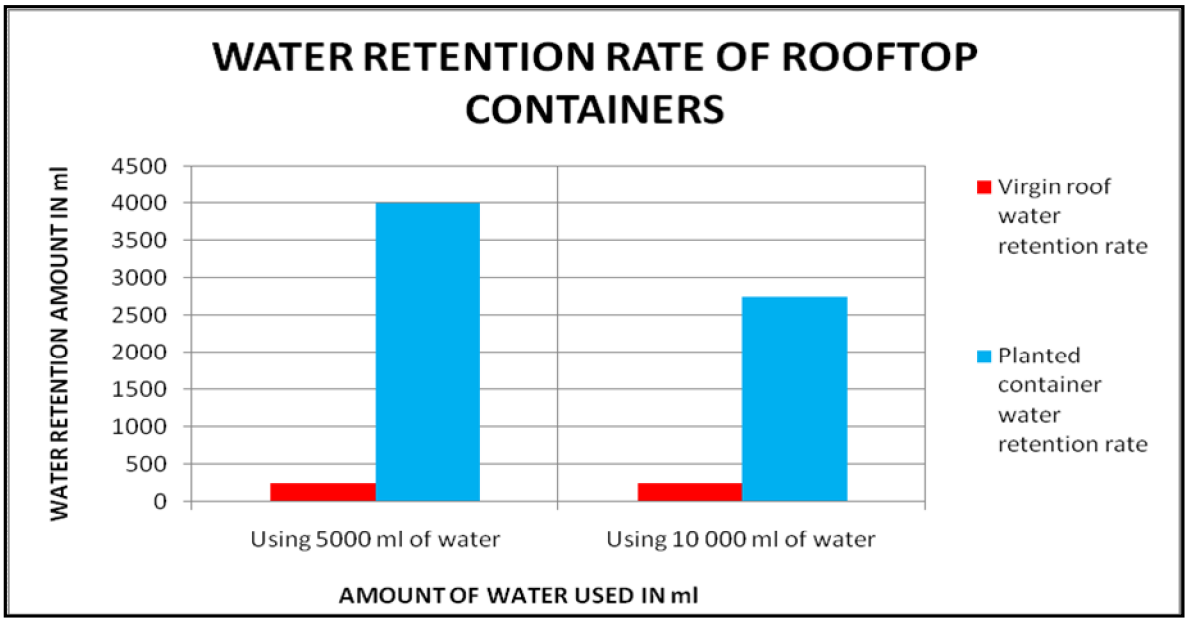
Rooftop gardens will minimise rainfall runoff thus supporting storm water capacity	**Scholars (Glenwood High School)**	**%**	**Student (UKZN)**	**%**	**Professionals**	**%**	**Total**	**%**
Strongly agree	2	7	46	20	1	11	49	19
Agree	14	52	85	38	3	33	102	39
Neutral	5	19	60	27	5	56	70	26
Disagree	4	15	23	10			28	11
Strongly disagree	2	7	11	5			13	5
Totals	**27**	**100**	**225**	**100**	**9**	**100**	**261**	**100**

Source: Surveys, 2008

Overall the interviewees recognized the value of rooftop garden as a tool for storm water management. However what was an interesting was that municipal line departments have

different views on this issue. According to Rich, (2008) although one might expect there to be links between rooftop gardens and storm water management. The reality is that prevailing policies and departmental activities are not yet aligned. The pilot study investigated the potential merits of using modular or direct rooftop garden systems in order to test the validity of theories about storm water management and thus highlight one of the many benefits of rooftop gardens. One of these is the ability of rooftop gardens to absorb a certain amount of rain that falls on above ground[32] surfaces. Chart 4.1 depicts the findings of the pilot study for water retention rates of the rooftop garden containers for rainfall simulation of 5 000 ml and 10 000 ml.

Chart 4.1: Water retention rate



Source: Pilot study, 2008

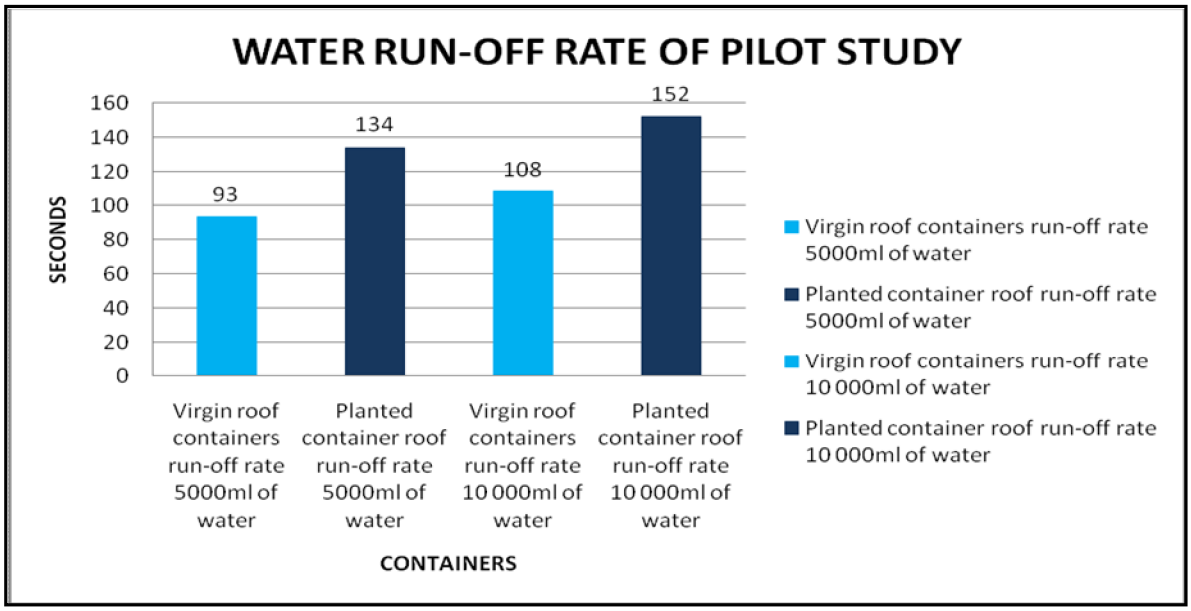
When analyzing Chart 4.1 it is evident that the planted container managed to absorb 4000 ml under a rainfall simulation of 5000ml and 2750 ml under rainfall simulation of 10 000ml. In stark contrast the virgin roof absorbed only about 250 ml in both rainfall simulations. The

[32] This term is used to include rooftop gardens as well as other built structures that exist within an urban environment. For example bus shelters, electrical sub stations and even petrol stations forecourt roofs.

investigation also showed the beneficial ability of rooftop gardens to reduce the velocity of rain fall run -off.

In Chart 4.2 below, the rainfall simulation of 5000 ml on top of the virgin roof containers produced a run-off rate of 93 seconds. The 5000 ml simulation on the planted container was 134 seconds. However when the simulated rainfall amount was doubled to 10 000 ml, the virgin roof containers produced a run-off rate of 108 seconds whereas, the planted container roof having already been saturated by the first 5 000 ml of water and thus resulting in its absorption capacity been greatly diminished, still resulted in 10 000 ml of water taking 152 seconds to run out. The virgin roofs water retention rate therefore is insubstantial in comparison to the vegetated roof container (see Chart 4.1). In Chart 4.2, the planted container takes longer to run off and is able to retain a lot more of the water whilst doing so results in the runoff being slower. This slowing of the water run- off rates enhances the effective capacity of existing storm water infrastructure. An extended run off period at a slower rate is far more beneficial than a greater quantity of water at a faster rate.

Chart 4.2: Water run-off rate



Source: Pilot study, 2008

4.2.3 Heat Island reduction

The awareness of all three groups about the benefits of rooftop gardens was again supported by their responses to the proposition that rooftop gardens can curb the heat island effect in cities see (Table 4.3).

Table 4.3: Heat Islands and climate conditions within cities

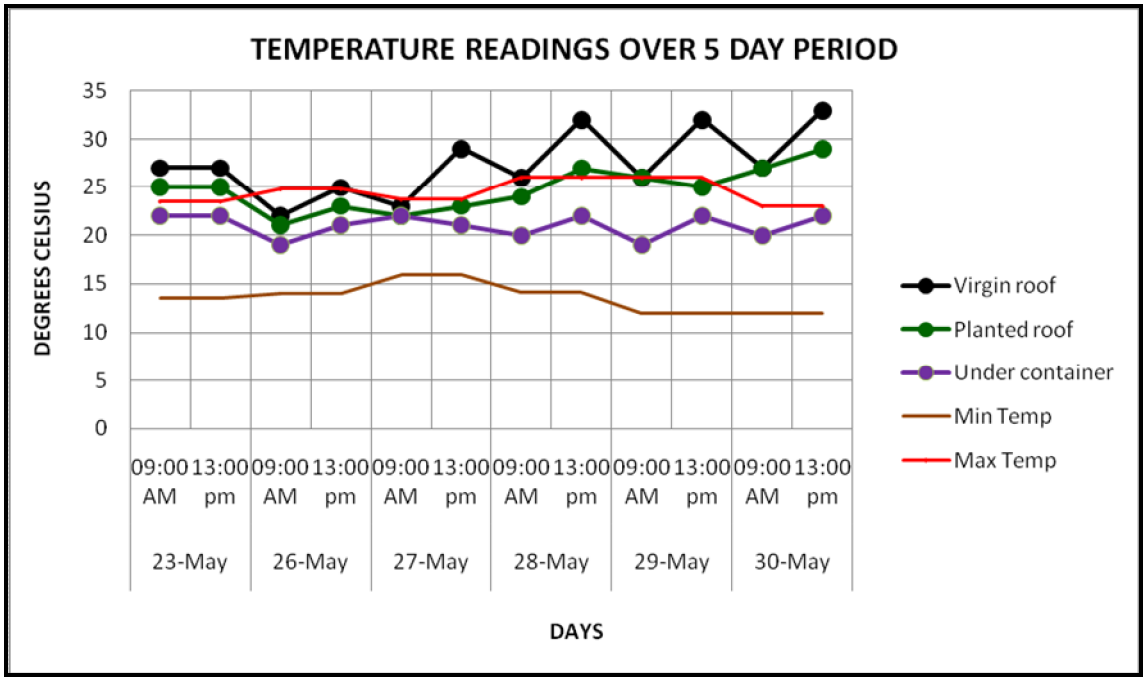
Rooftop gardens will help the general climate of cities, by reducing heat from cities and the built environment	**Scholars (Glenwood High School)**	**%**	**Student (UKZN)**	**%**	**Professionals**	**%**	**Total**	**%**
Strongly agree	4	15	64	28	2	22	70	27
Agree	9	34	94	42	6	67	108	41
Neutral	8	30	51	23	1	11	60	23
Disagree	5	19	14	6			20	8
Strongly disagree	1	2	2	0.8			3	1
Totals	**27**	**100**	**225**	**100**	**9**	**100**	**261**	**100**

Source: Surveys, 2008

Table 4.3 shows that 27 % and 41 % of the surveyed groups either agreed or strongly agreed that rooftop gardens will help the general climate of cities, by reducing heat from cities and the built environment. This analysis in conjunction with the pilot study was vital in supporting the views about the temperature reduction capabilities of rooftop gardens

Chart 4.3, below only shows the temperature recordings taken in the pilot study over a 6 day period[33].

Chart 4.3



Source: Pilot study, 2008

What was apparent was that the temperature varied depending on where the test thermometers were situated (see Image 2.6). For example the virgin rooftop recorded and reached temperatures between 22° Celsius and 33° Celsius during the test period. However the roof directly under the containers displayed a significantly lower temperature ranging from 18° to 22° Celsius the thermometer placed on top of the planted tray also showed temperature reduction in comparison to the virgin roofs. At no stage during the five day period did the temperature for the readings under or on top of the containers reach the maximum temperature recorded on the virgin roof.

[33] For a more in depth analysis of temperature readings and more detailed support of rooftop gardens to mitigate the Heat island effect (see page 68).

This highlights one of the several benefits put forward by the interview groups all of whom supported the notion that rooftop gardens could curb the heat island effect and offer insulation. According to architect Derek Van Heerden (2008) there is reflected heat that comes off rooftops, especially flat concrete rooftops. This affects the heat dome so a non reflective application such as a rooftop garden must impact on that micro climate and therefore there must be a reduction of heat. Geoff Nichols (2008), an urban ecologist and landscape designer, stated that there is no doubt about rooftop gardenôs ability to mitigate against the increase in urban heat. Rooftop gardens in Tokyo, which is a highly dense city, have been constructed on apartments and it has reduced the heat generated by hardened surfaces (Jessica Rich, 2008). In Singapore Wong et al (2003:500) found that by constructing green rooftop gardens in Singapore, the solar radiation, external temperature, relative humidity and winds are slowed down. Rooftop gardens can shield off as much as 87% percent of solar radiation while a bare roof receives one hundred percent exposure. While a typical asphalt roof can reach seventy one degrees Celsius on a summer day, rooftop gardens and other vegetated surfaces rarely exceed twenty six degrees Celsius. Evaporative cooling reduces heat transfer by means of the roof into the building. This results in the inside of the building being cooler thus reducing the need for air-conditioning (Earth Pledge, 2005:17). All these benefits allow for the running costs of buildings to be greatly diminish. Derek Van Heerden (2008) supports this sentiment further by the ability of rooftop gardens to prolong the waterproofing on top buildings, ñé it protects the waterproofing and prolongs its lifespan. Basically, waterproofing that was going to last 10 years is now going to last 30 years.ò

4.2.4 Food security

Urban agriculture makes a significant, and growing, contribution to the livelihoods of many city residents and according to the research surveys there was a positive response to the idea

of urban crop production on top of rooftops in the city of Durban. For example 63% of the scholars, 68 % of the students and 100% of the professionals agreed that it was possible to grow food on rooftops as opposed to thirty one percent overall who disagreed.

It was estimated by 2005 that urban farms would contribute 33 % of world food production (Allen & Young, 2002:64); this percentage is increasing owing to the priority being accorded to food security. Rooftop gardens could be a significant part of the future of urban agriculture especially owing to the unavailability of productive land within city boundaries. Roof container gardens consist of ornamental plants and can hold almost any kind of food plant depending on the container size. Container gardening can help subsidise nutrition as it is a highly flexible form of gardening suitable for urban settings (Nowak, 2004:20). Thus one of the benefits of rooftop container gardens is that residents can control the soil quality and content. Communal rooftop gardens generate a sense of harmony that could benefit the South African society by providing a calm place for interaction and social discourse. This is because community gardens provide an arena for building relationships across age, ethnic, cultural, and linguistic lines through working together and the common interest of gardening. The gardens provide an avenue for people to connect to each other.

The sample groups as well as government officialsô[34] experts[35] and architects all recognize the possibilities of urban agriculture on top of rooftop gardens. The pilot study of growing food on top of rooftops such as the MTB proved that this form of urban agriculture can be successful. Out of the 15 food crop plants selected for the pilot only the Dwarf paw-paw failed to survive and did not produce fruit (see Table 2.1). However what was of significance

[34] The ANC Agricultural Policy 1994 makes mention of need for greater emphasis on domestic, self sufficiency and urban agriculture

[35] According to the interview with Geoff Nichols ñproducing food for a group of people on top of a flat roof could be an allotment in the airé rather than an allotment on the groundò.

and of importance to the interview groups was the need for a rooftop garden manual and programs promoting agriculture on rooftops within the eThekwini Municipality.

Programs supporting urban agriculture have been developed in Cuba for example, where the aim is to provide each person with at least 300 grams of fresh vegetables per day. According to Girardet (2008: 243) this program incorporates 35 000 hectares of urban land some of it being made up of rooftops. These gardens employ 117 000 people to work in these gardens and produce over half the vegetables grown in Cuba.

In St. Petersburg, Russia where waiting in long bread lines was a daily occurrence and food security a major concern, rooftop food production has become a progressive step in alleviating these issues. Here, the Eco house program transformed the roofs of high rise apartment blocks into rooftop gardens that provided food, employment and a new sense of community for the residents, who were primarily pensioners and the unemployed (Earth Pledge, 2005:54).

4.2.5 Aesthetics

The response to the aesthetic role of rooftop gardens in an urban environment was met with positive perceptions. For example 52% of the scholars, 72% of the students and 89% of the professional survey groups agreed that this form of intervention would certainly help to create a more pleasant and softer cityscape (see Table 4.4). The surveys confirmed international theories and perspectives about the positive ergonomic benefits as well as the aesthetic role of rooftop gardens in urban settings.

Table 4.4: Aesthetic role of Rooftop gardens and urban greening

Rooftop gardens and greening will surely help to create a more pleasant and softer cityscape	**Scholars (Glenwood High School)**	**%**	**Student (UKZN)**	**%**	**Professionals**	**%**	**Total**	**%**
Strongly agree	4	15	98	44	2	22	104	40
Agree	10	37	62	28	6	67	78	30
Neutral	10	37	44	19	1	11	55	21
Disagree	2	8	14	6			16	6
Strongly disagree	1	3	7	3			8	3
Totals	**27**	**100**	**225**	**100**	**9**	**100**	**261**	**100**

Source: Surveys, 2008

Theories that highlight the role of nature in the city and its intrinsic values have been a part of urban planning for centuries. One only needs to engage with Olmstedôs notion of the City Beautiful Movement that supported the fundamental role that nature played in the restorative, re-creative influences of natural landscapes on city bound people (Wilson, 1989:10). The aesthetic appeal of rooftop gardens is ultimately linked to human psyche**.** According Balling & Falk cited in White, 1994:144), there is a historical connection between nature (trees) and humans. These ideas are supported by many contemporary theorists such as Girardet, Hough and Register.

The mere presence of natural areas, trees and established landscapes can influence the well being of humans (Thomas, 2003:35). Urban trees and forests provide both contrast and relief from the highly built up cities and environments and subsequently can have strong relaxing effects on people (Dwyer et al cited in White, 1994:138). In support of the above statements,

trees and green spaces[36] should be included in built environments for aesthetic reasons. This can also contribute to a healing mechanism within hospitals and clinics. One question in the survey was ñDo you think that hospitals and health clinics should incorporate rooftop gardens into their designs so as to support healing and well-being of patients?ò Derek Van Heerden answered as follows, ñé we are involved in a project at the moment in Wentworth. It is a place where ARVôs (Antiretroviral) are provided for children born with Human Immunodeficiency Virus (HIV). By the time they get to 7 or 8 yrs old theyôve develop full blown AIDS (Acquired Immune Deficiency Syndrome). Their cd4 count drops and thus are administered ARVôs. This becomes a lifelong addiction so we are designing this building with a tropical garden inside. Unfortunately we donôt have time and place for rooftop gardens because of existing roofs but we are trying to develop the internal arrangement with plants in order to make it more of a place of life and positivity than a place of worry and negativity.

In relation to the same question, Jessica Rich replied, ñI used to go to a clinic that had a herb garden within it. Everybody went up there to have coffee so it is very important I think to the human psyche to have access to a green space in whatever form.ò

4.3 Constraints

Having discussed some of the benefits associated with rooftop gardens, it is necessary to explore the constraints that limit its widespread introduction.

36 The term *green* refers to the natural environmental space inclusive of all organic, natural systems that are not green in colour- waterways, grasslands and others.

4.3.1 Human mindsets

According to Jessica Rich (Manager of Policy Coordination and Implementation for eThekwini Municipality Environmental Management Department), there are many different perceptions about rooftop gardens and it will often be an issue of personality as to who is going to buy into the concept. One needs open minded architects and planners, as well as education programs about the multiple benefits of rooftop gardens. Derek Van Heerden, when interviewed by the researcher, stated that constraints were invariably based on human mindsets. A case in point is the perception that rooftop gardens will load the existing structure unnecessarily. This is a common misconception because most roofs have been designed to have at least one person standing on the roof per square meter, and a light weight medium is used when installing rooftop gardens. Thus the weights of rooftop gardens are insignificant in comparison with human loading.

It is through my observation that attitudes and perceptions are key elements in changing mindsets and improving the urban fabric as a whole. However in South Africa, I am of the opinion that the case has yet to be made that the greening of cities, and in particular rooftop gardens, can significantly influence the quality of urban life. This requires a shift in the mindsets of urban residences, built environment and policy makers.

4.3.2 Policies for rooftop gardens

Policy formulation and coordination will be of extreme importance in the future of rooftop gardens. If rooftop gardens are to become a popular intervention then Municipalities that envision rooftop gardens performing a role in the urban framework must concentrate on

transparent government as well as collective visioning[37]. Furthermore rooftop gardens can be used as key tools in creating synergy across all municipal departments. For example in order for rooftop garden installations to be successful on a municipal level the units responsible for architecture, planning, environmental management, storm water and drainage, parks, health and agriculture would need to interact as all departments can benefit from this type of innovation. They can increase capacity building and ensure a more interdisciplinary approach by government and corporate interests. The research investigated whether the government, public or private sector should be driving the process of developing rooftop garden.

The surveys indicated that both the government (national, provincial and local) as well as the general public should be responsible for promoting rooftop gardens in South Africa. The professionals argued that municipalities should take the lead in introducing new interventions as municipalities often own a significant amount of building stock in the city. So if a municipality were to start implementing rooftop gardens on all publically owned buildings that were deemed suitable for rooftop gardens, then potentially the public and private sector role players would follow suit. An Example of this is in Portland USA, where 30 rooftop gardens were built by the municipality; this increased the awareness around rooftop gardens to such an extent that the private sector began to construct them on its own (Earth Pledge, 2005:123).

The research showed that there was mixed reactions regarding the need for some form of incentive like a rate rebate, if one has rooftop gardens. For example 34% of the scholars, 61% of students and 33% of the professionals claimed that government should introduce financial

[37] According to Oberndorfer, Many German cities have introduced incentive programs to promote green roof technology and improve environmental standards (2007:825).

incentives to increase the number of rooftop gardens. An alternative approach could be intervention by policy or legislation, which requires that rooftop gardens are installed on public and private buildings.

Progressive examples of this type of municipal legislation are found in several cities around the world. For example Stuttgart municipality in Germany, promotes rooftop gardens in its annual budgetary allocation, whereby most rooftop gardens are installed when roofs needed to be replaced. Furthermore the municipality subsidizes 50 % percent of the costs to install rooftop gardens (www.toronto.ca/greenroofs/pdf). Munster municipality, also in Germany, charges storm water fees, according to the amount of storm water that runs off a property and into the underground infrastructure. The fee is reduced by 80% or more when a rooftop garden is installed (www.toronto.ca/greenroofs/pdf). In the 1980ôs Portland municipality recognized roof gardens as an asset to the urban environment and had created the ñFloor Area Ratioò zoning code bonus for buildings that included rooftop gardens. In Japan, Tokyoôs municipality has developed an informal incentive program that provided a technology discount and free consulting (Earth Pledge, 2005:113- 115).

In South Africa, policies and building code specifications to coerce developers, residents, companies and the public sector into installing rooftop gardens would need considerable research. Moreover the concept of rooftop gardens may be far too new a form of urban intervention, for it to be ratified in policy, legislation and building codes. This view was supported by both the survey groups and the interviewees. No less than, 96% of the scholars, 99% of students and 89% of professionals reported not being aware of any polices that encouraged rooftop garden development. Nevertheless, current approaches and legislation are beginning to support the need for rooftop gardens and the role of nature in cities, namely,

Local Agenda 21 and the National Environmental Management Act (NEMA). As a case in point, Durbanôs Local Agenda 21 Program is a blueprint for working towards development that is socially, economically and environmentally sustainable - benefiting both people and nature. It furthermore promotes development that does not compromise the natural resource base and the ability of future generations to sustain themselves. NEMA[38] (No 107:1998), Principle 4 (b) states that, environmental management must be integrated, acknowledging that all elements of the environment are linked and interrelated, and it must take into account the effects of decisions on all aspects of the environment and all people in the environment by pursuing the selection of the best practicable environmental option[39]. In addition to this the heat island effect mentioned earlier has its roots in processes ratified by NEMA. For example, it states that ñeveryone has the right to an environment that is not harmful to his or her health or well-being; thus including one free of pollutionò. This means any change in the environment caused by substances; radioactive or other waves; or noise, odours, dust or heat[40].

4.3.3 eThekwini Municipality and its role in urban greening

One of the constraints regarding the implementation of rooftop gardens in Kwazulu Natal is the lack of synergy between eThekwini Municipalityôs line departments. An intervention such a rooftop garden has benefits for several of the municipal departments such as Environmental management, Coastal and Storm water management, Architecture, Parks and

[38] NEMA (No 107:1998), Principle 4 (b) states that, tangible products and poverty reduction through environmental improvement, which incorporates the demonstration of how sustainable urban environment, can improve quality of life. Furthermore the ability of capacity building, which ensures that all stakeholders understand the need for sustainable development and environmental management (http://www.environment.gov.za).

[39] http://www.polity.un.org

[40] National Environmental Management Act ï NEMA (http://www.environment.gov.za)

Recreation, Engineering and Health. In order to make progress, one department within the eThekwini Municipality needs to take the lead.

This was viewed as a constraint towards the implementation of rooftop gardens and urban greening. However, through strong innovative leadership and skilled group dynamics one of the line departments, namely the eThekwini Environmental Management Department has currently implemented (2009) a pilot study of green roof development ensuring a more multi-disciplinary[41] and interdisciplinary approach[42] by government and corporate interests.

According to this research on rooftop gardens the constraints are primarily the lack of information about practical applications in South Africa. Furthermore it is my observation from the research that from a South African perspective rooftop gardens are not a common intervention with regard to architecture, urban planning and city design. The role of the eThekwini municipality and the associated policies allow for a greater scope into researching these types of urban interventions. As the role and benefits of rooftop gardens in the urban environment become widely accepted, so too will the constraints. As each rooftop gardens will be building and locality specific thus bringing new challenges to what plants and what applications would be suitable for that site.

[41] Multi disciplinary pertaining to all facets of rooftop gardens establishments from peopleôs perceptions, structural companies, waterproofing companies, town planners, architects, urban designers agriculturists, ecologists, water engineers the list is endless.

[42] Rooftop gardens could create a common space for the development of synergetic relationships especially within in government and municipalities allowing various department to congregate around a development like rooftop gardens. For example process where civil engineers, architects and the built environment line departments merge with environmental management and parks department etc.

4.4 Technical issues: containers and direct applications on rooftops

Table 4.5: Advantages and disadvantages of different rooftop garden systems

Options	Container application	Direct application
Maintenance & repair	Containers can be moved easily without disturbing plants and growing medium	Layers need to be lifted, rolled until problem found, could disturb plants
Easy Alterations Additions	Option of containers allows for the installation of green roofs in sections. Thus offers opportunity for future add-ons and alterations	Often difficult and expensive to change/add-on due to edge design requirements
Installation	Trays can be pre-planted, thus offering quick installation. The container system components can quickly be put in place on the roof in accordance with design	Various layers are needed to be installed prior to planting
Lightweight	Trays can be installed on basically on any existing roof surface in good condition and structural capacity	Direct systems are often heavy and may require additional roof surface replacement or support
Plants	Some plants may struggle as their roots need space to roam	Plants roots have a greater a space to move and network

There are various types of roof gardens and green roofs and Table 4.5 above addresses the primary technical advantages and disadvantages of these different systems. With regards to rooftop gardens in South Africa there is no primary research[43] into the field of container rooftop greening and the response of the sample groups supports this statement. Whereby, 96 % of the scholars, 84 % of the students and 89 % of professionals were not aware of container/ modular style rooftop gardens. Recently however the author of this thesis has formed a company, Green Roof Designs (2009), which has subsequently introduced container rooftop garden systems to a pilot project in the eThekwini Municipality.

[43] Most useful resources for green roof development focus on international examples; therefore, less information is available for building owners and policymakers to use when considering the potential for green roof retrofits on existing buildings in South Africa.

4.5 Limitations of research project and lessons for future applications

One of the main limitations of this research project was the time constraints associated with the temperature readings, only a five day window period during May 2008 was recorded. A longer period of time, for example 6 months to year, would have been more beneficial. Furthermore better equipment for measuring rainfall proved too costly for the project and thus rainfall had to be simulated. In addition to the above a more widely stratified sample selection would have been extremely beneficial when assessing human mindsets and understandings. Such a sample would incorporate students and academics views in each faculty and discipline and more interviewees would have been included from engineering and other faculties. More interviews with civil engineers and storm water drainage practitioners would have been of value. With regards to the pilot study on top of MTB additional planted containers would have been an advantage, as it would have provided a better approach for aesthetic analysis regarding peopleôs perceptions on the planted rooftop.

The types of plants that been utilized in the international example will bear no resemblance on South African pilot projects. This is because the indigenous plants and succulents found in South Africa offer different relationships and directives towards rooftop gardens and the dynamics involved.

4.6 Conclusions

In a province that does not promote rooftop gardens it was surprisingly refreshing to find that the majority of individuals surveyed understood and knew what a rooftop garden was. In addition the high proportion who promoted rooftop agriculture as a source of food was encouraging. People are aware of rooftop gardens however; their mindsets need to be

directed by municipal policies and incentives. With regards to the knowledge about the benefits of rooftop gardens the responses where quite mixed and it is evident that the concept is not seen as a necessity in urban development yet. The involvement of citizens in the implementation of policies around nature and environmental management and sustainable development is very weak.

What was of importance is the awareness of the sample groups in their response towards increasing green spaces within the city. The sample groupsô response to the modular systems was expected as it is fairly new in the international arena. The pilot project produced the results needed to offer support for the relevant theories pertaining to rooftop gardens, namely, that the waterproofing membrane and the life span of the roof would be increased; that temperature varied between the planted test area and the conventional rooftop; and water flow was affected by the test area.

As a result of this research eThekwini Environmental Management Department have introduced a Green Roof pilot study on the Old Fort Road City Engineers Building that began in January 2009 (see section 5.4) and are beginning to drive the trend towards a more sustainable form of urban ecology.

CHAPTER FIVE – CONCLUSION AND RECOMMENDATIONS FOR FURTHER RESEARCH

5.1 Introduction

This chapter reviews the research objectives and questions which were set out in section 1.5 above. It briefly addresses the validity and understandings of rooftop gardens, the constraints and benefits that are attached to this type of urban intervention. Section 5.2 considers further research of rooftop gardens within a South African context, while local opportunities for greater use of rooftop gardens are discussed in section 5.3.

5.2 Review of research objectives and questions

The benefits of rooftop gardens have been addressed extensively throughout the dissertation. Sections 3.7 to 3.9 as well as section 4.2 investigate these benefits Examples are the capabilities of rooftop gardens in reducing the velocity of rainfall runï off and mitigating against the urban heat island effect. In addition to this their construction and understanding has received constant international recognition. At present from a local perspective, an eThekwini Municipality Green Roof Pilot Project (GRPP) has begun to try and understand their benefits and constraints in greater depth by implementing them in South African climates.

The capabilities of rooftop gardens to provide a haven for insects and to increase biodiversity looks promising. This is confirmed by some of the entomological results to date from eThekwiniôs current pilot project (see pages 68 and 69). Urban agriculture and food security issues are prominent in an increasingly urbanized world and rooftop gardens are one of the progressive solutions that could mitigate the plight of the urban poor as well as educate people about growing their own food. Still policy development that makes rooftop gardens

obligatory on all new developments seems quite distant. However with the current GRPP more scientific data is being recorded thus allowing for tangible evidence to become available offering support to the argument that rooftop gardens should be integrated into future development plans.

5.3 Considerations regarding further research of rooftop gardens in South Africa

There is a need to maintain and implement a more inter-disciplinary approach with regards to municipal departments, especially towards finding solutions for environmental issues pertaining to the urban environment. A result of this will increase innovation and common visions across all line departments.

Arising from this dissertation there are avenues for further research into the realm of urban agriculture and how food crops can be grown extensively on the rooftops of South African cities. In addition to this the following information requires supplementary investigation before the future of green roofs, inclusive of crop production, can be fully appreciated and implemented in a South African context:

1. What are the energy saving costs associated with installing green roof. For example what is the reduction in air-conditioning costs?
2. A more inorganic growing medium needs to be investigated. As a high organic content breaks down to quickly causing loss of substrate and nutrients.
3. What is the velocity of the rainfall run-off that is entering the existing storm water infrastructure, and to what extent can this be reduced by roof gardens?
4. What type of food crops can be successfully grown on rooftops in the Durban CBD area?

5. It will be necessary to find a palette of plants that will both grow in companionship with each other as well as withstand the harsh conditions of rooftops in a South African climate.
6. It may be necessary to circulate grey water and rainfall run-off back onto the roof gardens. This will help reduce the amount of fresh water needed for the irrigation of roof gardens during the dry winter months.
7. How can green roofs from part of urban policy frameworks and development initiatives?

5.4 Local opportunities for greater use of rooftop gardens

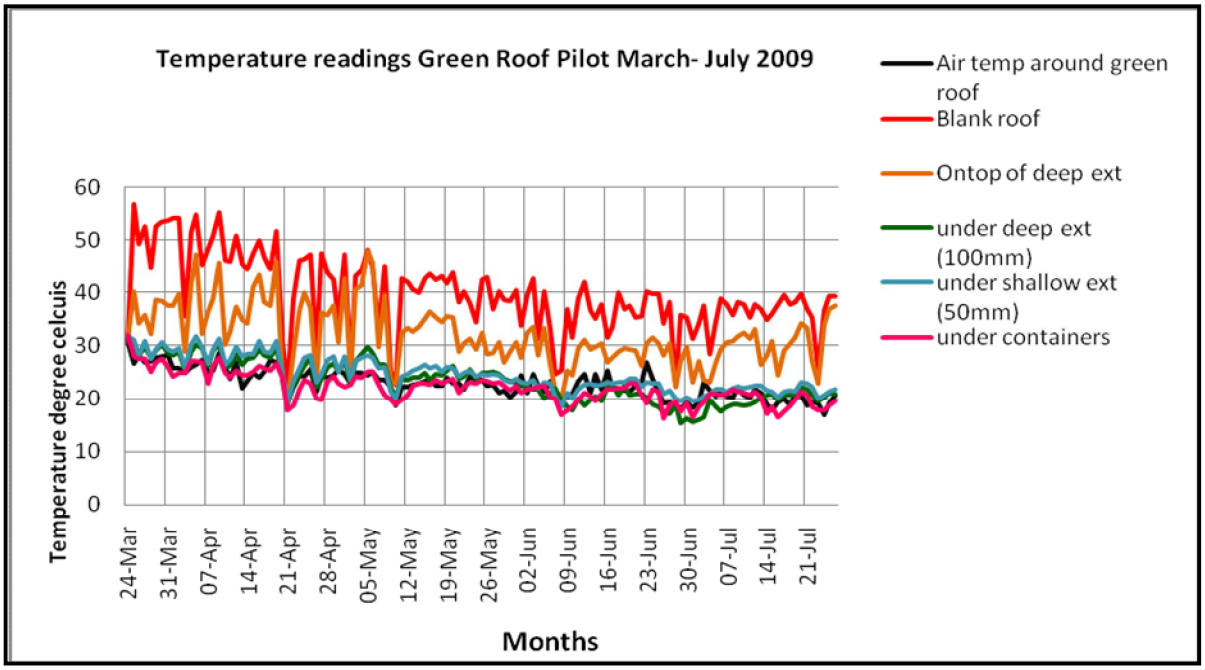
From a local government perspective, the eThekwini Municipality has begun to pave the way for future opportunities for a more widespread use of rooftop gardens. The GRPP is part of eThekwini Municipalityôs Municipal Climate Protection Programme. This program was initiated in 2004 and focused initially on understanding the vulnerability of the city to the impacts[44] of climate change. The GRPP was a response to the higher temperatures and increase in the frequency and severity of floods and droughts that are expected as the result of climate change. From an urban environment perspective these changes will exacerbate the already high temperatures experienced as a result of the Urban Heat Island effect and the high levels of surface run-off and flooding that result from the hardening of permeable surfaces. A summary of the eThekwini Pilot Project results regarding temperature reading and a brief overview of the insect biodiversity findings are shown on (page 68 to 69).

[44] For example, increases temperatures, changes in rainfall, rising sea levels and the increase in the severity and frequency of extreme weather events and patterns.

The chart shows the temperature recorded at exactly 13:00 pm everyday between the dates 24th March 2008 to 21st July 2008. The following readings were measured using temperature probes located in the following places:

- 1 probe placed in a Stephenson screen to record ambient air temperature.
- 1 probe on top of the blank roof,
- 1 probe on top of a deep green roof.
- 1 probe under the deep green roof with soil100mm deep
- 1 probe under a shallow green roof with soil 50mm deep
- 1 probe under planted containers

Temperature readings recorded from the 24 March 2009 to 21 July 2009



The chart shows the decrease in temperature of the roof that has been retrofitted with green roof applications. All the green roofs both container and direct applications temperatures are significantly lower than the blank roof.

Insect statistics of eThekwini Municipality Green Roof Pilot Project

The following insects were collected over a month period:

- Flies - 23 different species being recorded, they play an important role in the ecosystem. Apart from their role as decomposers (maggots use decomposing material as a food source); up to 17% of all pollinators are flies.
- Hemiptera (true bugs) are insects that either use plants as a food source or as a hunting ground. Thus the presence of 17 different species represents a solidly developing ecosystem.
- The 209 Hymenopterans (wasps, bees and ants). The presence of these insects is positive in a garden as they are pollinators and they are finding a suitable food source.
- Lepidoptera (butterflies and moths) are one of the most well known groups of insects. Their presence however again indicates a healthy ecosystem.
- Although there were Coleopterans (beetles) present, there were only 3 different species. As the garden develops and grows, one would expect more species to be attracted to the garden.
- Thysanoptera (thrips) were also present. They can reproduce parthenogenically which means large numbers can be produced without the need for a mate.

The future of green roofs in South Africa is promising as the current Green Roof Pilot Project has been extended for an additional year (2010). Furthermore a green roof team has been selected to continue the research as well as to implement green roofs on all municipal owned buildings that are considered suitable for this type of application. Once

the municipality proves to its citizens and commercial sector that it is leading the way regarding sustainable building techniques and issues around food security, the process of green roofing and urban agriculture should begin to grow exponentially.

BIBLIOGRAPHY

Allen, A & Young, N (2002) Sustainable Urbanisation Bridging The Green And Brown Agendas, UN Habitat

Banting, D, Doshi, H, Li, J, Missios, P, Au, A, Currie, BA & Verrati, M (2005) Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto, Ontario Centers of Excellence Earth and Environmental Technologies

Bullock, G.H (2008) Valuing Urban Green Space: Hypothetical Alternatives and the Status Quo, Journal of Environmental Planning and Management. Vol.51, No.1

Connelly, J & Smith, G (1999) Politics and the Environment, From Theory to Practice, Routledge London and New York

Devereux, S & Maxwell, S (2001) Food Security in Sub- Saharan Africa, University of Natal Press, PMB, South Africa

eThekwini Municipality Environmental Management Department (2007), Durban Biodiversity Report

Earth Pledge, (2005) Green Roofs, Ecological Design and Construction, Publisher Schiffer Books

Edwards, B (1998) Green Buildings Pay, Routledge London and New York

EThekwini Municipality (2003-2007) Integrated Development Plan

Frazer, L (2005) Paving Paradise the Peril of Impervious Surfaces, Environmental Health Perspectives, Vol. 113, No.7

Girardet, H (1992) The Gaia Atlas of CITIES, New directions for sustainable urban living. Gaia Books Limited

Givoni, B, (1998), Climate Considerations in Building and Urban Design, library of Congress Cataloguing-in-Publication Data.

Green Architecture, Urban Green Files (April 2006), Looking 10 Years Ahead. Publisher Brooke Patrick, Pub Ltd.

Green Roof Designs cc, a landscape company established, 2008

Hough M, (1984) City Form and Natural Process, Croom Helm London Sydney

Kaplan, R. (2001). The nature of the view from home: Psychological benefits. Environment and Behavior, 33, 507-542.

Kellet, J (2007) Community ï based energy policy: A practical approach to carbon reduction, Vol. 50, No .3

Kumar, R (1999) Research Methodology A Step-By- Step Guide For Beginners. Sage Publications, London.

Lomborg, B (2004) Global Crises, Global Solutions. Cambridge University Press

McDonough, W (2005) Green Roofs, Ecological Design and Construction. Earth Pledge, Schiffer Publishing Ltd.

Nicholson-Lord, D (1987) The Greening of The Cities, Routledge and Kegan Paul London & New York.

Our Biodiverse City, The value of Durbanôs Biological Diversity, Ethekwini Municipality Management Department, 2008/2009.

Platt, R. H (1994) The Ecological City: preserving and restoring urban biodiversity. University of Massachusetts Press

Porta, S & Renne, J.L, and (2005) Linking Urban design to sustainability: formal indicators of social urban sustainability field research in Perth, Western Australia, Urban design International, Vol 10

Price, M.L & Meitzner, L.S (1996) Above ï Ground Gardens, published 1996 ECHO

Purvis, M & Grainger, A (2004) Exploring Sustainable Development, Geographical Perspectives, Earthscan Publication Limited, London, Sterling, VA

Reekie, FR (1972) Design in the built environment, Edward Arnold Publishers

Register, R (2006) EcoCities Rebuilding Cities in Balance with Nature, New Society Publishers

Roberts, D & Diedrichs, N. Durbanôs Local Agenda Programme 1994-2001, Tackling Sustainable Development

Roseland M, (1997) Eco- City Dimensions, New Society Publishers

Sarantakos, S (1993) Social Research, Macmillan Education Australia Pty Ltd.

Satterthwaite, D (1999) Sustainable Cities, Earthscan Publication Ltd, London.

Shaw, WW, Harris, LK & VanDruff, L (2004) Proceedings of the 4th International Symposium on Urban Wildlife Conservation. May 1-5, 1999

Sowman, M & Brown, A.L (2006) Mainstreaming Environmental Sustainability into South Africaôs Integrated Development Planning Process, Journal of Environmental Planning and Management. Vol.49, No.5

Taylor, DA (2007) Growing Green Roofs, City by City, Environmental Health perspectives, Vol. 115, No.6

Thomas R (2003) Sustainable Urban Design, an Environmental Approach. Spon Press
Taylor and Francis Group London and New York.

Thompson, J, W& Sorvig, K., (2000), Sustainable Landscape Construction, A Guide To Green Building Outdoors, Island Press, Washington D.C-Covelo, California

Town and Country Planning Association Journal (Oct 2004)

Town and Country Planning Association Journal (Jan 2005)

Tuan, Yi ï Fu (1974) Topophilia: A Study of Environmental Perception, Attitudes, and Values, Prentice Hall Inc.

Wheeler SM & Beatley T (2004) The Sustainable Urban Development Reader. Routledge Taylor and Francis Group London and New York.

White RR, (1994) Urban Environmental Management, Environmental Change and Urban Design. John Wiley & Sons Ltd.

Wilson, EO (1984) Biophilia: the human bond with other species. Cambridge: Harvard University Press

Wilson, WH. (1989) The City Beautiful Movement, The John Hopkins University Press, Baltimore and London

Yuen, B & Wong NH (2005) Residents perceptions and expectations of rooftop gardens in Singapore, Landscaping and Urban Planning. Vol 73 issue 4

Internet Resources

http://www.abc.net.au/gardening/stories/s728127.htm-assessed 5-3-2008

http://www.alternatives.ca/article1165.html-assessed 13-4-2007 and again 5-3-2008

www.baylocalize.org-assessed 20-3-2008

www.bioone.org, Brad Bass; Bas Baskaran, (2003) Evaluating Rooftop and Vertical Gardens as an Adaptation Strategy for Urban Areas- assessed 20-3-2008

http://www. cityfamer.org, Michelle Nowak, Urban Agriculture on the Rooftop, (2004) Cornell University Senior Honors Thesis-assessed 19-2-2008

www.cityfarmer.org/russiastp.html - assessed 19-2-2008

http://www. cityfamer.org St Lawrence, Joseph (1996) ôUrban Agriculture: The Potential of Roof Top Gardeningô- -assessed 21-2-2008

www.cityofchicago.org/Buildings, The City of Chicago Department of Buildings ï assessed 24-1-2008

http://www.container-gardens.com/- assessed 6 -3-2008

http://www. Container-gardens-pot.htm ï assessed 6-3-2008

www.containergardeningtips.com ï assessed 6-3-2008

www.egsf.org.za ï assessed 17-3-2008

www.eltgreenroofs.com ï assessed 5-3-2008

http://www.environment.gov.za/-assessed ï assessed 17-3-2008

http://www.environment.gov.za/ National Environmental Management Act ï assessed 17-3-2008

http://www.enviropaedia.com ï assessed 17-3-2008

http://www.fao.org/newsroom/en/news/2007/1000484/index.html: assessed 18-7-2007

http://www.fao.org/NEWS/2002/020102-e.htm-assessed 18-7-2007

http://genoa.ecovillage.org/genoceania/newsletter/archive-assessed 18-3-2008

www.greengridroofs.com- assessed 24-1-2008

www.greenroofs.ca-assessed 24-1-2008

www.greenroofs.com - assessed 24-1-2008

www.groundwork-sheffield.org.uk-assessed 24-1-2008

http://www.johannesburgsummit.org

http://www.lib.umd.edu, Laura M. Schumann, Master of Science, (2007), Ecologically inspired design of green roof retrofit-assessed 25-3-2008

www.liveroof.com-assessed 8-2-2008

www.livingroofs.org.uk- 24-1-2008

www.livingroofs.org/NewFiles/retrofittingofgreenroofs.pdf, Beatrice Munby ï Submitted (2005) Feasibility Study for the Retrofitting of Green Roofs. The University of Sheffield-assessed 29-11-2007

http://magma.nationalgeographic.com/ngm/0503/feature2/fulltext.html- assessed 25 -1-2009

www.naturalengland.org.uk-assessed 24-1-2008

www.nhbrc.org, South African guidelines for human settlement planning and design (2000) assessed 15-9-2008

www.polity.un.org-assessed 17-3-2008

http://www.rooftopgardens.ca, Pedersen, M (1999-2002) Rooftop Permaculture Transformation of Inner City Environment ï assessed 18-7-2007

http://www.rooftopgardens.ca, Rotem Ayalon, Supervised Research Project Final Draft Submitted April 28, 2006, for the degree of Masters in Urban Planning- assessed 21-2-2008

www.safegaurdeurope.com ï assessed 24-1-2008

http://www.temple.edu/env-stud/seniorsem/section5 -assessed 24-1-2008

http://www.wbdg.org/index.php - assessed 17-3-2008

www.worldtrans.org- assessed 15-9-2008

Newspapers and Magazine Articles

AGRICULTURE REPORT - Building a Rooftop Vegetable Garden by Bob Bowen Broadcast: September 21, 2004 ï assessed 8-10-2007

Cape Gateway- 6 February 2006 Pollution and Waste Management (Department of Environmental Affairs and Development Planning, Provincial Government of the Western Cape)-assessed 5-2-2008

Lawlor, G, Currie B.A, Doshi, H (2006) A research manual for municipal policy makers-assessed 21-2-2008

On line magazine- Up on the roof, NC State University
http://www.cals.ncsu.edu/agcomm/magazine/spring03/roof.htm-assessed 5-3-2008

Men Health Magazines 2008

SA Gardeners Magazine 2008

Sunday Tribune 31 October 2002 Green Roofs to solve Canadaôs heat problems.-assessed 5-2-2008

APPENDICES

Appendix 1 - Questionnaire used in the sample survey

Age: _____

In what area do you live _____

What type of Dwelling i.e. (House, Block of Flats, Townhouse etc) _____

a) What does a rooftop garden mean to you?

b) Please indicate your opinion about the following statements, by stating the score that presents your feelings.

1-Strongly disagree 2- Disagree 3- Neutral 4- Agree 5- Strongly agree

	1	2	3	4	5
Rooftop gardens will help the general climate of cities, by reducing heat from cities and the built environment.					
Rooftop gardens will help minimise rainfall runoff thus supporting storm water drains carrying capacity?					
Rooftop gardens and greening will surely help to create a more pleasant and softer cityscape?					
The government should introduce financial incentives to increase the number of rooftop garden developments?					
It is of great importance to increase green spaces?					
Looking out over green rooftop gardens instead of plain roofs will improve peopleôs mindsets both at home and place of work					

d) Do you feel that green roofs can be used as an effective design tool for improving biodiversity? (The variety of plant and animal life in an area).

e) Do you know of any relevant policies encouraging these types of developments?

f) Who should be the main character/s in driving this trend?

Government	
Public	
Developer	
Architects/ Designer/ Planners	
Other	

g) In relation to your answer for Question f, why do you think so?

h) In your opinion what are the major challenges that hinder development of rooftop gardens?

Do you know about container/ portable/ modular rooftop gardens?

yes	no

j) What do you think the benefits of container style rooftop gardens are in comparison to the conventional roof gardens?

K) Do you think it is possible to grow food on buildingôs rooftops ? If yes what are the benefits of this form of agriculture ?

Appendix 2: Professionals Interviewed

Geoff Nichols- Urban Landscaper and Ecologist (24 April 2008)

Derek Van Heerden ï Architect Partner East Coast Architects (25 April 2008)

Jessica Rich ï Manager of Policy Coordination & Implementation Coordinator for eThekwini Municipality (6 June 2008)

Appendix 3 - Interview Sheets for Geoff Nichols (24 April 2008)

1. What is your profession and how long have you been at it?

2. In your capacity as an urban landscape designer/ ecologist do you feel that one of the primary barriers to rooftop gardens is the structural implications attached to them?

3. What are your feelings regarding the following aspects pertaining to rooftop gardens?

- Rooftop garden will help the general climate of cities by reducing heat from cities and the built environment?
- What are your feeling s regarding the following é rooftop gardens will minimize rainfall run off thus supporting storm water drains carrying capacity?
- Should the government introduce a financial incentive to increase the number of rooftop developments?

4. Primarily in Durban or any of the cities in South Africa is it of great importance to increase green spaces?

5. Do you think that people who live and work in tree lined streets or who look out over rooftop gardens instead of plain roofs will have more positive mindsets towards life in general?

6. Do you think that hospitals and health clinics should incorporate rooftop gardens into their designs so as to support healing and well-being of patients?

7. Do you feel that rooftop gardens can be used as effective design tool for improving biodiversity and how effective would this be for example what fauna species will benefit from a rooftop garden?

8. Do u know of any government polices and principals encouraging rooftop gardens and these types of developments?

9. With regards to implementation and driving the trend of rooftop gardens which do u think or who do u think should be the main characters instigating this process and why, firstly governmenté . do u think government should be the ones doing it?

10. What about the public?

11. The developer should they be the one driving this trend?

12. Should the architectôs planners and urban designers be driving this process?

13. From an urban landscape designer/ ecologist of view how does one go about setting up, planning, or designing a conventional rooftop garden?

14. Do you know about container portable or modular rooftop gardens?
15. What do you think the benefit s would be of a container roof top garden as opposed to the conventional method?

16. Do you think it is possible to grow food on Durbanôs rooftops?

17. What are the benefits do u think if this forms of agriculture on top of rooftops if you are growing food?

18. With regards to ecology, horticulture and urban landscape design do u think that little attention has been devoted to investigating small scale urban green spaces and again examples using rooftop garden as a small scale green space?

Appendix 4 - Interview sheet for Derek Van Heerden (25 April 2008)

1. What is your profession and how long have you been at it?

2. In your capacity as an architect do you feel that one of the primary barriers to rooftop gardens is the structural implications attached to them?

3. What are your feelings regarding the following aspects pertaining to rooftop gardens?
4. Rooftop garden will help the general climate of cities by reducing heat from cities and the built environment?
5. What are your feeling s regarding the following é rooftop gardens will minimize rainfall run off thus supporting storm water drains carrying capacity?
6. Should the government introduce a financial incentive to increase the number of rooftop developments?

7. Primarily in Durban or any of the cities in South Africa is it of great importance to increase green spaces?

8. Do you think that people who live and work in tree lined streets or who look out over rooftop gardens instead of plain roofs will have more positive mindsets towards life in general?

9. Do you think that hospitals and health clinics should incorporate rooftop gardens into their designs so as to support healing and well-being of patients?

10. Do you feel that rooftop gardens can be used as effective design tool for improving biodiversity and how effective would this be for example what fauna species will benefit from a rooftop garden?

11. Do u know of any government polices and principals encouraging rooftop gardens and these types of developments?

12. With regards to implementation and driving the trend of rooftop gardens which do u think or who do u think should be the main characters instigating this process and why, firstly governmenté . do u think government should be the ones doing it?

13. What about the public?

14. The developer should they be the one driving this trend?

15. Should the architectôs planners and urban designers be driving this process?

16. From an architectôs point of view how does one go about setting up, planning, or designing a conventional rooftop garden?

17. Do you know about container portable or modular rooftop gardens?
18. What do you think the benefit s would be of a container roof top garden as opposed to the conventional method?

19. Do you think it is possible to grow food on Durbanôs rooftops?

20. What are the benefits do u think if this forms of agriculture on top of rooftops if you are growing food?

21. With regards to architectural research probably ties more into landscape architecture do u think that little attention has been devoted to investigating small scale urban green spaces and again examples using rooftop garden as a small scale green space?

Appendix 5 - Interview sheet for Jessica Rich (6 June 2008)

1. What is your profession? And how long have you been at it?

2. What does a rooftop garden mean to you?

3. What are your feelings regarding the following aspects pertaining to Roof top gardens:

    a. Rooftop gardens will help the general climate of cities, by reducing heat from cities and the built environment.
    b. Rooftop gardens will help minimize rainfall runoff thus supporting storm water drains carrying capacity
    c. Rooftop gardens and greening will surely help to create a more pleasant and softer cityscape?
    d. The government should introduce financial incentives to increase the number of rooftop garden developments?

4. In South Africa, primarily in Durban is it of great importance to increase green spaces?

5. How important would a policy around storm water management and rooftop gardens are for Durban with regards to climate change effects?

6. Environmental consciousness places respect for our world and, consequently, human life at the forefront of each and every endeavor- do you feel that in general development and planning policies are achieving this directive?

7. In your capacity as a policy developer what do you feel are the barriers of implementing a policy around storm water management and rooftop gardens that one of the primary barriers to rooftop gardens is the structural implications attached to them?

8. Do you think environmental aesthetics has been thoroughly investigated in development policies? Or has it been misunderstood as a minor concern in development?

9. Do you think that people who live and work in tree lined streets or who look out over green rooftop gardens instead of plain roofs will have a more positive mindset towards life in general?

10. Do you think that hospitals and health clinics should incorporate rooftop gardens into their designs so as to support healing and the wellbeing of patients?

11. Do you feel that rooftop gardens can be used as an effective design tool for improving biodiversity? And how effective will this be, for example what fauna/ species will benefits from rooftop gardens?

12. Do you know of any government policies or principles encouraging rooftop gardens and these types of developments?

13. With regards to implementation and driving the trend of rooftop gardens, which do you, think should be the main character/s instigating this process and why?

Government
Public
Developer
Architects/ Designer/ Planners
Other

14. In your opinion what are the major challenges that hinder development of rooftop gardens?

15. Do you know about container/ portable/ modular rooftop gardens?

16. What do you think the benefits of container style rooftop gardens are in comparison to the conventional roof gardens?

17. Do you think it is possible to grow food on buildingôs rooftops?

18. What are the benefits of this form of agriculture?

19. Jessica lastly, with regards to policy research, do you feel that little attention has been devoted to investigating the following developments:

Small-scale urban green spaces
Food security and rooftop agriculture
Aesthetic benefits and human behavior-
City images

20. In terms of the current environmental/ development plans for eThekwini do you foresee rooftop greening as being feasible and if so how?

21. How does rooftop gardening be integrated into other city management departments?