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Extensive Green Roof Design in the City of Cape Town: Barriers and Opportunities for Developing a Green Industry

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Abstract

In today's world of increasing energy costs and rapid ecosystem service decay, a result of direct human disturbance from development, habitat loss and fragmentation and the increasing frequencies of extreme weather events, it is critical that building practices in the next decade adopt a more adaptive and holistic approach to building design. Design that provides multifunctional buildings and landscape must be sought after at all income levels of housing. This challenge is compounded by the necessity to fulfill these needs, while simultaneously building more sustainable cities that mitigate the negative impacts associated with climate change (CPT Guidelines 2009). Population demographics and shifts in economic processes show that the greatest growth in future demand for ecosystem services will be in cities.

City planners are foreseeing and quantifying the direct benefits associated with developing their urban environments with multiple benefits and functions in mind, where humans are regarded as interdependent with the ecosystem services they depend upon (Broman, 2000). When one looks at the recent growth of roof greening in cities, it is clear that site specific research into using indigenous plants, roof design and an appropriate growing medium is needed to efficiently maximize the benefits most desired from roof greening (Oberndorfer, 2007). A shared experience in most cities is the need to actively promote the industry, through benefit research and providing the initial projects to train an initial work force in order to see real gains in roof top greening (Peck 1999, EThekwini GRPP).

Given this, the aim of this research is to investigate how the City of Cape Town's relevant guidelines, policies and standards can be interpreted, used, and coupled with public and environmental concerns to promote extensive green roofing.

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Chapter 1: Introduction

1.1) Background on Green Roofs

The practice of roof greening, the re-enforcement, protection and insulation of a rooftop with a growing medium and plant organisms is not a new concept in house design. The Netherlands have been using such methods since the 1800's (Oberndorfer, 2007, pg 827), and Germany has been developing and refining this technology for modern building use for over half a century. Germany and other innovators are incorporating the uses of plastics and petroleum based water proofing materials and levels of root barrier cloth, filtration padding and runoff substrates to make green roofs suitable to the modern builder's designs and demands, with an example of standard green roof composition shown in Figure 1.

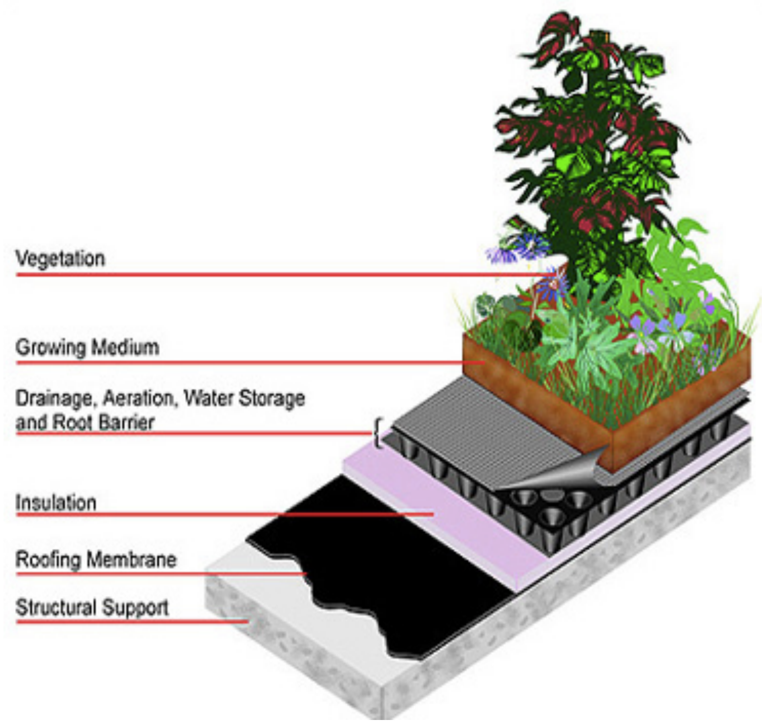

Figure 1: Standard Green roof composition.

Source: http://www.toronto.ca/greenroofs/images/colour_layers.jpg

Over the last decade, city planners concerned with urban storm water runoff logistics, public health, urban heat waves, declining biodiversity, and building energy efficiency and their Cities green profile have been adopting the practice of roof greening to mitigate and adapt to such scenarios.

When one looks at the recent growth of roof greening in cities, it is clear that site specific research into using indigenous plants, roof design and an appropriate growing medium is needed to efficiently maximize the benefits most desired from roof greening (Oberndorfer, 2007, pg 828). These benefits are different depending on local urban areas weather patterns and the city planners current concerns and as well as those future outcomes that need to be locally addressed.

Roof greening can be prioritized at many decision maker levels, from international agreements and obligations, to national government regulations, city officials, to local homeowners and entrepreneurs. A shared experience in most cities is the need to actively promote the industry, through benefit research and providing projects to train an initial work force in order to see real gains in roof top greening (Peck 1999, EThekwini GRPP). Traditionally, a cost-benefit analysis of infrastructure development often overlooks the benefits and extended lifecycle of a green roof and emphasizes the comparable higher initial construction costs associated with green roof applications (Carter 2008, pg 355). Proven by different and innovative cost-benefit analysis to be, in the long run, more cost effective and cheaper than conventional rooftops, this technology has now been given an economic appreciation by developers (Wong et. al 2003, Getter 2006 pg 1280). These savings are not realized immediately and many developers, homeowners and building authorities remain uneducated in the exact economic measures of a cost-benefit analysis of a green roof, and what costs are ignored as 'externalities'. The private investor that greens his rooftop will in many cases only see a return on his investment after 20 years (Banting, 2005, pg 8), a time when many conventional roof lifetimes expire and need to be removed and replaced; a time when green roofs, if properly built, only realize half of their expected lifetime. The cost benefit literature on green roofs will be looked at more closely in the literature review section of this paper.

There are many different designs and concepts of design involving green roof technology and its application on buildings. These differences can be categorized into either extensive or intensive green roofs. Intensive green roofs, or roof top gardens, involve a very solid roof top structure, to support deeper levels of soil to accommodate much more diverse and rich vegetation and trees. In many cities building restrictions require the support system of the roof to resemble that of an extra floor on a building (with stair access and fire escapes) and make the costs of such intensive green roofs very high

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(McConnelly, 2009 Interview). Such intensive green roofs are designed not only for their storm water and building efficiency contributions, but also for their aesthetic appeal and biodiversity values. Extensive green roofs, on the other hand, utilize vegetation that can survive lower levels of soil depth, nutrition and growing mediums and require much lower levels of maintenance and irrigation. Green roof companies have developed lightweight growing mediums from recycled materials and lighter soils. The structure of the roof still must be engineered to support the additional weight of materials, vegetation, soil and high amounts of water retained in the substrate. Extensive green roofs are the roofs that have the greatest benefits to costs ratio and are simpler to install than the expensive, intensive roof top gardens. Extensive green roofs are the design that will be used as the case study for this research in the City of Cape Town, drawing upon literature from local and international sources.

1.2) Global Context and Need for Roof Greening Initiatives

In today's world of increasing energy costs and rapidly deteriorating ecosystem services, a result of direct human disturbance from development and the increasing frequencies of extreme weather events, it is critical that building practices in the next decade stray from conventional western design and towards a more adaptive and holistic approach to building design. Design considerations that provide multifunctional buildings and urban landscapes must be sought after at all income levels of housing. In light of these concerns many of the 'Developed' world's urban planners and city officials are acting now to change both the way the urban environment is valued and the expectations of citizens in terms of benefits that they should expect from their urban environments. Today's leading city planners are foreseeing and quantifying the direct benefits associated with developing their urban environments and buildings in a more environmentally responsible way where humans are regarded as interdependent with the ecosystem services they depend upon (Broman, Holmberg et. al, 2000).

The year 2008 marked a tipping point in human history, as more than half of the worlds population now is considered to be living in an urban environment (Balk, Anderson et. al, 2007, pg19). This crossing into an urban majority world is a result of the human race's second wave of urbanization, in contrast to the first wave of (1750-1950) (Pietersen, 2008). This second wave has been brought about by globalization, a geopolitical and economic movement that has pulled, or pushed, rural populations to the urban centers out of necessity. This is a trend that will not reverse itself anytime in the near future, as

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population growth rates in urban areas are far higher than those in rural areas (Pietersen, 2008). This discrepancy between urban and rural growth rates is largely brought on by the economic draw of the cities and the push from rural areas created by low wages and lack of opportunity. The 20th Century saw urban populations rise from 220 million in 1900 to 2.84 billion in 2000. The present Century will match this increase in 4 decades (Pietersen 2008). Most of this growth in urban populations will be poor people living in sprawling urban shantytowns, and informal settlements. Because of these growth rates, coupled with the challenges posed by climate change, the growth of urban environments with sustainable design and ecosystem service protection and enhancement is critical. The planning and development of urban environments will be an important frontline for sustainable development practices. Urban buildings, spatial planning, and city policies that address the threats of climate change, increased frequencies of extreme weather events, deteriorating ecosystem services, local food security, energy needs, and loss of wildlife habitat, will prove to yield the greatest fruits for the residents of such an unpredictable future (Oberndorfer Lundholm et. al, 2007 Pahl-Wostl, 2007).

Today's leading city planners and policy makers are having the foresight to see the potential in, and future demand for, green technologies and design, research experience and context sensitive structural planning. Such considerations that work to mitigate the negative impacts of the urban environment on its surroundings (wildlife habitat loss, air quality, high levels of harmful runoff, heat waves) will add much greater value to the lifetime of the development. Building practices and technologies that enhance and protect ecosystem services, while at the same time increasing building energy efficiency and the health and lifestyles of its inhabitants are needed to address the complex socio-ecological challenges ahead. The goals of such technologies involve decreasing buildings dependencies on high amounts of energy, and exploit its environmental qualities to societies advantage. Green roofs are just one of the many ideas that provide a range of services that touch upon multiple concerns.

Green building practices have come along way in the last decade. This is in conjunction with a gradually growing awareness that we are in fact interconnected with the earth and its living systems. National government Kyoto obligations (CO2 Emission reductions), corporate risk management strategies, and shifts in residential and consumer market demands driven by increasing awareness of topics such as climate change and its human

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induced drivers are all also spurring on positive change. The creation of the United Nations Framework Convention on Climate Change (UNFCCC) is acknowledged as a huge step forward in recognizing and researching the effects of climate change (UNFCCC website). The Kyoto Protocol is a binding agreement under the UNFCCC that holds 37 developed countries to targets of carbon reduction. South Africa signed the UNFCCC in 1997, agreeing to reduce emissions by 5% by 2012 from the 1990 levels, and in 2002 (EnviroWorks 2009).

Forward thinking leaders and innovators are anticipating future changes that will be demanded of society, government and private businesses to realign products, and people's environments with more sustainable alternatives. Future challenges such as a global carbon economy, climate change, and increased consumer demands for more significant corporate responsibility are also allowing such green technologies to be incorporated into private company considerations (Langdon 2009). Many of the more developed world governments have fostered healthy green building technologies and industries by providing economic incentives, imposed structural and environmental building restrictions and property tax rebates to foster the building of a greener and more efficient urban environments. Examples exist at different points in time in Chicago, Malmo Switzerland and Germany (Banting, Doshi et. al 2005, Carter, Keeler et. al 2006). These policies will be examined more closely in my literature review.

1.3) South Africa/Cape Town's Context

South Africa, when compared to the northern hemisphere, has not come very far in terms of fostering green roof development in its city centers. The City of Cape Town is lagging behind other international cities in this green building push, but it is making promising headway, which will be described in my practice analysis.

In the new millennium Cape Town, like other cities around the world and South Africa, will be challenged to provide sufficient food, shelter, basic services and jobs for all of its urban residents. This challenge is compounded by the necessity to fulfill these needs, while simultaneously building more sustainable cities that mitigate the negative impacts associated with climate change (CPT Guidelines 2009). Population demographics and shifts in economic processes show that the greatest growth in future demand for ecosystem services will be in cities. Thus the drive to transform these urban

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environments into more sustainable ecological spaces is a necessity (Balk, Anderson et. al 2007).

It is expected from scientists that Cape Town will experience an increasingly warmer and drier climate, with an increase in both intensity and frequency of extreme weather events (EnviroWorks 2009). This will lead to loss of unique and globally critical biodiversity, coastal flooding and erosion, longer and more intense heat waves, and extreme wind and rainfall (EnviroWorks 2009). With strategic and creative planning solutions from both municipal governments and citizens, the urban environment can mitigate these challenges. Such planning solutions can also offer healthier and more cohesive sustainable lifestyles and choices for its citizens. One way of enacting this transformation is through the utilization of empty rooftops, which currently only act to contribute negatively to the urban environment and provide no mitigative functions against these predicted disturbances to the urban environment. If properly utilized and designed, these empty and underutilized urban spaces can provide a wide spectrum of social and private benefits (Alexandra 2006, Banting 2005, Brenneisen 2005, Ngan 2004). I argue that communicating these benefits and promoting a green roof industry (through proper policy design, and effective private participation) is needed to realize this rooftop transformation in the City of Cape Town.

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Considering the scale and diversity of problems the City of Cape Town faces, it needs to maximize its underutilized urban spaces to contribute positively to society and the urban environment in which we live. Although such benefits have been proven and quantified in a few leading and developed countries, outcomes do differ across biomes, geography and climate conditions (Oberndorfer, Lundholm et. al 2007). Because of these differences local, context specific research into the exact economic measures of the benefits is needed to push the importance of this technology into the design considerations of city officials, architects, private homebuilders and developers. Policy needs to be in place to support this growth and transition to a transformed urban environment. The way citizens and urban planners value and evaluate their built environment, and what they expect such infrastructure investments to provide to society must also transform. Buildings need to serve more purposes and provide more social, human health and environmental services. This may not be possible without some form of financial incentives or regulations and provisions. This policy support, and the need to communicate and measure the benefits in economic terms that incorporate a more holistic, life-cycle approach is the focus of my research.

1.4) Research Aims and Objectives

Research investigates what policies and guidelines are currently infringing on, or assisting in the uptake of a more holistic, environmentally sensitive and socially responsible urban design and planning. I will explore what building policies are creating barriers to 'new' green technologies blooming here in South Africa and Cape Town as well.

My research will address the experiences to date of Cape Town and South Africa's green roof developers and promoters. I will ask what is hindering this small group of innovators in Cape Town and South Africa; what beneficial experiences have these initial projects seen, and what benefits have been quantified? I will also assess what policies are currently helping to nurture green industries in Cape Town and what lessons there are for legislated by-laws from green roof projects to date.

My research will look at the current urban planning and city policies of Cape Town, and highlight inefficiencies and suggest policy changes that hold potential results in terms of positive reinforcement for green building practices such as extensive roof greening in the urban environment.

Given this my research aim is:

> To investigate how the City of Cape Town's relevant guidelines, policies and standards can be interpreted, used, and coupled with public and environmental concerns to promote extensive green roofing.

My research questions are:

- What are the potential policy avenues to pursue and support extensive green roof development in Cape Town?
- What are the main barriers and opportunities for practice that have faced current green roof developments in Cape Town?
- What collaborations can be suggested between sectors?

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1.5) Methodology

The research was conducted over the time period from January until July 2010. During this time the author resided in Vancouver for two months and conducted interviews pertaining to the initial years of the green roof industry in the City of Vancouver and the details to getting green roof design accepted by city planners and urban designers. The majority of the research and interviews were undertaken in Cape Town.

Research methods include personal interviews of an informal, and at times formal, nature. Interviews were sometimes off the record, and some were recorded for more accurate transcribing results. Themes revolving around technology diffusion, green roof benefits and the current research being undertaken to quantify their benefits in urban areas of the world, and effective ways of pursuing these objectives in Cape Town centralized these interviews. This author's personal general observations and documentation of conversations and events form a basis for this study. Questions were also asked over following emails and over the phone. All data collected should be considered qualitative apart from discussion on the available academic literature concerning costs. These interviews and lines of communication are supplemented by the literature review, which defend statements made concerning my research aims as well as is allowed with such a complex subject.

Literature, educational resources, and policy produced by the City of Cape Town, City of Vancouver and the EThekwini Municipality is drawn upon extensively. When going through these documents the themes of green roof research, benefit quantification and communication, and avenues for potential support through the different City departments that would find benefit in green roof promotion were considered. Strategies and policies developed by Cape Town's roads and storm water department[1] were investigated and drawn upon to find avenues of promise in terms of getting the benefits green roof development could offer in helping this entity meet its future goals. The educational literature produced by the City of Cape Town on sustainable options available for developers of low-income urban projects[2] was drawn upon to investigate if opportunities exist to further push low cost green roofing technologies in Cape Town. The

[1] Catchment, Stormwater and River Management Branch (CSRMP). *Management of Urban Stormwater Impacts Policy Version 1.1* **(2009)** Roads and Stormwater Department. City of Cape Town. Approved 27 May 2009.

[2] City of Cape Town. *Sustainable Options for Developers (Low-Income Urban)* **(2008)** City of Cape Town. Sustainable Energy Africa. Association incorporated under section 21.

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City's green building guidelines were looked at for mentions of green roof design and degree of promotion, acceptance, and understanding of the benefits such technologies could provide.[3] The Department of Minerals and Energy's draft energy efficiency strategy was also included, looking for avenues that would allow a greater acceptance and interest in technology development and research in terms of insulation and cooling properties existent in green roofs. Enviroworks' Special edition on climate change and energy, a biannual newsletter produced by Cape Town's Environmental Resource Management Department, was also drawn upon heavily for context and confirmation of the City's commitment to biodiversity issues and sustainable development.

Successful examples of policy or research undertaken by other cities have also been assessed, including Canadian and relevant South African examples. Research papers undertaken by the environmental adaptation research group, commissioned by Environment Canada[4], concerning the forging a green roof industry in Canada and the strategies that can be adopted by the city to promote its growth was drawn upon to structure my analysis, as it confirmed and conformed with what is currently being undertaken by the EThekwini municipality with its green roof research project.

Insight into what impedes green and sustainable design in Cape Town was also obtained through attendance of the panel debates *Counter-Currents: Experiments in Sustainability in the Cape Region*, facilitated by Edgar Pieterse, with debate topics including *Leadership and the City* and *Designing Alternative Futures*. In the panel debate, guest contributors Mark Swilling, Tau Tavengwa, Andrew Burraine, and Gita Goven to name a few debated the questions of what changes in the City are needed, and how to imagine these changes becoming reality. Topics of equality, population cohesion, environmental sustainability, public safety and health and economic opportunities within lower income communities were all discussed in a multi-disciplinary setting.

Limitations: Limitations existed in my interview sample. Not all green designers or architecture firms were questioned. Selected and available city officials were interviewed,

[3] *City of Cape Town Green Building Guidelines: Draft.* **(2008)** Integrated Metropolitan Environmental Policy City of Cape Town. www.capetown.gov.za/environment

[4] Peck, S. Callaghan, C. Kuhn, M. Bass, B. *Greenbacks from green roofs: Forging a new industry in Canada status report on benefits, barriers and opportunities for green roof and vertical garden technology diffusion.* **(1999)** Environmental Adaptation Research Group, Environment Canada. Prepared for: Canada Mortgage and Housing Corporation.

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but many that some would consider important for this topic were unable or unwilling to partake in the interview process or communicate with me. The literature review was also limited, as literature on green roof development is inherently limited at this time, and almost non-existent as a low income housing application with solid research and quantification of benefits. Literature coming out of South Africa is almost non-existent, making many of my references and points North American or Euro-centric. The lack of existing extensive green roof application in Cape Town also limited my results and analysis section. Research was also impeded by the availability and willingness of professionals to take time in their workday to schedule an interview.

Scope: The extensive green roof application was used to refine the idea of green design applications in the City of Cape Town. The scope in this paper may be confusing at times, as it is very broad and global in terms of sources drawn upon, and case studies used. Due to the topic chosen, and research questions posed, it is important to remember this paper is about the diffusion, quantification and communication of the potential benefits green roof technologies and applications could offer to the City of Cape Town. Because it is exploring potential benefits of something that could happen in future, it was necessary to draw on a range of secondary sources, including literature and reports. Due to lack of actual on the ground practice here in Cape Town, such secondary sources must fill the void and provide reliable and adequate suggestions and reference to the research questions posed and findings derived.

The EThekwini Green Roof Pilot Project Report (2010) was essential to gain insights into specific data sets such as biodiversity and runoff measurements. It is the only successful green roof pilot project in South Africa to date. Low income housing projects that are currently trying to portray a more sustainable design with minimal cost is found in the Edward road project.

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Chapter 2: Literature Review

2.1) Existing Cost-Benefit Analysis from International Research

It has been the experience worldwide that urbanization has drastically, and irrevocably altered terrestrial and aquatic ecosystems (Wilby, Perry et. al 2006, Meehl, Tebaldi 2004). This direct conflict between the built and natural environment has been resulting in the elimination or degradation of related ecosystem services such as water regulation and supply, erosion control, sediment retention, nutrient cycling, climate regulation, and waste treatment. The development of buildings and impervious surfaces that are the defining feature of urban areas are a strong cause behind this environmental decline in aquatic ecosystems and the further systems they support (Arnold and Gibbons, 1996). One reason why construction practices lead to environmental degradation is that the costs of environmental degradation are not fully realized by the party responsible, and thus not accounted for in design considerations or building lifetime costs (DeGroot, Wilson et. al 2002 pg 395, Langdon 2009). The biggest obstacle to green development is the misrepresentation of cost in the conventional cost benefit analysis that is undertaken to weigh development options concerning design and use (Pahl-Wostle 2007 pg 53, Peck, Callaghan et. al 1999). In economic terms, external costs are not directly accounted for, and are realized only later and usually become a shared cost by the public, easily alluding the party that is responsible for such external costs on the public. Due to the public nature of the services and goods affected and the cost distribution of the impacts, these costs are referred to as externalities in economics, and are not usually included or considered a direct cost. Literature and research suggests, at times, that perception is changing globally with an increasing consciousness concerning the impacts of the built environment on our finite ecosystems. But the opposite is also revealed as developers still make land use decisions without considering the full cost of environmental damage their activities will create[5](Carter 2008 pg 353, referring to developers in general, not specifically South Africans).

Despite being a widely used method for decision-making, the cost benefit analysis (CBA) method has had limited comprehensive application to green roof projects (Banting, Doshi et. al 2005). The underlying premise of CBA is that all costs and benefits, both present and future, can be standardized in monetary terms and consequently compared at a specific point in time (usually the present). Future costs and benefits, even if measured in real (or constant-dollar) terms, are considered not directly comparable to present costs and benefits for a number of reasons, including time preference (impatience, tendency to consume and spend today), risk, and positive rates of return on investment (opportunity costs). Future values are discounted at the appropriate capital rate and probabilities are occasionally assigned to future benefits and costs to determine expected future values.

The cost benefits analyses and life cycle studies analyzed on green roof projects follow an

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approach that apply future values to the multiple benefits provided by green roofs (Banting 2005). As each building needs some type of roof, the appropriate choice is not absolute costs and benefits, but incremental; for instance, the costs of a green roof above a standard roof. Discount factors do differ across past studies and time, and so make direct comparison possibly inaccurate when compared. Each study to date varies, as they usually examine different combinations of costs and benefits of green roofs, and accounting values also were different across the selected literature reviews. As important as the service life, the discount rate applied to future costs and benefits has significant effects on net benefit calculations. A higher discount rate implies lower present values of future costs and benefits, and thus discounts the value of an extended roof lifetime. Private discount rates vary by industry, country, time and the researcher's economic expectations of the future.

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Green Roof technology has gained acceptance in many urban centers as a practice that has the potential to help mitigate the multifaceted and complex environmental problems of today's urban environment. With the increasing value attributed to sustainable multifunctional landscape creation and management that integrates human production and landscape design into the ecological fabric of a ecosystem functioning, service flows and biodiversity retention, green roof technologies are generating a lot of interest. But with the absence of regional or local policies, regulations or enforcement of green standards in Cape Town, coupled with relatively high installation costs (Bruce Beyers, email correspondence 2010). Investment in such design is hampered in the context of a developing country.

Mostly this initial lag in success is a result that building practices can often take advantage of economies of scale, as increasing developer experience and efficiency; market acceptance and increasing competitors, and local industry growth make for eventual lower costs of installation. Literature (Wong et. al 2003, Peck et. al 1999) confirmed interviews on green roof cost and benefits that the initial days of a roof greening industry are the most costly and problematic due to a lack of industry efficiency, local material suppliers, local developer's skills, experience, and acceptance of the technology by developers and urban designers. This also means that initial green roof developments are delivered at a premium cost, which can be problematic for the initial years of the green roof industry. An example exists in the German green roof industry, which has roughly 30 years experience, can deliver a green roof for as much as 50%

cheaper than what a green roof contractor cost in the United States during initial years (Carter 2008).

Cost benefit analysis must not only take into account the initial construction costs, which total 20% of costs when looking at the lifetime of a building in South Africa (GBG Draft 2009), but must also effectively incorporate the lifecycle costs (Langdon 2009). A need to account for the range of benefits of green roof design into an economic model that captures the building-specific scale of impact on its environment is needed. Obviously, placing an economic value, over time, on benefits such as urban climate regulation or existence value is more difficult than estimating energy efficiency gains, for more insight on these complications refer to De Groot (2002). The proper valuation of some of these previously ignored benefits has been proven to reduce the Net Present Value (NPV) of a green roof (Clark, 2008).

The test of NPV is a standard economic method for assessing the present value of competing projects over time. In the case of the green roof/ conventional roof comparison, the roofing scenario with the lowest NPV is the preferred option as the lower value means the least costly alternative. The existing cost benefit literature chosen for this literature review uses Net Present Values extensively (Carter 2008). The literature that exists for green roof cost-benefit analysis concerns itself with extensive (thin substrate) green roof systems as they compare to typical flat roofs in an urban watershed. Intensive roof top gardens are not economically competitive (Connelly Interview 2010, Peck 1999).

The Cost-Benefit analysis of green roof applications does have its weaknesses. Inconsistencies exist in the benefits derived from site to site. Future commodity prices, market access, building practices, climate and geography can also alter the cost benefit analysis from site to site. Of the literature drawn upon for this analysis, each cost benefit analysis was conducted with low energy costs and high green roof construction costs (Carter 2008). This was applied under the assumption that, as time passes, energy prices will most likely continue to increase (Berkes et. al 2002). Under economies of scale and the assumption that with time and practice contractors will be able to find materials locally and build green roofs more efficiently, construction costs should, theoretically fall with time in Cities new to green roof design (as seen in the Germany/USA comparison). Energy will inevitably increase in price, and with time, increasing experience and market

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demand the green roof industry will be able to supply products at lower prices (Carter 2008, Connelly Interview 2010).

A valuation of green roof benefits can reduce the net present value of a green roof if investors can devalue the upfront capital costs and account for extended lifetime. Net present value (NPV) analyses that compare a conventional roof system to an extensive green roof system in the United States demonstrate that at the end of the green roof lifetime the NPV for the green roof is between 20.3 and 25.2% less than the NPV for the conventional roof over 40 years (Banting 2005). The additional upfront investment required by a green roof is recovered at the time when a conventional roof would be replaced. Green roofs have been documented to out live conventional roofs by 200% in the US (Carter 2008 pg 355); in Europe, on average, the same doubling of lifespan is being seen (Kohler 2005). All valuation scenarios considered from the United States agree that the NPV of the conventional roof only exceeds the NPV of green roofs beginning when the cost of the roofs replacement after 20 years is included in the NPV calculations (Clark 2008). This increase in membrane longevity is the main catalyst in promoting green roofs as more economical than conventional roofs in the existing literature on Cost Benefit analysis concerning this technology.

In Carter's (2008, pg 358) case studies and interviews, he valued the installation costs of a conventional roof at $83.78/M^2, and green roof installment costs at $158.72/ M^2. The cost for the green roof application, as noted by the researchers, is more variable, as costs depend strongly on accessibility, structural integrity, and design considerations.

Storm water retention values of green roofs have also been cited by studies as an important and economically viable and measurable benefit (Carter 2006, Alexandra 2006, Banting 2005). The green roofs under study for a particular cost-benefit analysis, retained as much as 77% of all storm water runoff (Carter 2006). The translation of peak storm water level reductions is possible, as seen in Peck's cost benefit analysis for the Canadian Mortgage and Housing Corporation (Peck 2006).

In one study in the United States, reductions in storm flow volumes from the watershed outfall were calculated for a variety of storm events. It was shown that cost savings from a reduction in pipe size and retention needs, resulting from increased retention at point sources (green roofs), translated to a 4.6% reduction in the needed size for a 25 year

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storm event, and a 4.4% reduction in the needed size for a 100 year storm event (Carter 2008 pg 360). Other relevant features of storm water retention values delivered by green roofs are the reduction of storm water in combined sewer overflows. The City of Toronto utilizes this system of water management, and through the cities adoption of extensive green roofs in its urban areas, it was estimated that by avoiding combined sewage overflows would save the city 46.6 million$ in infrastructure savings (Banting, Doshi et. al 2005). These benefits will not be explored too deeply in this literature review, as Cape Town does not have this water management system. While storm water fees affect the NPV over 40 years, air pollution mitigation and energy savings can have greater impact on the NPV of green roofs (Clark 2008).

In terms of quantifying savings relating to increased energy efficiency, results vary over countries, building structures and climates. Regardless, studies involving modern buildings and green roof applications that monitor the insulation benefits and resulting energy savings all show promising results. Some research suggests that considerable energy costs savings can be realized over the lifetime of the green roof, enough over the lifecycle of a green roof to lower its NPV to less than a traditional roof when energy savings alone are included in a cost benefit analysis (Wong et. al, 2003, pg 504). In one US study, an energy savings of 3.3% was realized (Carter 2008), this is less than half of the 8% resulting energy savings recorded by Wong et. al (2003 pg 506) in his Singapore research. This energy savings value is believed by cost benefit studies to increase during the lifetime of the green roof, due to the nature of continually increasing demand for energy, and increased policies to limit pollution and climate change by policy makers (Carter 2008).

Considering different climatic conditions and architectural standards, research results should be interpreted in terms of where the study is undertaken and how relevant it is to the South African environment. Similarly, the conversion of energy savings into cost savings must recognize South African housing design. Governments and citizens are increasingly valuing air quality as a desired implication in urban design, as the negative health effects of air pollution and urban smog is becoming more known and evident in everyday life (Banting 2005, Getter 2006, Herzog 2003). Air quality in urban areas suffers greater, on average, than other environments (Corburn 2009 pg414). The air pollution mitigation ability of green roofs into an economic benefit analysis can act to further reduce the NPV of green roofs by up to 5-20% (Carter 2008 pg359). While the potential

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may be great for green roofs to improve air quality in densely populated areas, the type of vegetation found on the rooftops is largely the determinant of the amount of air-quality improvement. Cross-applying air quality improvements from one type of vegetation application to another can be misleading and produce inaccurate results (Johnston and Newton 1993). The literature on air quality contributions comes largely from European and North American countries, and research results are determined by vegetation used.

The approach to putting an economic value on carbon sequestering is not new, and basic economic quantification in one study was accomplished by including a sedum-covered roof into a cap-and-trade emissions credit system. By using 2005 market values for NOx emission credits of 3375$ a ton, (Clark, Adrians et. al 2008, pg 2159) researchers estimated the credit for a sedum covered roof to be 0.11$/m^2. Both the private and public sector benefit from this public, non-excludable good, as the roofs reduce pollutant levels in the urban environment. If green roof applications were involved in cap-and-trade carbon markets, building owners would be able to receive economic compensation annually for providing an air cleaning service to the public. Considering no such market exists here in Cape Town, it will not be elaborated upon. A suggested reading for informative value includes: Burkett, M. *Just Solutions to Climate Change: A Proposal for a Domestic Green Development Mechanism*. Policy Summary. **(2006)** University of Colorado Law School.

Housing and property markets have long failed to effectively calculate the value of buildings that incorporate green technology and design (Langdon 2009). The move away from financial modeling that focuses on immediate payback and capital cost reduction, and towards a life cycle cost approach is revealing a more accurate picture of true costs and benefits. When methods that incorporate storm water fees, energy savings and air pollution uptake are used during a 40 year lifetime of a green roof, the NPV is between 25% to 40% lower than the conventional green roof scenario (Clark 2008 pg 2157).

There are benefits that are derived from extensive roof greening, that are non-existent with the application of a conventional roof. Green roofs are a unique tool to urban planners because they can provide multiple benefits by utilizing one sustainable technology. While it is difficult to find a building technology that addresses such a range of concerns in the urban environment, there are technologies available that either singly or in combination can provide some or all of the benefits green roofs offer (Kohler 2005).

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Abroad, many urban planners have made gains over the last decade in terms of quantifying, confirming, and communicating quantitative data results to achieve relatively high levels of acceptance by developers, investors, and residents (Moxen 2000). This confirmation and ability to put an economic number on the diverse range of social, environmental and lifecycle benefits that green roofs yield has been cited in numerous stakeholder interviews[6] as being instrumental in legitimizing the technology to developers, urban planners and potential home owners.

In practice, accounting and assigning values that are easily and effectively communicated to a wide range of stakeholders is critical. In terms of accounting for costs and benefits when designing the built environment, stakeholders, city planners and developers need to transform how we value ecosystem services, our urban and natural environments, and diversify our demands from such developments.

2.2) The Quantified Benefits of Green Roofs:

2.2.1) Biodiversity Conservation and Habitat Creation.

Suitable habitat can be reclaimed for endemic hardy vegetation species, thus improving upon corridors of interaction and viable habitat to support higher and more complex levels of urban biodiversity (Brenneisen, 2006). The built environment needs landscapes that assist species in responding to increasing climate pressures, facilitating movement and establishing in new emerging ecosystems (Farrell 2010 pg 57). Only by doing this we will be able to maintain some degree of ecosystem service provision into the future. This will allow for increased socio-ecological resilience and improved service provision under scenarios of change (Farrell 2010 pg 57).

Roofs can represent up to 32% of the horizontal surface of the urban built environment (Oberndorfer 2007 pg 828), creating a 'concrete desert'. This statistic obviously differs depending on the nature of the urban environment. Studies report that this elevated urban ecosystem affords unique protection from grade level predators, traffic noise and human intervention. Research has shown that butterflies can access green roofs up to the 20th floor of urban building (Johnston & Newton, 1992). Bees, spiders, beetles and avian

[6] These stakeholders involve successful business owners Lance Sparling of Wakefield Homes, John O'Brien of WetCoast Enterprises, and former president Lynn Mueller of Earth Source energy and current CEO of Free Energy. (All British Columbian, (Canadian) companies).

communities have all been documented to benefit greatly from the habitat reclamation that green roofs are able to provide, and their diversity is directly linked to the richness and diversity of rooftop vegetation (Brenneisen 2006). Switzerland is the leader in terms of quantifying biodiversity benefits from extensive green roof programs that have been established decades ago (Brenneisen 2006). The EThekwini Municipality has been recording high levels of diversity from its green roof pilot project (GRPP 2010), which is a promising omen for biodiversity conservation and habitat creation in Cape Town's urban areas.

2.2.2) Storm Water Retention

The water retention abilities of green roofs are recognized by numerous urban planners and city officials over the world as the single greatest quantifiable economic and environmental benefit (Getter 2006 pg 1279). Green roofs are regarded as a Sustainable Drainage System (SUDS) technique, and can help to attenuate surface runoff, as well as to trap pollutants and promote groundwater recharge (GLA, 2005).
Urbanization and the increase in impervious surfaces typically associated with urban development have consistently been shown to result in degraded aquatic ecosystems (Carter 2006). With climate change comes an increasing frequency of air and water pollution episodes; rising sea levels and increased risk of storm surge; and changes in the timing, frequency and severity of urban flooding associated with more intense precipitation events (IPCC, 2001). These changes will, in turn, have both direct and indirect impacts on the ecological resources of urban communities (Wilby and Perry, 2006).

The water retention ability has been the major catalyst for the widespread adoption of extensive green roof development in Germany, Japan, Singapore, Toronto and New York as storm water infrastructure is a relatively expensive city utility service to expand (Getter 2006). It is also a benefit that can be quantified and measured in context of direct economic benefits to urban centers and thus holds great promise for positive reception by policy and decision makers. An American study found that if only 20% of all buildings in Washington DC that could support a green roof had one, they would add more than 71 million liters to the city's storm water storage capacity and store 958 million liters of rainwater a year (Getter 2006 pg1280). In North Carolina urban planners found that a 57-87% reduction in flow rates was possible on green roofs (Getter 2006 pg 1280).

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Ecosystem services will also be enhanced with the reduction, delayed release, and evapo-transpiration provided. Green roofs not only reduce the quantity of runoff from roofs but can also filter contaminants from rainwater, and provide a new source of green space for multifunctional landscape designs. Only by incorporating multifunctional landscape design coupled with a detailed understanding of the workings of our ecological systems to the development of land use strategies in the urban environment will we be able to maintain some degree of ecosystem service provision into the future (Farrell 2010 pg 59).

High levels of urban runoff pollute the receiving water bodies with heavy metals, petrol fuels, diesel, pesticides and animal waste. In some cases these substances can be taken up and broken down by the plants themselves (Johnston and Newton 1993). Most of these heavy metals and nutrients that exist in storm water runoff are bound in the green roof growing substrate instead of being discharged in the runoff (Banting 2005). Johnston and Newton (1993) also concluded that over 95% of cadmium, copper and lead and 16% of zinc could be removed from the storm water runoff through this binding and uptake in the growing substrate. According to the United States Environmental Protection Agency (USEPA, 2003), "the most recent National Water Quality Inventory reports that runoff from urbanized areas is the leading source of water quality impairments to surveyed estuaries and the third largest source of impairments to surveyed lakes".

2.2.3) Urban Heat Island Mitigation

Extensive green roof adoption has been documented in Toronto and New York to be very effective in mitigating the urban heat island effect (Getter 2006, Alexandria 2006 pg 486). In Toronto, a conventional roof can reach 70 degrees Celsius in the afternoon, while a neighboring green roof will reach only 25 (Getter 2006 pg 1272). The intensity of an urban heat island depends on many factors, such as the size of city and its energy consumption, geographical location, absence of green space, month or season, time of day, and synoptic weather conditions.

The urban heat island effect has been recognized and documented in publications since early in the industrial revolution (Howard 1818, cited in Landsberg, 1981). City centers can be several degrees warmer than surrounding rural areas due to the UHI effect (Wilby 2006) In the urban environment, it has been proven that the lack of vegetation, which controls evapo-transpiration, is the most significant factor contributing to the urban heat

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island effect (Alexandria 2006 pg 486).

Heat waves are expected to increase in frequency and severity in a warmer world (Meehl and Tebaldi, 2004 pg 996). With the increasing frequency of high temperatures as a result of global warming and rapidly increasing urbanization, heat waves pose a serious threat to human health in urban centers. More people die in the United States from extreme urban heat events than tornadoes, lightning, hurricanes and floods combined (Getter 2006 pg 1273). Using present-day relationships between extreme heat and summer excess mortality for the Los Angeles metropolitan area, heat-related deaths were found to increase by up to seven times by the 2090s even with acclimatization (Hayhoe, Cavan *et al*., 2004).

2.2.4) Existence Value

The importance and value of green space existence is recognized by the City of Cape Town as a viable and desirable benefit that increases community health, aesthetics, and decreases risks of "sick building syndrome" by boosting the positive psychological effects of the built environment in which people spend the majority of their time (GBG Draft 2008). Also, green roofs have effects in terms of decreasing sound pollution, and thus increasing the livability of cities. This acoustic effect is currently being researched and measured in the City of Vancouver (Connelly Interview 2010). Green roofs also work to filter air of pollutants, and have proven very effective with appropriate vegetation to filter diesel residuals out of the air near airports (Banting 2005).

Universities and private businesses have documented positive effects in terms of student, staff, client, customer, and employee satisfaction, retention, and recruitment results based on the green profile of their infrastructure (Herzog, Maguire et. al 2003 pg 162). Through the promotion of the aesthetic appeal of an urban center and the existence value of the built environment in which residents spend their time, a city can create more interest in itself for international and national tourists. More and more vacationers are basing their decisions on travel based on the aesthetics and green profiles of cities (Herzog, Maguire et. al 2003 pg 163).

Research suggests that the need for meaningful contact with nature may be as crucial for human health as the individual's need for interpersonal relationships (Kaplan 1993, pg 195). Green roofs provide psychological benefits to residents of urban environments by

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adding tangible, accessible and natural viewing space for social interaction, recreation, and relaxation. Research on human behavior suggests that a view of gardens and green plants serves to restore calm and reduce stress in humans (Thorns 2002).

Multiple studies suggest that humans generally prefer a view of natural settings rather than the built environment. Access to such organic environments, even if it's just by looking out a window, improves worker concentration and job satisfaction, and reduces the effects of work related stress (Hertzog et. al, 2003. Laumann et. al, 2003 and Leather et. al, 1998.) An interesting study by Taylor (2001 pg 55) concluded that children with Attention Deficit Disorder (ADD) were noticeably more relaxed and better-behaved after playtime in green settings compared with children who did not have access to such a green space. People's exposure to natural elements has been proven in multiple research studies over the world to improve individual's ability to focus, cope with stress, generate creative ideas, reduce volatility and promote the perception of self as part of a meaningful greater whole (Banting 2005). One of the greatest costs to a business, on average, is that of salaries. Any improvements in productivity, through occupant comfort, lighting, temperature and increased natural ventilation will have a major impact on the bottom line. The building commission of Victoria, Australia, indicates that optimal levels of indoor environmental quality would increase the Australian workforce's productivity by 30% (Langdon 2009).

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2.4) Adaptive and Mitigative Capacity: Management Principles and Practice

2.4.1) Determinants of Adaptive Capacity

Adaptive Capacity is the ability of an individual, ecosystem, species, or organization to respond to change, and the amount of time it takes to recover from such change. Increasingly, adaptation to present and future risks is understood as a process precipitated by the necessity of coping with extremes within gradual changes in mean climate parameters (Kelly and Adger 2000, Jones 2001). Many organizations and societies get locked into certain systems and ways of living and eventually become very adverse, rigid and un-able to perceive or predict change. Ecological and human organizations, from local governments, to rural farmers; from biome regimes to national corporations are facing new changes at variable intervals of speed (Robinson 2006 pg 4). Urban areas must adapt to a changing environment characterized by increasingly extreme weather events, heat fluctuations, disturbances to supply chains and stresses on public goods and energy sources. This ability to deal with change is alluded to throughout this report. Green roofs provide an option to increase opportunities available; an idea that can be drawn upon when this change in what we demand and expect from our built environment transforms in South Africa and the World. Response strategies themselves need to be flexible enough to be able to adjust to ongoing environmental and social change. Bare roofs offer an option to increase such flexibility with an increased number of options created from a space that previously offered no such thing. Hence, when faced with some degree of uncertainty, management approaches need to be iterative, flexible, and inclusionary; they must also take into account the technological, institutional, and management options that are available to individuals and communities (Adger 2001).

Adaptive management builds resilience that can sustain social-ecological systems in the face of surprise, unpredictability, and complexity (Adger 2003 pg 389). Management that enhances an organization's resilience must be flexible and open to learning. Attention and resources are applied to fundamental variables that create the capacity to innovate in both the social and ecological components of the system. By conserving and promoting the diverse elements necessary in reorganizing and adapting to novel, unexpected, and transformative circumstances, adaptive capacity in theory will be enhanced (Adger 2003 pg 289). Adaptive Capacity increases the range of surprises with which a socioeconomic system can cope (Adger 2003 pg 290). In the case of green roofs, such surprises will be the increasing frequencies of extreme weather events such as heavy rains and urban heat waves, and the issue of eco-system degradation that is directly correlated to our rate of urban expansion. Our success depends on how we adapt to these changes, and one option is vegetating unutilized rooftops to decrease the developed environment's negative impacts on an ecosystem's processes. Bringing together projections of change in the vulnerable physical and biological systems with potential human actions and responses through stakeholder engagement and conflict resolution is an important part of the adaptive ecosystem management approach (Adger, Kelly et. al 2004).

Gregory Bateson in a lecture at the University of California suggested that: nature is both creative and conservative (Weyler 2004). This lecture was in 1971. He termed the phrase "Embryology", which explains that while Nature demands that every new thing shall conform or be compatible with the regularities of the status quo the outside world is changing and ready to receive creature's which have undergone change. "Our human systems must honor coherence in their structure and imagination in their function"

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(Weyler 2004).

Although development is ultimately dependent on the processes of the biosphere, western culture has tended to take the support capacity of ecosystems for granted (Naess, Bang et. al 2005). Erosion of nature's support capacity leads to vulnerability. Adaptive capacity literature calls for policy and design to strengthen the perception of humanity and nature as interdependent, something that is strengthening through social evolution (Naess et. al 2005). Policies and design should interact with and stimulate development that enhances resilience in social-ecological systems, recognizing the existence of ecological thresholds, uncertainty and surprise (Adger 2003). Policy should create arenas for flexible collaboration and management of social-ecological systems, with open institutions that allow for learning and enhancement of decentralized communication (Adger 2003). Policy should stimulate ecosystem friendly technology and the use of economic incentives to enhance resilience and adaptive capacity. Policy should provide incentives that encourage learning and build ecological knowledge into institutional structures in multi-level governance. Successful examples of this include the BAF system adopted in Germany and Switzerland, or the involvement of multiple environmental groups with the USA's EPA in its green infrastructure initiative, as mentioned above.

Decentralized systems can contribute their successes and failures to personal initiative, voluntary cooperation, joint ventures, committee work and networking. Urban Blocs, Housing and Environment, traditionally fall within the jurisdiction of local governments, but in practice, the major decisions that can have the greatest impacts on these realms are made by National Government, such as the financing of large public works, housing programs, and the enforcement of environmental legislation (Sivaramakrishnan, 1996). A decade of research on vulnerability to climate change shows that inevitably it is the marginalized who suffer the impacts of changing environmental conditions (Ribot et al. 1996, Adger et al. 2001, Smit and Pilifosova 2001). Thus, adaptation to climate change requires a broader conceptualization of equitable, legitimate, and sustainable development in effective and resilient response. The public housing initiative currently underway in South Africa is a promising opportunity to experiment with the application of accessible green designs and technologies for the lower income groups of the urban environment.

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2.4.2) Determinants of Mitigative Capacity

The IPCC's Third Assessment Report defines a nation's mitigative capacity as reflecting 'its ability to diminish the intensity of the natural (and other) stresses to which it might be exposed' (Winkle Howells et. al 2007, pg213). The definition termed by Yohe (2001), and also used by Winkler (2007 pg 214), of mitigative capacity is "a countries ability to reduce anthropogenic greenhouse gas emissions or enhance natural sinks" (Winkler, Howells et. al 2007). Ability is the skills and competences, fitness and proficiencies that a country can contribute to GHG emission mitigation.

Green roof technology addresses multiple negative consequences generated by the urban built environment and make it a valuable tool in urban planning and design to help mitigate global warming and its predicted consequences. To design, implement and enforce policies, regulations or standards that would effectively foster the adoption of this technology could be considered what the UNFCCC refers to as pursuing sustainable development policies and measures (SD-PAM's). SD-PAM's are able to create synergies between sustainable development objectives and climate change policy (Winkler 2007 pg221). South Africa's National government has experience with implementing SD-PAM's in its current push to increase energy efficiency in the industrial sector through setting standards. The South African Government has outlined an energy efficiency strategy, setting a goal for an improvement in energy efficiency of 12% by 2014 relative to projected consumption (DME, 2005).

Steps that correlate to extensive green roof development from the SD_PAM approach include the identification of policies and measures that would make the development path more sustainable primarily for reasons other than climate change (such as greater social equality, and local environmental protection) while maintaining or enhancing economic growth (Winkler, Howells et. al 2007 pg 220). The UNFCCC, underlines the importance of quantifying and communicating the benefits from sustainable development as far as possible. These SD-PAM's can be existing sustainable development policy that is not fully implemented or new policies and/or more stringent measures. Another ability is to mobilize investment for the implementation of the SD-PAMs.

SD-PAM's suggest we look backwards from a desired future state of development. These involve key objectives such as accessible education for all, sustainable energy, energy efficiency, food security, poverty eradication, job creation, etc. This need for a future

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vision is critical to mobilize efforts to structure a development and design strategy. Cape Town has been criticized for the lack of a long-term cohesive vision or strategy in its city development (Counter Currents Panel Discussion 2010).

Sustainability in this context is defined as “providing services for basic human needs in a way that can continue overtime, resulting in a smaller carbon footprint while also providing more social benefits and economic benefits” (Winkler, Howell et. al, 2007). In meeting these diverse and different needs, different paths are infinitely available, and the aim of SD-PAM’s is to shift towards a more sustainable path of development. The UNFCCC believes that all parties have a right to sustainable development and ‘the policies and measures to protect the climatic system should be integrated with national development programs” (Winkler, Howell et. al 2007).

To build upon the institutional, economic and technological factors Winkler draws upon, I am including Yohe’s (2001) proposal for a more diverse set of determinants. The availability and distribution of resources required to underwrite their adoption and the associated , broadly defined opportunity cost of devoting those resources to mitigation must be identified. There must be a skilled and trained stock of human capital, including education and personal security. Countries access to risk-spreading processes (insurance, livelihood options, future markets etc), which also indirectly addresses inequality. The ability of decision makers to manage information, the processes by which these decision makers determine which information is credible, and the credibility of the decision makers themselves (Winkler, Howell et. al 2007).

A project will be effective only if it encourages public and private urban agents from the very beginning and is translated into concrete actions and measures that can be implemented. Only then will the viability of the plan be confirmed, generating trust among the actors promoting the plan and consensus among the population. Consensus instills loyalty and civic culture that becomes the backbone to strategic planning. A strategic plan must build or modify the image the city has of itself and in the eyes of others. Such transformations must also question the international presence and organization of the city governance. (Sivaramakrishnan, 1996 pg 230)

The UNFCCC created the term SD-PAM, to communicate the importance of properly designed policies and measures in increasing mitigative capacity as this capacity in

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decision-making and authority may provide an important link in the shift to new development pathways (Winkler, Howell et. al, 2007). Alternative development paths lead to different emission levels and compositions. It is the capacity of planners, society, private champions, business, etc that alters the development pathway's direction, collectively, through non-climatic policy (Robinson, Bradley et. al. 2006 pg 3). Edgar Pieterse, an author and Cape Town Architect, believes that Cape Town needs a strong behavioral shift if it is to get the application of available technologies right (Counter Currents Panel Discussion 2010). Paradigm shifts, highlighted by Pieterse (Counter-Currents Debate 2010), needs to move design and planning from the short term to the lifecycle approach of accounting for infrastructure costs. A shift from sectional efficiency to integrated performance, as Pieterse calls for a shift from private interests in development projects to a strong public interest (Counter Currents Panel 2010).

Technology is a critical capacity, which includes the ability to absorb existing climate-friendly technologies or to develop new ones (Winkler 2006). Institutional factors include the effectiveness of government regulations, clear market rules and trust, a skilled work force and public awareness and levels of education. Basic education plays a role in the deployment of mitigation technologies, a precondition for the ability to learn and adopt available technologies to a countries specific context, and further develop a countries own mitigative technologies. The higher the number of researchers per million citizens, the higher the mitigative capacity of a country tends to be. Green roofs need such researchers to dedicate themselves to quantify and communicate these benefits in economic terms. Public attitudes and awareness are also important to the success of mitigation capacity. Generally, a culture of compliance enhances regulatory effectiveness, while a society with a more international orientation is more likely to take mitigative action than an isolated one. Societies and countries that are directly exposed to the detrimental and traumatizing impacts of climate change, while also being informed of and educated in the anthropogenic causes, are more effective in taking mitigative action and supporting movements from capacity to action (Winkler, Howell et. al 2007 pg 220).

Mitigative capacity is based on objective factors such as economic factors, institutions and technology. This does not translate directly to nations taking up practices to increase their mitigative capacity. Abatement costs and political willingness, for instance, can deter capacity from translating to action in response to the risks of climate change. Response capacity (translating mitigative capacity to mitigation) is rooted in the

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country's development path. There are a small set of actions that achieve both mitigation and adaptation, such as an energy efficiency agency (Winkler, Baumert et. al 2006). With respect to climate change, differing perceptions of risk may lead to a wide variation in adaptation and mitigation. With high levels of perceived risk, this may lead to the activation of adaptive or mitigative capacity, and the subsequent implementation of effective response policy. Pieterse describes these risks and challenges to urban planners as being on an unprecedented scale, urgency and interconnection that will challenge decision makers to adopt a strongly systems approach to thinking, which on its own enhances an organizations and society's mitigative and adaptive capacity.

When considering the main barriers and opportunities that have faced current green developments in Cape Town some made themselves evident in the Panelist discussion, Counter Currents, (06.04.2010). The lack of a comprehensive city development strategy/ vision was discussed and unattested. Panelists agreed that a large part of the reason for a lack of a strategic vision is the absence of a cohesive identification of what it means to be a Capetonian. If you have no identification of what a typical Capetonian wants and how he/she lives, how do you agree on a shared and consensual vision for the future?

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<u>Chapter 3: Analysis of Policy and Avenues of Support in Relation to Green Roofs</u>

Policy Instruments to Aid Urban Roof Greening

Policies that have been designed to aid and promote roof greening in the urban environment can be grouped into a number of general categories. These would be direct and indirect regulation, direct and indirect financial incentives, and the funding of demonstration or research projects to quantify and communicate the benefits provided by such green space creation.

3.1.1) Direct and Indirect Regulations

Existing policies that fall under this category that have been used in urban centers to promote extensive roof greening include technology standards, performance standards, city guidelines, and homebuilder education institutions (Winkler 2007, Sivaramakrishnan 1996). By approaching extensive green roof promotion through technology standards and performance standards, a more command control approach is effectively adopted compared to other approaches that utilize a market-based approach (financial incentives). When determining which approach is most appropriate and effective, it is important to consider whether the costs of implementation are homogenous across the industry or if there is a significant degree of heterogeneity. If costs are relatively similar, then a policy based on standards can be as efficient as market–based approaches (Carter, 2008).

In North America, a number of states have adopted or drafted storm water management manuals, which identify storm water management standards primarily for new developments (Ngan 2004). Green roofs are specified in some cases as a storm water Best Management Practice (BMP) that can be used to meet the new development standards. Cape Town's storm water policy, is currently striving to promote the uptake of BMP's but fails to strongly suggest the use of green roofs in practice under BMP options, but does mentions it in passing (Roads and Storm Water Department 2009).

Areas of a city can be prioritized based on point source data, or a simple standard may apply across a jurisdiction. An innovative urban greening policy, which encourages green roofs, exists most strongly in Berlin, Germany, and Malmo, Sweden, and is generally known as the Biotype Area Factor (BAF). The objective of this policy is to improve upon an ecosystem's functionality as a whole and protect and enhance the related ecosystem services (Carter, 2008). It also promotes the development of biotypes in the city center to help host representative avian and insect communities. BAF can be defined as the degree of ecologically effective surface areas (indigenously and richly vegetated) as a percentage as the total land area under consideration. Different surfaces have different BAF values according to the ecosystem services provided, such as storm water retention, habitat creation, or connection with existing environmental features of the site (Carter 2006, Herzog 2003). This is a very interesting tool for placing economic value on biodiversity and ecosystem service concerns.

Technology standards include building code requirements that mandate the use of green roofs over all or part of a building's rooftop. Performance standards may specify an amount of on-site storm water retention that may be met through the use of green roof technology (Kohler 2005), or energy efficiency standards.

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3.1.2) Direct and Indirect Financial Incentives.

Because public benefits are, by nature, not fully realized by the party bearing the costs of roof greening installation, intervention needs to take place through policy to help compensate for the public benefits provided by the private individual (Ngan 2004). Many local authorities over the world have adopted this policy measure in some shape or form to promote roof greening (Ostrom 1999 pg 281, Ngan 2004). Usually the prioritization of areas or jurisdictions are mapped out depending on where it is believed that green roofs will most efficiently function. Such considerations include where the point sources of high levels of runoff exist, or high-energy use, temperature fluctuations and urban heat waves exist and need to be mitigated. Financial incentives have been offered in the form of density credits to developers, and storm water utility fee credits to help overcome the initial barriers of market entry for new technology (Ngan 2004).

The most prevalent green roof policies use some form of indirect financial incentive to support the construction of green roofs. Of these indirect incentives, a credit towards a municipality's storm water utility fee is used for encouraging green roof growth in the private sector (Ngan 2004). Unfortunately, the storm water management department of Cape Town currently has no program set up to collect utility payments for storm water fees. Such fees would normally be based on the amount of impervious surface that is found on a given site. Measures to minimize or mitigate for impervious surface, such as green roofs, are then rewarded a credit towards their storm water utility bill. This practice is being adopted largely in the United States to fund storm water programs with some research estimating there will be over 2500 municipalities and jurisdictions that adopt such utility programs in the United States by the end of this decade (Carter 2006).

In the United States, the Environmental Protection Agency (EPA) is promoting green roofs as well, under the Green Infrastructure Initiative, which includes under its letter of intent (Carter 2006) a partnership with four national environmental groups, formalizing a collaborative effort in promoting the benefits of using green infrastructure in "protecting drinking water supplies, public health, climate change mitigation, and reversing the loss of wildlife habitat" (www.epa.gov). This is a valid example of formalizing relationships between planning authorities and concerned environmental groups.

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The adoption of an evaluation mechanism much like the Biotype Area Factor (BAF) that is being used in Switzerland and Germany has been recognized as an effective way to assign value to the expected contributions habitat creation/preservation generated to local Biodiversity levels (Carter 2008). This is seen as enabling a platform for the evaluation of biodiversity and ecosystem service protection, and thus a degree of worth, which can be credited to those providing it. The BAF is useful in creating value for a market, which the authorities can use to incentivize the creation of habitat on rooftops. Policy makers must first decide how to assign value to biodiversity, steps that have already been taken by the City of Cape Town (Enviroworks 2009). The City of Cape Town already has an existing Biodiversity Network (BioNet) which has identified the minimum natural vegetation remnants needed to conserve a representative sample of Cape Town's Biodiversity (EnviroWorks 2009).

The US's Environmental Protection Agency's (EPA) active promotion of green roofs, under the Green Infrastructure Initiative, which includes a partnership with four national environmental groups, formalizes a collaborative effort in promoting the benefits of using green infrastructure in protecting drinking water supplies, public health, climate change mitigation, and reversing the loss of wildlife habitat. Cape Town has the human capital, practical knowledge and expertise to undertake this initiative. The development of a storm water utility fee, to promote the adoption of impermeable surfaces in infrastructure design is recommended by my literature review. The creation and support of a carbon financial market in the City of Cape Town would also be an important step forward to incentivizing the design of buildings to create such tradable credits.

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3.2) Building Standards and Guidelines

When reviewing the South African Building Standard guidelines (2008), the documentation and instruction on standards in terms of actively promoting, enforcing, and enhancing current energy efficiency of homes and buildings was of prime interest.

Mention of minimal standards, and the promotion of setting standards, or realizing high levels of recognition in terms of green design or sustainable development considerations was searched for in this document. The South African building standards and guidelines from 2008 dedicated a large portion of their sustainable development considerations into energy efficiency practices such as promoting energy efficient household appliances and light bulbs (DME 2004). There is no mention or promotion of green roof technologies in either the building standards or the building options for developers and low-income developers. This could be translated as a low level of understanding, political acceptance, and innovation in the building sector of South Africa and the leading building authorities when green roofing is concerned. The practice of painting rooftops a light color, or with reflective metallic paint is given a high level of acceptance as an effective temperature mitigation practice. This practice offers no other benefits, doing nothing for storm water runoff levels, the lifetime of the roof, and very little for interior temperature regulation. And yet this practice is mentioned when considering green building practices, with minimal reference to extensive green roofs (DME 2004).

The Council for Scientific and Industrial Research (CSIR) in South Africa is one of the leading scientific and technology research, development and implementation organizations in Africa. It undertakes directed research and development for socio-economic growth. Research areas are diverse, and there is branch that deals with natural resources and the environment. Such sub sections include climate change mitigation and adaptation, resource based sustainable development, pollution and waste, ecosystems, and water body protection. The organization also has a research branch for the built environment, which encompasses planning support systems, infrastructure engineering, and rural infrastructure and services. This organization is directly associated with conceptualizing and measuring the outcomes of building innovations for Agrément South Africa certification applications.

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Agrément South Africa plays an important part in the introduction of innovative construction products and building systems. Agrément South Africa's mandate states that "it shall support and promote the process of socio-economic development in Southern Africa as it relates to the construction industry by facilitating the introduction, application and utilization of satisfactory innovation and technology development" (Odhiambo 2007). Agrément's technical assessment and certification can persuade users of the merits of innovative products that contribute to sustainability in construction, by providing assurance to the consumers and thus facilitating the introduction of innovative construction products and building systems.

Engineers in South Africa have come to rely so heavily on products and design procedures for which there are SABS standards and codes of practice. Such professional behavior leaves a gap in the path of construction innovations, as without Agrement there could be no standards for innovation in design. The Minister of Public Works established Agrément South Africa in 1969, (Odhiambo 2007) to facilitate the introduction, application and utilization of innovation and technology development in the construction industry. Tali Bruk of ARG Design also argued the opposite, that in many instances, especially with building techniques and designs that are traditional and low income, the high costs of certification can hamper the growth and acceptance of more environmentally responsible building methods (ARG design interview 2010).

However, where a product falls outside the experience of the local authority's building control officer, the product champion has the option to require an assurance regarding the fitness-for-purpose of the product before approving it for construction. This assurance can be given in one of four ways; by submission of a test report from the CSIR, the statutory science council for research and development; by submission of a test report from the South African Bureau of Standards (SABS); by submission of a valid certificate issued by Agrément South Africa, or by verification of a design by an independent Professional Engineer (Odhiambo 2007).

There are two independent organizations in South Africa that are concerned with technical approval - the South African Bureau of Standards (SABS) and Agrément South Africa. While SABS operates in a wide range of areas, Agrement SA limits its activities to the construction industry. Agrément South Africa assesses innovative, non- standardized construction materials, products and systems and maintains links with the World Federation of Technical Assessment Organizations (WFTAO) and other Agrément organizations (Odhiambo 2007). Agrément's evaluation and certification becomes relevant during the product development phase when, through technical assessment of prototypes, it can indicate to the entrepreneur whether the product will be fit-for-purpose. Agrément South Africa's role is strongest during the product's introduction into the market, when its certificate provides the entrepreneur with the instrument he needs to demonstrate his product's suitability for specified uses, while providing the user with the necessary independent, objective information and advice on the product's characteristics, benefits and limitations.

SABS's role generally starts at the market acceptance and growth phase of a new industry's life, and can eventually play the dominant role in the ongoing marketing of the new product (Odhiambo 2007). A product's listing through SABS's marking schemes

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provide the entrepreneur with the quality image needed, and the consumer/user with a reliable, credible source of quality assurance. Within the World Federation of Technical Assessment Organizations, there is scope for liaison agreements between national member organizations. For instance, the Canadian Construction Materials Centre (CCMC) and Agrément South Africa have a liaison agreement in terms of which they: maintain communication on new developments, information exchange, and share technical information from research (Odhiambo 2007).

Agrément certification of each new construction product is not generally a prerequisite for entry into the construction market, unless for specific construction products where consumer bodies such as the National Home Builders Registration Council insist on Agrément certification (Odhiambo 2007). Many manufacturers apply for certification because it is an effective marketing tool as it lends credibility to their products. It remains unclear whether Green roofs would require Agrement certification as a prerequisite for market entry. Agrement certification is one route available to entrepreneurs and manufacturers of sustainable construction products and to encourage the use of innovation.

Section 4.1 of the National Building Regulations and Building Standards Act (Act 103 of 1977), is the enabling Act under which the National Building Regulations are made. These regulations define how South Africa's built environment is designed, planned and constructed. Building standards in South Africa are governed by the National Building Regulations. These are functional regulations. They specify how the building must perform but do not prescribe how this may be achieved. Compliance with the regulations is facilitated in the case of conventional building methods, by the provision of deemed-to-satisfy rules that are set out in SANS 10400 code of practice for the application of the National Building Regulations. Neither the National Building Regulations nor SANS 10400 makes any reference to neither thermal performance or energy usage.

The only comprehensive green roof guidelines in existence today is released annually by Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (FLL) a landscape industry organization in Germany (Banting 2005). Germany today is the industry leader in green roof design, technology and manufacturing, and their green roof guideline is thus considered credible. The first English version entitled "Guideline for the Planning, Execution and Upkeep of Green Roof Sites" was issued in 2002. The document covers

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design, construction and maintenance of green roofs. In addition to green roof standards, many European jurisdictions have established green roof performance requirements. These performance requirements are different from standards. They build and rely on standards for green roof specifications to meet specific policy or incentive requirements in a municipal jurisdiction. This would be important in the case of Cape Town if for instance, the green roof industry were being mainstreamed for biodiversity and storm water management concerns.

The FLL Guidelines in English contain very detailed information pertaining to the planning, execution and upkeep of green roofs. The guidelines also include requirements for quality control and assurance. Section 12 provides details of the tests that should be conducted to ensure components meet the requirements set out in the guidelines. The FLL guidelines, in general, could be applicable to green roofs in the City of Cape Town as long as those of local plant species replace the plant requirements, and consideration for local building materials and building practices (structural integrity) are taken into account (Tali Bruk Interview).

Some of the barriers such as lack of knowledge in terms of green roof construction and design implications can be addressed directly through learning from other countries, more specifically Germany's FLL Guideline. For greater acceptance in markets across South Africa, and further guarantee of a product, Agrement Certification is recommended and in many design applications considered a prerequisite (Odhiambo 2007).

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3.3) Biodiversity Conservation and Habitat Reclamation

Healthy and functional ecosystems are globally recognized as the first line of defense against climate change and storm damage. The importance of increased vegetation to help manage the increases in extreme rainfall events is declared in the city's energy and climate change biannual report (EnviroWorks 2009). This document acknowledges that it is critical that Cape Town applies appropriate considerations to all future development in order to halt the destruction and ensure the conservation of remaining biodiversity. Biodiversity conservation in Cape Town today has strong policy connections in terms of reaching conservational goals while simultaneously producing local employment and opportunity (working for water, Cape Flats Flora Program) (Maze 2002). Such experiences in the successful design and implementation of SD-PAM's is an asset of experience and knowledge for the city of Cape Town. Green roofs provide an excellent avenue to reclaim lost wildlife habitat from previously barren and inhabitable open spaces. This section will explore how biodiversity concerns and initiatives have been mainstreamed here in Cape Town, and how green roof policies could draw upon Cape Town's internationally recognized levels of biodiversity to promote green roofs, much like the example set by Malmo, Switzerland (Brenneisen, 2006).

The City of Cape Town's Economic and Human Development Strategy realizes the impossibility of placing a value on Cape Town's environment, but they have made an attempt to estimate the contribution of unique species and the natural beauty that is made to Cape Town's economy. Conservative estimates place it between 2-6 billion Rand annually, with the natural environment making up 60% of this value (EnviroWorks 2009). Ecosystem services require monitoring, evaluation and re-evaluation (Farrell 2010).

The Western Cape in particular has a history of time-consuming and costly conflict between conservation interests (societies such as WESSA, BotSoc) and development (Gelderblom et. al 2002), which has subsequently seen the ongoing destruction of habitat and biodiversity in leeway of human population and economic growth. On October 2001, the City adopted the first Integrated Metropolitan Environmental Policy (IMEP), which encompassed a Biodiversity Strategy that aims to protect, optimize or enhance Cape Town's unique biodiversity (EnviroWorks 2009). To implement this strategy, the city now works closely with key regional conservation initiatives. A fundamental principle underpinning this strategy is the working in partnership with a wide range of organizations and individuals. Before this, biodiversity and conservation was low on the City's agenda. Approaches to biodiversity have historically been characterized by fragmentation between actors and interest groups. With many different authorities responsible for the protection of biodiversity and little coordination or integration between parties, the few reserves were set aside on a site specific basis, rather than within a systematic conservation planning approach (EnviroWorks 2009). During the 80's and 90's there was no clear strategy or delegated body for implementation (Enviroworks 2009). With the creation of the City's biodiversity strategy, an opportunity to start afresh was presented.

The eventual independent initiation of the systematic planning programs by both biodiversity conservationists and the development planning authorities has resulted in

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an environment conducive to collaboration between the two potentially conflicting interest groups (Gelderblom et al. 2002). Gelderblom et al. (2002) recognizes that the independent conservation planning which involves the defensible identification of priority areas with visual biome mapping, fatefully corresponded to the launch of the Western Province's building authority's new strategic bioregional planning initiative. This marked the beginning of biodiversity considerations being mainstreamed into decision-making processes in land use planning and implementation. This collaboration is benefitting both the housing authority with more efficient land use planning and development control, and the biodiversity conservation community with a cooperative atmosphere for informed decision-making.

This initiative could not have taken place if it were not for South Africa's long history of excellent biodiversity research, record keeping and mapping that dates back to the 18^{th} Century (Cowling 2002). Much of the understanding for mainstreaming biodiversity has its origins in collaborative and trans-disciplinary research that was fostered by the Cooperative Scientific Programs (CSP) of the Council for Scientific and Industrial Research, which ran from the mid 1970's to mid 1980's, and is still providing benefits to the country through this independent collaboration (Gelderblom et al. 2002).

Bioregional planning emerged as an integrative concept that brings knowledge together with decision-making in a cooperative environment that combines ecosystem management and development planning into a single framework. This formalization of cross-sectoral partnerships, brought about by the collaboration of dynamic individuals who built the bridges between two competing sectors under a different light, has now bloomed into a more effective way of sustainable planning and making responsible development decisions in Cape Town. This bioregional planning approach is particularly well suited for biodiversity initiatives in the Western Cape, and should be considered in green roof development when selecting viable indigenous species, and selecting growth mediums on the roofs that will make the greatest contributions to supporting further gains in biodiversity (plants that host endemic insects and birds).

Maze (2002) argues that there is still a great need to improve the ecological understanding of urban conservation, especially the effects of population isolation and the role of corridors. Extensive green roof adoption could possible alleviate the stressors

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on urban biodiversity over time and with growing numbers of green roofs and research to understand their impacts (Breinneisen 2006).

South Africa is one of the few countries in the world to have a Biodiversity Act and a National Biodiversity Institute, the South African National Biodiversity Institute (SANBI website). The Urban Nature Program through SANBI engages with ecological scientists, agencies of local governance and civil society, to promote the environmental perspective that the urban environment is of importance for human and ecosystem well-being through project-based activities, a national networking initiative and a communications facility.

The national networking initiative aims to co-ordinate urban related work within SANBI and to identify channels for the development of good practice to enhance or conserve levels of biodiversity. The aim is to make institutional knowledge, expertise and skills regarding biodiversity available to municipalities and other local authorities with the mandate for management and protection of urban ecosystems, especially those with high ecological and heritage value (Holmes 2008).

SANBI's Climate Change & Bio-Adaptation Division leads and co-ordinates research and communication regarding South Africa's response to the biodiversity impacts of climate change. They undertake scientific work, and also provide communication and policy products to support world-leading efforts by the national Department of Environmental Affairs in climate change responses. This Division's activities include the understanding of carbon dynamics, climate change impacts and vulnerability, and adaptation to climate change

Research undertaken in Switzerland suggests that in the most successful cases that green roofs can host healthy levels of biodiversity and can become functional biological systems, and over time, can become host to valuable endemic patches of vegetation and fauna habitats (Breinneisen 2006). The ability and importance of this technology to re-create indigenous habitat to promote urban biodiversity would compliment and relieve the stressors that threaten City of Cape Town's Biodiversity. Cowling et al. (2002 pg 145) suggest that "The production of under-represented biodiversity might require the integration of conservation in production landscapes… with due consideration of socio-economic issues, especially incentives and alternative employment opportunities."

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3.4) Cape Town's Green City Guidelines

Cape Town realizes that they need to start moving towards a more compact, resource efficient city. The city realizes that to achieve this without further contributing to global warming, means that they must start embracing new technologies, dense city planning and a low-carbon economy (EnviroWorks 2009). The City of Cape Town recognizes the massive opportunities for job creation, skills development and poverty alleviation through the movement of the city towards a low carbon economy and use of renewable and green technologies (EnviroWorks 2009).

The *Sustainable Landscapes, Practices and Guidelines (2008)* released by the City of Cape Town's facilities management is an informative resource designed to increase resource efficiency, minimize waste, and enhance the performance of Cape Town City's buildings and facilities.

One of the sub headings under sustainable landscape practice is water management. Under this section water efficiency, quality, rainwater harvesting, irrigation methods and pollutant concerns are expressed, yet no mention of the use of impermeable surfaces, or rooftop gardens is mentioned as a measure that can be taken to help manage water runoff on site, and minimize point source effects. The City Guidelines, through the discussion of the importance of greening projects, low maintenance costs and the promotion of indigenous vegetation in landscape design, indirectly connect the benefits the City most values, and those that would be expected from an extensive roof greening in Cape Town.

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Under section 8 of sustainable landscapes, *Hardscape Materials and Structures*, green roofs are recognized as a viable substitute for lost areas of landscape. The City of Cape Town recognizes the benefits to biodiversity and water management that can be realized from roof greening projects. The guidelines state on page 15 "Green roofs offer new habitats for fauna and flora to remain within urban areas and reduce the immediate water run-off by rainwater retention on site. Moreover, green roofs improve the microclimate and reduce dust and smog levels. Green roofs reduce sound reflection and improve sound insulation. Green roofs also improve the thermal insulation, which reduces the cost for heating and cooling. They protect the waterproofing from UV exposure, heat, cold, and hail, which considerably increases the life expectancy of the roof

(CPT Guidelines).” The Guideline goes on to say that the quality of life in urban environments is making the issues surrounding these benefits more critical than ever before. They acknowledge that green roofs meet the objectives of many of the mandates to improve air quality of cities by mitigating the urban heat island effect, reduce storm water runoff, the addition of valuable space that provides economic and mental benefits, contributes to energy efficiency of the building year round, and acts to purify air and water. This acknowledgement is significant as it indicates that the endorsement of these guidelines by Council and could translate to a commitment to these values and ethics concerning planning, design and development.

The Guideline concludes its section on green roof technologies by expressing the increasing interest in the green roof system as a sustainable building design option in South Africa. Of all the benefits listed in the guideline, it fails to mention the possible gains in biodiversity concerning insects and avian communities, and how this benefit meets the biodiversity conservation objectives of the City of Cape Town’s sustainability planning.

The section on Biodiversity in the sustainable landscape guideline outlines the City’s objectives for protecting and enhancing Cape Towns Biodiversity. The guideline strives to promote the creation of landscapes that are environmentally sound. The guideline recognizes that South Africa’s plant conservation efforts could be improved as it has the second highest number of extinct plants in the world. The recognized threats by the guideline to the Cape’s biodiversity are: high rates of land transformation, urban development, environmental pollution, climate change and land degradation. Green roofs can directly address the first three of these concerns brought forward by the loss of biodiversity. As human populations grow, there is a corresponding higher amount of pressure on natural resources. “Incorporating the principles of sustainability into new or existing landscapes will enhance the environment for humans, plants, and wildlife. It is critical for South Africa to actively engage with sustainable landscape objectives and contribute to the City’s environmental concerns and global warming”(Green Building Guidelines 2008). The re-creation of landscapes, a benefit the city has realized in green roof projects, can be incorporated into biodiversity enhancement concerns by creating indigenous, environmentally valuable landscape designs on urban rooftops.

Another aspect of achieving sustainable development is addressing the methods of

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measuring benefits from such green initiatives, and setting and enforcing standards that are proven to produce such benefits. Section 12 of the City's green guidelines, Setting Standards and Training, addresses this issue. In this section it is acknowledged that to reduce the negative environmental impacts of urban facilities, changes in various standards must take place. This change is also needed along with operational procedures and other documents that define how urban facilities are designed and managed (Green Building Guidelines 2008). Modifying standards need to be followed by a comprehensive training program geared towards benefit communication and importance of sustainable practices is strongly recommended by the guidelines. The guideline offers up its contents as material for such training, to be supplemented with a wide range of government, private sector, and academic information resources concerning environmental issues as they relate to the design of Cape Town's urban environment.

Even more critical and difficult for the City's sustainable design goals are the financial issues that are associated with this initial change. This financial challenge can be addressed with the effective communication and education of the true costs and benefits of green design, quantifying the economic, social and environmental benefits that will be reaped during the lifetime of the building. Increases in property value, tenant satisfaction, and public health should be communicated and valued.

The Green Building Guidelines Draft (2008) of the City of Cape Town is currently a guideline, but in the long-term the City will work towards design manuals and legislation to ensure the implementation of green buildings (GBG Draft 2008). The Green Building Guidelines document is aligned with the Green Building Council of South Africa, which has incorporated the Green Star Rating system of the Green Building Council of Australia. It is envisaged that the City of Cape Town will incorporate the Green Star Rating system in the future (GBG Draft 2008), as it is the rating system with the strongest presence in South Africa, promoted and used by the Green Building Council of South Africa.

The Green building guidelines draft provides practical guidelines for the implementation of green technologies into building design and site planning. Each section provides an overview of relevant issues and specific recommendations that should be implemented to address such issues. Sections have been included that address particular concerns that green roof technology can address directly.

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The establishment of a knowledgeable and trans-disciplinary team is recognized in section 3.2.1 of these guidelines. The need to establish a design team that is familiar with the principles, and ethics of environmental sustainability and green building design is held in the guidelines as the most important aspect of sustainable building. The importance of providing information, and training, to ensure that all parties (such as engineers, architects, demolition and construction workers including sub-contractors) understand the reasons, and goals for developing a site in a sustainable manner is understood.

Increasing access and opportunity for recreation and gardening in urban areas is becoming increasingly valued in Cape Town where space is limited (GBG draft). Hydroponics and other lightweight methods, are recognized by the guidelines as a promising technology to increase access to green roof technology as they decrease the weight of green roofs, and thus enhance structural capacity. Peter MacKintosh of MDC Holdings in Mozambique offers a light weight growing medium made of coconut husks and other local derivatives, such local products and innovations can lend a valuable input to Roof top landscaping and decrease the structural support requirements needed to install a green roof.

Economic impacts and employment generation are an important aspect when considering the design or refurbishment of a building, in section 3.2.12. The city recognizes that the link between the capital costs and the operational costs of a building is seldom considered. Capital costs are usually about 20% of the total costs of a building over the lifetime of the building here in South Africa (GBG Draft). A strong and diversified local economy is also identified by the guidelines as imperative for sustainability. Local industries can grow and benefit from developers and design utilizing local contractors, building materials, and components such as fittings and building materials and supporting local businesses during construction and maintenance.

Recommendations are made for the design phase of new building projects in section 3.2.13. The guidelines recommend taking the operating and maintenance costs into account. Incorporation of design features that minimize the natural weathering and degradation of the building is mentioned. The guidelines ask for the consideration of the implementation of a roof garden, and other integrated planting, where appropriate. Visual mitigation measures are also referred to in the guidelines in section 3.8. The

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previous chapters in this section refer to practical design solutions, which aid in achieving green buildings.

Section 17 of the Act establishes the framework within which the Counsel (City of Cape Town) may make regulations. This framework is largely framed around administrative matters, the protection of property and the general safety, health and convenience of the public in so far as they relate to the erection of buildings and of users and occupiers of buildings.

3.5) City of Cape Town's Storm Water Policy.

Cape Town's City Management of Urban Storm Water drafted an Impacts Policy, which was approved by Council (City Management) on the 27th of May, 2009. Urban water bodies are recognized in *Cape Town's Management of Urban Storm Water Impacts Policy* to be valuable environmental and recreational resources. The city is well aware and informed of the need for protection and enhancement of ecosystem services in the face of climate change. Local and international strategies that target sustainability and climate and energy issues are being enhanced in face of the negative impacts produced by our urban environments (Ngan 2004). The deleterious urban environment impacts on receiving water bodies (rivers, streams, estuaries, groundwater, wetlands, and coastal waters) from storm water runoff. Such concerns include declining water quality, diminishing groundwater recharge and quality, stream channel degradation, increased flooding events, floodplain expansion, and loss of ecosystem integrity and biodiversity. These negative effects are direct results from human's interference on a large scale of the natural water cycle mostly through urban development. The storm water department in Cape Town recognizes that this is a result of the creation of impervious surfaces, and the concentration and acceleration of storm water runoff through pipe and canal networks. Thus absorption, attenuation, and quality improvement of runoff through natural processes are completely lost, exposing ecosystems to polluted, heated and heavy medaled waters.

The policy's stated intention is to 'minimize the undesirable impacts of storm water runoff from developed areas by introducing Water Sensitive Urban Design principles (WSUD) to urban planning and storm water management in the Cape Town Metropolitan area (Roads and Storm Water Department 2009). Objectives include: to reduce the impact of flooding on community livelihoods and regional economies, to safeguard

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human health, protect natural aquatic environments, and improve and maintain recreational water quality. Best Management Practices (BMP's) are defined as devices, practices or methods for removing, reducing, or retarding runoff flows, or preventing targeted storm water runoff constituents, pollutants and contaminants from reaching receiving waters (Roads and Stormwater Department, 2009). BMP's include structural and non-structural controls and devices as well as operation and management procedures. The policy also draws upon the term Water Sensitive Urban Design (WSUD) which is an approach that seeks to ensure that development in urban areas is holistically planned, designed, constructed and maintained so as to reduce negative impacts on the natural water cycle and protect receiving water bodies and aquatic ecosystems. This approach encompasses sustainable water supply, sanitation and storm water management. Source controls, which are non-structural or structural best management practices to minimize the generation of excessive storm water and pollution at or near the source are also recognized as valuable entities. Green roofs would fall under this definition, and throughout the policy such terminology is used.

The Catchment, Stormwater and River Management Policy (CSRMP) of the City of Cape Town was well received by external audiences such as DEADP and the Department of Water and Forestry (Candice Haskins email interview, March 9, 2010). The policy also prompted the Branch to undertake a series of seminars aimed at professionals in the engineering, architecture, landscape and environmental fields. Candice Haskins reports that already this initiative and roll out of the new policy is being rewarded by an increase in development applications coming in with various aspects of the policy being implemented. Haskins also reported that to date, there has been no use of green roof technology in development applications trying to impress upon the new policy recommendations.

This policy document is openly concerned with the lack of parameters and guidelines for best management practices. The existing building and storm water management guidelines do not prescribe under what circumstances water quality treatment and what BMP's must be applied to new developments, and fail to specify the parameters and required outcomes to enable detailed town planning and engineering plans of BMP's. While the road and storm water department's guidelines for new developments are generally adhered to in respect to limiting peak flows (CSRMP 2009), the measures do little to limit other impacts on receiving water bodies.

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The fundamental principle this policy is pursuing is that the person or body, whether private or public, who creates a development should do so responsibly and should ensure that such development does not adversely impact on present and future communities and on ecosystems. This policy realizes that to succeed, building law must make developers accountable for the improved or degraded quality of storm water runoff, through controlling quantity and rate of storm water runoff; and encouraging natural groundwater recharge. This is a promising step forward for the City of Cape Town, as an initial movement towards making a building, and its developers, responsible for a development's impervious surfaces and polluting storm water runoff. The enforcement or widespread adoption of such environmental concerns can open up opportunity for roof greening as a BMP option for developers who want to comply with storm water management concerns.

Policy implementation, as in the application of water sensitive urban design (WSUD) into urban developments through the thoughtful application of urban drainage systems in new and existing developments creates a healthy environment for new green designs such as green roofs in the city of Cape Town. New developments shall be planned and designed to incorporate sustainable urban drainage systems in accordance with the *City's Storm Water Management Planning and Design Guidelines for New Developments* as well as with international best practice. The policy also reserves the right for Council (City of Cape Town planners) to, under certain circumstances, require a storm water management plan to be submitted.

The following two sections of the Storm Water bylaw of Cape Town have been highlighted as promising in the adoption of green roof technologies in Cape Town. The ability of the city to develop and experiment with incentive schemes that touch upon these two sections is critical to the initial years of establishing a green roof.

6.2.7, Integration into the environment: Best management practices should promote urban biodiversity, and enhance the amenity and aesthetics of the development site and its surroundings.

6.2.8, Incentive schemes: Council (The City) may introduce incentive schemes to promote and facilitate adoption of WSUD measures by private developers and individual households where appropriate.

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It is valuable and indicative of a city policy that realizes the importance of storm water management that directly works to limit the negative impacts of urban development to water systems. The accounting for water sensitive urban design (WSUD) and storm water BMP's needs to be exercised in building application requirements strongly and practically. The conclusion of the CSRMP resulting in seminars and increased development applications taking into consideration the new storm water requirements is a telling result of the Cities receptiveness to such development pathway shifts.

This Chapter has highlighted the innovative, modern, holistic and sustainable policies of the City of Cape Town in dealing with biodiversity concerns, stormwater management and building guidelines. Although it is also being unearthed that such policies, bylaws and suggestions are not translating directly to action, results and political motivation. On paper, the City of Cape Town is an ideal political environment for the creation of new green technologies and designs, but in reality such processes are being hampered by lack of certain City department commitment, more pressing concerns, and lack of funding. As Gregg Adams of DEADP said, it will take the actions of the private sector to get green industries going, as the City already has too much on its plate.

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Chapter 4: Practice Analysis and Potential Support

The selection of case studies was used to reflect the broad context and scope that the rest of the thesis portrays and needs. The final analysis and product of the research is meant to inform and prepare suggestions for the City of Cape Town in terms of what other urban areas have achieved in terms of green roof adoption. Cape Town is the main case study focus, but because of lack of developments that have incorporated green roof technologies the spatial scope of analysis has been broadened. The case of EThekwini is used as an example of how municipalities through partnerships can research and experiment for the most effective growing mediums. Vancouver and EThekwini are drawn upon as secondary case studies as they provide examples of capacity building practices that were not evident in the City of Cape Town.

4.1) EThekwini Municipality: Green Roof Pilot Project

Durban, like Cape Town is also addressing energy and climate issues in its municipal climate protection program, which was adopted in 2004. The EThekwini case study shows that individuals and NGO's concerned with biodiversity can influence decision making processes and planning at a municipal level with effective communication tools (biome mapping, natural resource economics, ecological data and effective communication) to demonstrate the real benefits of measures that protect and enhance biodiversity. Detailed ecological data was cited as being instrumental in communicating to urban planners the criticality of conserving biodiversity. The municipality of EThekwini is experienced in mainstreaming biodiversity issues not through pure conservation, but through the use of urban open space planning as a body for biodiversity interests in Durban (Roberts and Lewis 2010).

The EThekwini municipality, with the help of WESSA and other individuals, were able to design an urban green space system that was an ecologically viable and self-sustaining alternative, as opposed to being a collection of isolated conservation sites. Resource economics was also used as a tool, allowing the value of open space to be communicated in terms that were meaningful to the diverse majority of stakeholders involved with open space design and planning. Prior to the use of resource economics, the value of open space was not well understood, and was previously undervalued during decision-making and resource allocation processes (Roberts and Lewis 2010). Through this

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communication process, a NGO that was concerned with ad-hoc development and its impacts began to influence provincial policy development. Perhaps this use of resource economics in valuing open space can be seen as a potential catalyst for communicating the external benefits associated with the open green spaces created by green roofs.

Urban and regional planning's ability to coordinate with biodiversity interests in South Africa make the partnership in EThekwini of particular interest when looking at possible avenues to foster and promote roof greening practices here in Cape Town. As party to the convention on biological diversity, South Africa's government is obliged to mainstream biodiversity issues into relevant cross-sector programs and policies. From the literature review the sectors that seem most effective in mainstreaming biodiversity concerns include urban and regional planning, natural resource use, and conservation. From the case studies of EThekwini, the Cape Flats Flora Program, Working for Water, and the use of biome mapping to coordinate between developing authorities and biodiversity conservationists in the Western Cape, prerequisites become apparent. Such prerequisites to mainstreaming biodiversity in planning include knowledge, capacity, a specific and accepted need, and stakeholder commitment, followed by a stimulus (factors external and internal to the sector that catalyses awareness of the need for mainstreaming actions) (Maze 2002 pg 93). Research and previous experiences in mainstreaming biodiversity is important, as such complex systems that are inherent in biodiversity levels are very difficult to facilitate in a manner that seeks to plan and impede upon on the systems we are trying to protect. Threshold limits and system capacities are largely unknown, and only with research and trial and error can urban planning effectively protect biodiversity levels in its design and planning.

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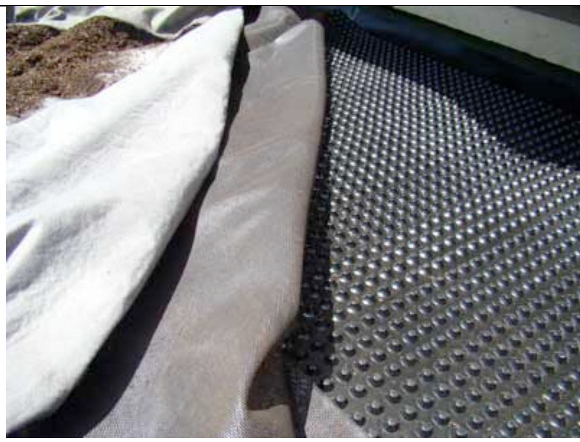
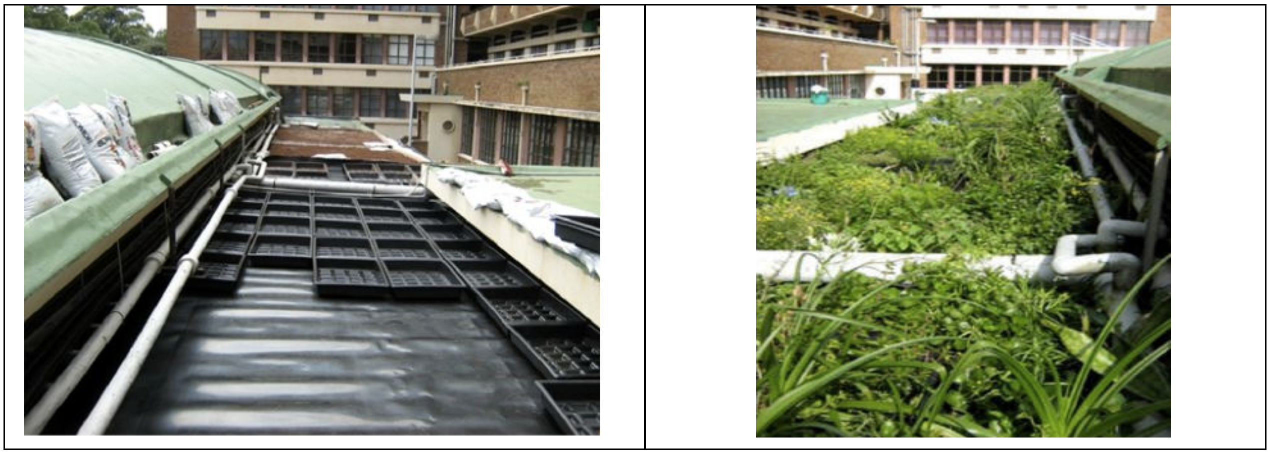
The EThekwini Municipality initiated a Municipal Climate Protection Program (MCPP) in 2004. As part of an adaptation work stream, the Green Roof Pilot Project (GRPP) was initiated in 2008. The aim of the GRPP is to promote urban biodiversity while simultaneously addressing the impacts of higher temperatures and increased frequency of high intensity rainfall events that are projected to occur in Durban (Roberts and Lewis 2010). The GRPP utilized both the modular and direct applications of green roof technologies, modular being removable trays of vegetation placed on a filtration and runoff network, in contrast to a direct green roof application is when vegetation is placed onto specifically designed green roof layers that are on top of the existing roof (as shown in Figure 2). This modular system is especially useful for first time experiments in green roof applications as alterations are easy to make as they can be removed without disturbing the plants and growing medium and easily changed, as opposed to the direct application where alterations create much more disturbance to the system. The GRPP is the first of its kind in South Africa in terms of producing primary research on modular and direct green roof applications. Green roof entrepreneur Clive Greenstone was involved in the construction and maintenance of the experimental green roof.





Left: 6 Months with the modular roof. Right: 6 Months with the direct green roof application.

Figure 2: EThekwini Green Roof Pilot Project
Source: http://www.greenroofs.com/content/guest_features010.htm (Accessed 5/01/2011)

The goal of the GRPP is to provide an analysis of green roof applications in order to "understand the complexities and benefits of this form of urban management from a South African perspective" (Roberts 2010). The project's research questions were:

- What are the benefits of the two types of green roof applications (modular, Direct)?
- What are the different growing mediums and their characteristics?
- What are the ranges of flora that can be considered suitable for future green roof interventions?
- How can rooftop greening address urban environmental, agricultural and food security issues?
- How can green roofs reduce surface run-off?

- What are the structural engineering implications as well as the construction techniques and constraints involved with green roof applications?
- Do green roofs offer an opportunity to promote inner-city biodiversity on underutilized empty roofs? (GRPP 2010)

This research is, to date, the most significant attempt to quantify the benefits of green roof applications here in South Africa, and may prove instrumental in getting a local self-sustaining green roof industry growing. This program is placing Durban ahead of any other South African Cities in terms of research and fostering a green roof industry expertise, which in future will be called upon by other South African Cities to green their rooftops. This project is also filling the gap when it comes to the information available to building owners, policy makers and designers when considering green roof retrofits or design in South Africa.

The report lists the lessons learned, ranging from footwear when installing the delicate waterproofing, to root systems of certain plants that can penetrate the root barriers compromising the water membrane, all lessons learned go to show how context specific research for green roof implementation is critical not only during the infancy stages of this technology's adoption, but along the way as it is an ever evolving technology that can be altered and played with in terms of engineering, substrates used, and vegetation cover.

Temperature probes were placed in various areas of the pilot project, and data loggers were programmed to record temperature readings at various times of the day. Storm water runoff was also measured, as separate collection drums were set up to collect run off from the modular, direct application, and conventional sections of the roof. This research proved that green roofs do in fact help mitigate storm water runoff to a great degree (Roberts 2010). In September of 2009, the EThekwini Coastal, Storm Water and Catchment Management Department installed data loggers, electronic tipping rain gauges, water usage meters and water runoff loggers at the GRPP site to replace the drum collection system, which allowed for more accurate data measurements. The measurement of water usage was deemed imperative for the second phase of the GRPP, where urban agriculture will be experimented with and the irrigation of crops will be needed during the dry months. Local biodiversity levels on the pilot projects green roof was also recorded, with promising results, as warblers and Prinia's were documented to use the roof as a breeding ground, as well as high levels of resident insects were recorded

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through the use of 8 yellow pan traps. The findings of 17 Hemiptera insects, which are insects that either use plants as food or as a hunting ground, represent a solidly developing ecosystem (Roberts 2010) Further research in food crops, water usage, quality of runoff, growing mediums, plants, design, structural engineering and the advocacy of green roofs in the future will continue on in phase two of the GRPP which commenced in December 2009.

What is happening in EThekwini is a South African example of what is needed to research and validate at a local level what international experiences are already showing; that green roof technology is a valuable tool in dealing with the multiple challenges of the urban environment. As discussed earlier, the municipality of EThekwini has already had experience in designing its green space designs to take into account biospheres and to ensure that such green space designs would leave a legacy of viable and diverse populations representative of a fully functional ecosystem. This experience and ability to involve stakeholders has translated into their capacity to design and implement the GRPP, by calling upon the services of local, private companies and individual specialists for expertise, and services. With the benefits of green roofs in Durban's climate better understood, and plants, growing mediums and substrate depths tried and tested, the municipality is well positioned to follow up the goals of the second phase, which consist of adopting the role of advocate in the region and assessing municipally owned buildings deemed to have potential for green roof applications (Roberts 2010). The Green Roof Team will also be adopting a structural engineer to the team and developing a structural engineering protocol, categorizing roofs and the appropriate green roof applications for those roofs. The mixing of food crops and green roof plants, and investigating more advanced waterproofing techniques is also some of the innovative research areas the municipality will be investigating in Phase 2.

Such demonstration projects often institutionalize a commitment, after benefits are confirmed and measured, to greening roofs on publicly-owned buildings as an effective way of establishing an educated roofing industry and providing contractors with valuable experience for future green roof construction (Langdon 2009). Risk aversion has been documented in some urban areas (Vancouver) as a major hindrance to roof greening (Maureen Connelly interview) as building owners may see their roof as leak prone if greening were to occur, and thus would incur a huge cost in re-roofing, mold removal and renovation costs, and the other multiple uncertainties that exist in an environment new

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to this technology. Banks and insurance companies can also smother the diffusion of unproven designs in building practices through risk aversion, not approving loans, insuring household rooftops, or recognizing roof membrane warranty.

4.2) Dea-dP Building.

Why has the Durban experience not occurred in Cape Town? A government sponsored green roof does exist in the City of Cape Town on a government building, but is very different than the EThekwini Municipalities green roof. Strong contrasts exist between the GRPP and the green roof located on the downtown office building for the Department of Environmental Affairs and Development Planning (DEA-DP). These contrasts include the fact that instead of being a modular design that facilitates experimentation, the DEA-DP rooftop hosts an intensive green roof. This roof top garden, with deep and direct substrates and more elaborate fauna, is in direct contrast to the modular model of EThekwini's GRPP, designed for experimentation. The roof was designed and installed by Bruce Beyers, a landscape designer in Cape Town. The roof was designed for aesthetic value and since its inception in 2006, there has been no attempts by the city to measure any of the benefits that would be associated with such a green roof. Due to time and funding constraints, along with the department's mandates, DEA-DP objectives revolve more closely to waste management issues rather than experimental green design initiatives. There is also a divide between city planners and the Council, as DEA-DP is a provincial entity. This has lead indirectly to the city losing interest in the buildings green roof and exporting the idea to other public buildings. "The city has so many other pressing issues that it needs to get the private sector involved to see roof greening, it cant fall on the shoulder's of the city alone" (Gregg Adams, 2010 interview)

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Being an intensive green roof, with deeper substrate and richer vegetation species, renders attempts to measure benefits not directly translatable to what could be expected from the very different extensive green roof design. The rooftop is open to anyone who is interested in checking it out for themselves. The roof has the 4 biomes of the Western Cape (Strandveld, Succulent Karoo, Mountain Fynbos, and Coastal Thicket) labeled and represented on the roof, along with artwork made from recycled materials, and a gazebo. The aesthetic value of the rooftop was apparent in the interview as it acts as the buildings aesthetic centerpiece for staff coffee and lunch breaks. This rooftop was not designed for research and benefit communication in terms of storm water management and urban heat island mitigation.

Gregg Adams explained that interest has been lost in replicating the buildings rooftop elsewhere as the DEAD-P buildings departments are not affiliated directly with the infrastructure development aspects of the city, and are funded for their particular waste minimization projects, and not to research and quantify the benefits of their green roof. He also claimed that many businessmen and city workers ask frequently to spend time on the buildings green roof and is a source of pride for people working in the DEA-DP building. Gregg Adams also reported birds nesting on the rooftop garden and bees and insects are plentiful.

The DEA-DP rooftop was constructed under the then head of the DEA-DP Tasneem Essop. Her support was critical to the construction of the roof, and without this political support from the upper end of the political spectrum, such innovative and green projects will struggle to become reality in the public sector in Cape Town (Gregg Adams Interview). This reiterates the importance of a project champion, and existence of political will to get new green design and technology adopted into City planning and building design.

4.3) Edward Road (Ottery) Residence Project

A notable greening project taking place through the City of Cape Town development plan is the Community Residential Units Project (CRU), which will use cost-saving, greening mechanisms- including insulated ceilings, among other efficiency applications in the renovation of 40,000 Council-owned rental units. Another City program is the retrofitting of low cost houses that were built before 2005 with ceilings. The national housing subsidy has only been providing for ceilings in the subsidy since 2005 in houses located in winter rainfall areas (Western and Southern Cape). Therefore many houses in Cape Town lack ceilings, which places a significant health, comfort and cost burden on the inhabitants. The retrofitting program for the council owned buildings aims to complete four buildings in 2010, and then roll out to all other council buildings and facilities. A retrofit can typically reduce energy consumption by 20% to 25%; the city could cut its energy bill by up to 30 million Rand (Enviroworks 2009); and is the main drive for the city in completing such a retrofit. Offering an avenue for the City to pursue and experiment with green roof technology and design, this program has also been highlighted as a potential opportunity to explore the insulation properties of green roofs (Enviroworks 2009).

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The City is also working on a low-cost housing project called the Ottery Greenfields housing project in the Edward Roads area to create a 'greener standard' for new low cost housing. Both of these projects could be promising avenues to pursue rooftop greening and benefit research. The Ottery Residential Project, from the very beginning, has had the City involved with design considerations for green space, urban agriculture, and passive surveillance in green space allocations (Cindy Jacobs Interview). There has only been one design that has been used for house building. This will be the first attempt by the City of Cape Town to provide green design to low-income community planning. Low maintenance and extended life of roofs has been identified through interviews with the City (Cindy Jacobs Interview) to be very important to sell as a sustainable practice.

The National Housing Subsidy, used by low-income households to build houses, fails to provide finance for architecture or alternative design considerations, so there is never any change in the design. At Edward Road (Ottery), the city is giving the money to design the layout and houses in the project. This initiative is the first of its kind in Cape Town, and will provide City planners with a huge learning opportunity as the learning curve will be steep. The City will own the designs that come from these projects for future use.

The City's Economic and Human Development Strategy (EHDS) is geared to enhance and aid the creation of an environment that grows visitor numbers to Cape Town. The EHDS is also aimed at positioning Cape Town as a leader in green industries and development through the promotion of energy efficient and renewable energy technologies. This also presents an opportunity to revitalize the manufacturing and construction sector by promoting the establishment of a new green industry. An increasing popularity of roof greening, across all income bracket communities, holds huge potential for foreign investment and green jobs. In an interview with PJ Carew Architect Michelle Ludwig, we discussed how many architects and designers that have specialized in green developments are either from abroad, or were educated abroad. The educational infrastructure may not be on par with what is being taught abroad. As experience is gained locally in Cape Town with the growth of a green roof industry, perhaps technicon's and other academic institutions will start offering classes on green roof design, research and construction, much like what is being seen at the British Columbia Institute of Technology in Vancouver (Maureen Connelly Interview 2010).

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Chapter 5: Findings

Findings were extracted both from the literature review, relevant policies set forth by the responsible authorities and interviews with industry leaders, Capetonian architects, and relevant city officials and planners. Correlations, backed by leading research both locally and internationally, complimented by interviews with academics and professionals. Vancouver is mentioned and drawn upon as it was deemed a valuable experience that could lend suggestion and guidance to city planners in Cape Town. Experiences include effective ways to pursue roof greening in a city such as Cape Town, where the green roof industry is just starting to take notice of the solutions it could offer to Cape Town's growing needs for stormwater and urban heat island mitigation along with biodiversity conservation and reclamation space.

5.1) Diversity of Needs, Cultures and Structural Design Across Cape Town Communities.

Cape Town, a relatively small geographical area/ jurisdiction, holds a large level of diversity in terms of housing, community cultures, maintenance costs, lot size, costs of housing, density and environmental impacts. Cape Town, having one of the world's largest gaps between the rich and poor, may find the command and control of regulations and technology standards less cost effective, desirable and appropriate in context, as many households will simply be unable, without financial incentives or aid, to comply. Differences in cultures, values and the needs of the diverse populations that make up the City of Cape Town will also require social sensitivity when trying to apply green roof technology to housing design, a concern expressed by Japie Seconna, of the Environmental Management Department of Cape Peninsula Technicon.

The diversity that defines Cape Town's social structure translates directly into diversity in building practices and their integrity. To achieve extensive green roofing, the technology must be made accessible to middle and lower class building structures of Cape Town. Such middle and lower class building structures can be defined as housing projects that are used by families and tenants that earn an income that restricts the quality of their housing, and housing that is located in economic zones that have been identified by the city as marginalized and in need of greater economic access and development. This falls in line with green design for everyone not just the iconic, which

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was expressed numerous times at Pieterson's panel discussion. "We have an obsession with iconic design, leaving out thoughtful, sustainable and affordable design for the poor, as there is an inequality in design" (Gita Goven, Counter Currents Panel 2010). This diversity of building needs will require research into the many different options of growing mediums and vegetation types that need to be tested in terms of the structural integrity. In Cape Town's urban centers, and immediate (upper class) surroundings, the homogeneity between costs and building types is more uniform, and the stepping up and enforcement of building standards and technology standards in new developments should be revised and enforced in the urban center.

5.2) Storm Water Policy and Bylaw

The stormwater retention abilities of green roofs, contributing on a large scale, can drastically reduce an urban area's need to expand storm water management facilities. In the United States the budget for storm water management was provided, traditionally, through property taxes and potable water use fees. In recent years, municipalities in the US have been moving towards storm water fees based upon total impervious surfaces on a property, creating an opportunity to credit green roof practices for storm water Best Management Practices (BMP's) (Roads and Stormwater Dept. 2009). Increasingly, in North America, jurisdictions are creating storm water utilities, which charge fees to parcel owners based on their parcels storm water contribution to the system.

The metro wide Spatial Development Framework under the City's storm water bylaw asks for the inclusion of the issues relating to receiving water bodies in the planning process. The bylaw calls for holistic and integrated planning in terms of drainage, water efficiency, Water Sensitive Urban Design (WSUD), protection of water bodies and water recycling. Such concerns shall be embodied in the metro-wide Spatial Development Framework as well as into other regional spatial planning approaches and mechanisms.

The proper valuation, and allocation of financial benefits to those who provide these public goods is not yet part of the strategy to realize such distant realities in Cape Town. Such considerations require changes to current policies and property tax structures. There are two popular strategies internationally that have shown potential to rectify this price discrepancy of those who bare the costs of providing public/ social benefits. The first is the proper evaluation of infrastructure costs via storm water fees, through the evaluation of a developments impact on storm water reservoirs and peak flow charges.

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The second strategy is a market based tradable permit scheme for contributing to impaired local waterworks and systems, contributions to the reduction of air and noise pollution, and aesthetic values (Pahl-Wostle 2007 pg 51).

The Catchment, Stormwater and River Management Policy (CSRMP) of the City of Cape Town was well received by external audiences such as DEADP and the Department of Water and Forestry (Candice Haskins email interview, March 9, 2010). The policy also prompted the Branch to undertake a series of seminars aimed at professionals in the engineering, architecture, landscape and environmental fields. Candice Haskins reports that already this initiative and roll out of the new policy is being rewarded by an increase in development applications coming in with various aspects of the policy being implemented. Haskins also reported that to date, there has been no use of green roof technology in development applications trying to impress upon the new policy recommendations.

The following two sections of the Storm Water bylaw of Cape Town have promising connotations for the use of green roof technologies in Cape Town. Section 6.2.7: “Best management practices should promote urban biodiversity, and enhance the amenity and aesthetics of the development site and its surroundings”. This section lends importance to a development’s ability to enhance biodiversity, habitat creation and amenity value of the surrounding and immediate area involved. Section 6.2.8 that deals with incentive schemes states “Council (The City) may introduce incentive schemes to promote and facilitate adoption of WSUD measures by private developers and individual households where appropriate”. This section lends power to Council to adopt such incentive schemes previously discussed, but no evidence of such initiatives was found in my interviews or literature review.

Council understanding and policy seems to be in place. Practice just needs to start reflecting the forward thinking applications in the policy and bylaw of the City’s storm water management department. Forward thinking language such as Best Management Practices and the ability of the City to develop and experiment with incentive schemes is critical to the initial years of establishing a green roof industry here in Cape Town. This initial action has yet to make itself strongly felt, as City Planners in Cape Town face unique, diverse and much more pressing immediate concerns in its infrastructure planning and providing low income housing for all. Reasons for inaction were revealed in

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interviews with both city workers (Cindy Jacobs, Gregg Adams) and Cape Town based architects and urban designers (Michelle Ludwig and Tali Bruk). Reasons included the lack of interest by the City's department of engineering to uptake new designs, lack of political ability and will and more pressing and immediate challenges to design.

5.3) National Energy Efficiency Policy

Green roof technology reduces the operational costs of buildings. This includes a prolonged roof life that has been documented in several studies to be twice that of conventional roofs (Corburn 2009 pg 417). Decreased energy consumption, especially during the hot months, has been documented to cut the buildings energy costs by 15-20% (Getter, 2006). This is significant not only on a private enterprise level but also at a national level, as 36% of total energy and 65% of total electricity is consumed by the world's urban buildings (Brenneisen 2006). Eskom is currently pursuing an energy agenda that is addressing energy efficiency practices, efficient household devices and living tips (Enviroworks 2009). The South African Government has outlined an energy efficiency strategy, setting a goal for an improvement in energy efficiency of 12% by 2014 relative to projected consumption (DME, 2005). The energy savings generated by more regulated heat patterns in the buildings that have green roofs will save the utility grid in peak hours. Buildings may also supplement their operations with rooftop agriculture, as the Fairmont in Vancouver has reported 30,000$ Canadian in savings annually from the produce grown off its roof top gardens that is then used in its restaurant and catering operation (Nat Geo 2009, www.fairmont.com/HotelVancouver). This operation could be of huge interest to the dense urban areas of Cape Town where urban agriculture is being pursued as a sustainable way to feed its growing population.

A brief review of the government's energy efficiency strategy quickly draws parallels between a need and a service that green roofs provide. Many of the measures that are being used to increase South Africa's energy efficiency by 12% are directly related to or enhance the need for a policy of extensive green roofing. These measures include, energy efficiency standards, research and technology development, support of energy audits, monitoring and targeting and lifecycle accounting. The energy efficiency benefits a green roof provides to the building can contribute to the national governments energy efficiency strategy to meet its carbon reduction commitments, and offers a potential avenue to pursue support for a green roof industry. With higher levels of efficiency from green roof buildings, it is hoped that local air pollutants and global green house gases will

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be reduced. Economic sustainability can be enhanced by energy efficiency in industry and household businesses, with improved competitiveness through lower costs. Such energy efficiency concerns are encouraging the City to undertake retrofits in its existing land and housing investments and future design and developments, such as the CRU Project and the Edward Roads (Ottery) development.

5.4) Need for a Carbon Market in South Africa

Air pollution mitigation from green roofs can translate into economic benefits that can reduce the NPV of green roofs by 5-20% depending on a host of factors. This 'translation' into economic benefits can only be realized with a market place to sell and a demand to buy carbon credits, through the establishment and support of a carbon economy in Cape Town. The Carbon Credit Corporation, a Canadian based company, with trading director Robert McCulloch here in Cape Town, is currently the leading company in Cape Town positioning itself for the uptake of very such a market (Michelle Ludwig Interview 2010). Through the creation of incentives, or through the incorporation of green roofs as an abatement technology green roof developments should increase, as has been the experience abroad (Nicholas 2010, Langdon 2009). Further research into these policy alternatives has been recommended by the conclusions of multiple studies (Langdon 2009, Harcourt 2008, Getter 2006), as appropriate policy alternatives will aid the design and development of strategies to translate the external and environmental benefits of green roofs to tangible economic benefits for building owners.

Government decisions, both national and municipal, on carbon trading, storm water fees, and utility fees and property tax implications can have a significant impact on green roof development if desired, however such polices are yet to be formed in Cape Town, taking only the form of guidelines and suggestions and minimal restrictions. In the case of rewarding a green roof owner's contribution to air quality, Cape Town today lacks capacity, political will and the existence of an entrenched carbon market to pursue these policy options. A growing civil knowledge of the impacts of climate change is gaining momentum and industry leaders seeing this shift in public opinion as the future driving force of urban planning and policy (Langdon 2009; Enviroworks 2009). A Carbon market is recognized as an important contributor to a city's mitigative capacity against climate change. The acknowledgement of biodiversity conservation and increasing green spaces as a strategy to increase Cape Town's resilience to climate change (Enviroworks 2009) is

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a forward looking perspective and one that is potentially promising to green roof development in following years.

5.5) Developer Attitudes

The importance of impermeable surfaces and this recognition in future development designs and concerns has been successfully recognized and enforced before in South Africa. A local example exists at the historic Grand Parade in Cape Town, which was retro fitted with permeable bricks to directly reduce urban run off. A recent example is found in the Ekurhuleni Council's decision to specify storm water retention and attenuation as one of the approval conditions for converting a property in Dunvegan from residentially zoned to commercial. Attenuation is the process by which storm water is held back. The developers hired a German engineering company, one of the worlds leading companies in permeable paving solutions, to incorporate the use of permeable road works in their proposal. The Council accepted that the permeable surfaces offered in the road works offered an appropriate solution. Such demands can be made by the Council in Cape Town (Cindy Jacobs interview 2010), and green roofs can offer an economically and environmentally rewarding option to fulfill such permeable surface needs and storm water concerns. These exercises of power through land rezoning applications, to promote green developments should be recognized as assets in realizing extensive roof greening in Cape Town.

Jason Busch, of the Green Building Council of SA, believes that developers are changing their ways slowly with the help of analysis from consultants on understanding and thoughtfully estimating payback periods. To address this problem, the costs, and the benefits that new green technologies can provide in protecting and enhancing such ecosystem services need to be incorporated into the traditional cost benefit analysis. Clive Greenstone, the developer for the EThekwini GRPP, believes that human mindsets still need to transform in South Africa's development industry, especially with conservative architects and structural engineers (Email Correspondence). ARG Architect and urban designer Tali Bruk, stated in an interview that one of the greatest barriers to green roof development would be the unwillingness of the City's engineering department to experiment and try new design and technologies.

The City of Cape Town, in its Green City Guidelines, realizes that leadership by example is important in setting standards, and to inspire the changes required to shift consumption

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patterns of resources, waste, and the creation of balanced and healthy urban environments. The Council realizes that to transform the City's organizational culture to one that fully internalizes the benefits of a more sustainable development path, firm commitment and leadership from an educated and informed senior management is needed. The City suggests a green star building standards and rating system be adopted into the City's management culture. There are a number of suggested green standards and rating schemes, and the City is still grappling with the wide range of requirements and potential solutions available to increase green improvements. It seems the Green Rating System is favored by Cape Town developers through my interview results (Jason Busch email correspondence). In order to meet and maintain this improvement, a continual and consistent feedback loop of priorities, evaluation, and course corrections will be needed from integrated design teams. Ways to implement an integrated team approach should also be sought. Establishing a clear process outline during training, noting "points of opportunity and obstacles", will allow participants to create realistic plans of action for sustainable design (Adger 2003).

The City's guidelines on green building expresses belief that in the near future many of the suggestions made will become by-laws or legislated national initiatives. The guidelines declare that it is imperative that the City leads the way in the reduction of environmental impacts and embraces the principles set forth by the guidelines and that the City sets an example to ensure the private sectors follow suit. The guidelines call upon the City to begin introducing the assessment tools and green building rating systems to develop the City's future plans as a target for environmental performance of new and renovated facilities. Guidelines suggest that current design and development processes of facilities should be reviewed in an attempt to locate opportunities and obstacles related to sustainable design.

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5.6) Green Design Certification: Market Incentive

Throughout this research paper, the policies that have been used internationally to help facilitate green roof development have been explored and offered as one of the most viable and effective ways to promote growth in a fledgling industry. In light of the barriers and lack of tools available to policy makers such as an existing carbon market or storm water utility fee, these policies may not be the most practical and efficient way to pursue roof greening in Cape Town. In an interview with PJ Carew green design specialist Michelle Ludwig, the importance of the relatively new Green Star Rating System became apparent. The private market may prove the most efficient and powerful force to drive green roof development in Cape Town. As Gregg Adams expressed in my interview with him, the responsibility cannot fall entirely on the City, as it is limited in capacity and political will. With the amount of financial restraints and amount of more pressing issues facing city officials, and provincial and national authorities, perhaps the private sector is the most efficient answer to addressing green design in future Cape Town developments. The Green Star Rating System is an incentive package to developers, who want to respond and capitalize on environmentally conscious investors and homebuyers. Of course the green star rating system is only one way of encouraging the use of green roofs in buildings, further research and the effective communication of green roof benefits to developers will also lend great advances in this industry, if benefits can be communicated in economic terms.

In Cape Town, Green design is being largely driven by green rating points, (Michelle Ludwig, 2010 Interview). The green rating system is the equivalent of North America's LEED green building rating system, and was developed in Australia, and implemented in South Africa by the Green Building Council of South Africa. Like LEED, the green rating system was designed to spur private interest and capital in green building design and to create a just and measurable certification system in which buildings and organizations rate themselves. The sections such as Land use and Ecology provide points for a change in ecological values (4 Points), indigenous gardens (10 points), and regenerated Indigenous Habitat (50 points). Watercourse pollution improvements and mitigation recognizes green roofs, but measurements are needed, as they are with all the benefits that green roofs could provide for green points. Everything has to be measurable to gain green points, they are not just given for incorporating new technologies; technologies must be proven to perform. The initial state of the site of development is assessed for ecological value, and then the development is compared to the site in terms of improvements or degradations.

The LEAF standards: "Leadership in Ecological Applications and Functions," is a building design rating system that looks at the ecology and natural processes and psychological functions in urban ecology as a part of the built environment and rewards designers and developers for having an understanding of their particular site capacity to support biodiversity. This rating system is being promoted by the organization as a driving force in looking at biodiversity performance, and how we can actually measure a site's capacity

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to support a healthy ecosystem even within the built environment. This rating system is different than the green rating system in its measurement methods, but also very similar in many regards concerning importance in green design and rewarding credit to designs based on proven performance. This means credit is not just given simply for involving green technologies into the design, but the appropriateness of design to the context, the same as the green rating system. Such rating systems promote integrative and regenerative designs to come forth where the idea of stacking functions and multiple process are included in the design.

5.7) Biodiversity Concerns: Collaboration and Communication

The combination of pressures for development and high existing levels of biodiversity make Cape Town one of the world's hotspots for global biodiversity preservation (Gelderblom et al. 2002). Most transformation has taken place on the more productive and accessible lowlands where more than 95% of some habitats have been lost. This loss of habitat can be countered in part through the creation of green spaces on barren rooftops (Wilby 2007). The use of regulations abroad has allowed developers to satisfy green space requirements by installing green roofs where demand for space is high, and urban design is becoming more oriented towards increasing density (Langdon 2009).

The Cost Benefit analysis shows that there is a need for architects, urban planners, and designers to participate in applying economic costs to the benefits and costs that are associated with infrastructure development and the built environment. How can city planners collaborate with Cape Towns Biodiversity Organizations to provide an incentive to developers to incorporate the creation of indigenous habitats in their design, and how should this be recognized to incentivize such considerations? How can planners design space and buildings to better adapt communities and populations to climate change?

Despite the challenges for biodiversity (ecosystem degradation, pollution, and climate change) there is a rare concentration of endemic species surviving in the Cape's urban environment. Despite only comprising 4% of South Africa's land area the Cape Floral Kingdom encompasses 9,000 of South Africa's 18,000 flowering plant species, 70% of which are endemic (Holmes 2008). 20 of 21 "critically endangered" national vegetation types are found in the Cape (Holmes 2008). This remaining floral diversity is under extreme threat from urban development and ecosystem degradation from polluted receiving water bodies (Maze, Katszchner et. al 2002 pg 93). The Cape Flats Flora

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Program, and the Working for Water Initiative in Cape Town is a promising example of how urban biodiversity concerns are working to alleviate social ills while addressing the degradation of endangered floral communities through multiple stakeholder involvement and collaboration. "The future of successful conservation on the Cape Flats depends on *creative conservation initiatives* that provide multiple benefits and contribute to an improved urban environment." (Maze, Katzschner et. al, 2002 pg 92). This need for creative conservation initiatives in Cape Town is the very opportunity that extensive roof greening can use to alleviate stresses on biodiversity levels.

A useful example of collaboration between private and government bodies to promote the biodiversity values of green roof benefits from the literature review was found in the United States. The Environmental Protection Agency's active promotion of green roofs, under the Green Infrastructure Initiative, includes a partnership with four national environmental groups and can be seen as an example of how environmental authorities in the Western Cape or South Africa can actively promote and develop green roofs. This formalization of a collaborative effort to actively promote the benefits of using green infrastructure to protect drinking water supplies, public health, climate change mitigation, and reversing the loss of wildlife habitat is a productive practice.

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The literature review outlines a rich history and experience in the Western Cape in the field of collaborative planning that accounts for biodiversity and ecosystem service concerns. This collaboration is favorable in strengthening ecosystem and built environment resilience. This is supported both by the literature review of adaptive and mitigative measures, and other successful green infrastructure promotion.

Cape Town city planners, when designing and planning public building rooftop utilization could also consider the European Biotype Area Factor previously discussed. The adoption of an evaluation mechanism much like the Biotype Area Factor (BAF) that is being used in Switzerland and Germany has been recognized as an effective way to assign an economic value to the expected contributions that are generated through biodiversity levels through habitat creation or preservation, making such benefits easier to communicate. Because the Biotype Area Factor assigns a degree of worth, it is then possible to credit those providing it. The BAF is seen as enabling a platform for the evaluation of biodiversity and ecosystem service protection. This is where the city's Biodiversity Network (Bio Net) can contribute. Bionet has identified the minimum natural vegetation remnants needed to conserve a representative sample of Cape Town's Biodiversity. By conserving these remnants, and corridors of vegetation, the City believes that it can ensure that the biodiversity that is vital to Cape Town's defense against climate change survives.

Perhaps this is an area in Cape Town that biodiversity organizations such as the Wildlife and Environmental Society of South Africa (WESSA), South Africa's National Biodiversity Institute (SANBI) or the Botanical Society of South Africa can actively participate to fill the gap and provide an estimate based on economic value for newly created green spaces for bug, avian and flora communities. This proper valuation of environmental benefits and habitat creation requires changes to current policies that affect the implementation of roof greening and a collaboration between urban planners, designer, researchers and biodiversity conservation organizations.

There is still a real need to move towards a more collaborative mechanism that involves sound scientific understanding in green roof design and biodiversity planning, complimented by appropriate institutional structures that support cooperative governance and community participation (EnviroWorks 2009).

There will be a challenge of coupling urban development and socio-cultural issues through local involvement in developing solutions. Such interactive processes are often imperative to a development's efficiency in providing life cycle benefits to the communities that are most vulnerable. Such success "will come by seizing opportunities provided by the emergence of new institutions, and the growing public awareness that environmental health is the corner stone." (Maze, Katzschner et. al 2002, pg 95).

The formalization of cross-sector partnerships to address the need of biodiversity conservation, job creation and community empowerment, has already been proven possible in the Western Cape, and can be replicated to involve the creation of wildlife habitats from bare concrete rooftops. Land reclamation must be noticed as valuable to conservation efforts. At the downtown Cape Town DEADP office building, Gregg Adams, in a rooftop interview, confided that he had personally seen an abundance of bees, insects and nesting birds on the building's green roof, although no formal research has been undertaken thus far on biodiversity levels on downtown green roofs in Cape Town, the benefits are apparent. In the Green Roof Pilot Project conducted by the EThekwini

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municipality, large gains in biodiversity were also reported. Green roof's value to biodiversity protection, and thus Cape Town's resilience to climate change is promising.

Mainstreaming of biodiversity interests cannot be sustained unless it is directly linked to the indirect benefits it is responsible for sustaining. The communication, understanding and quantifying of the economic value of urban biodiversity to urban residents is critical (Greenstone Interview). Knowledge on how to implement and manage projects and programs associated with the mainstreaming of biodiversity is an essential ingredient for this process in many sectors and should not be ignored by city planners and decision makers. Such experiences are an asset the city should not overlook when trying to mainstream other green urban initiatives. Perhaps this is why the EThekwini municipality has seen the greatest and earliest successes with its green roof pilot project. Experienced in linking and incorporating biodiversity research and knowledge to regional planning and urban green space design, they are well equipped to implement projects and programs associated with mainstreaming biodiversity concerns, and to recognize the potential of roof greening and the possible benefits for their municipality. Often linked to institutional capacity, this knowledge sometimes resides in the private sector or academia (Hamann 2006, Cleveland 2004).

Obstacles that exist when mainstreaming biodiversity concerns into development planning and open space design do exist. After apartheid ended, the government restructuring that took place left inefficiencies that hinder institutional capacity. The new regional (provincial tiers) structure has left some institutions severely incapacitated. Most of the newly identified municipalities lack the capacity to incorporate biodiversity concerns effectively into land use planning. These areas thus lack the ingredients of experience and decentralized, adaptive capacity that is pre-requisite for such green initiatives. Cape Town is not one of these newly identified municipalities, and has extensive experience in effectively addressing biodiversity concerns in its planning and design teams (Gregg Adams, Cindy Jacobs Interview). The problems that are facing the built environment can be transformed into a stimulus to promote ecosystem service protection in urban areas. Imaginative win-win solutions have been achieved in South Africa and the Western Cape in terms of biodiversity conservation. Through communicating the superior economic and ecological sustainability of biodiversity friendly activities as the stimulus for mainstreaming, these concerns can be mainstreamed.

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Chapter 6: Suggestions to Move Forward with Roof Greening

6.1) Low Income Housing Developments in Cape Town

Low-income housing is a highly demanded form of housing in Cape Town. The Edward Road Project is the City of Cape Town's first application of design to realize the green priorities that the city has set for itself in such low-income housing developments (Cindy Jacobs Interview 2010). National and Provincial grants for low-income households to build homes don't allot any expenses for alternative architecture designs or experimentation with new green technologies and alternative building methods. There is thus little effort or ability by both supply and demand sides of the market. And only further research will identify what innovation is occurring through the actions of on the ground actors at a local level with alternative housing design options. Efforts by government must be made to engage architects to address ecology concerns in design for this large segment of low-income households. "More barefoot architects are needed in South Africa, focusing on the needs of the poor, instead of the Iconic" (Gita Goven Panel Discussion 2010) Innovation is being hampered in this high volume, fast growing, low income segment of the housing market in Cape Town. This large opportunity for the city to experiment with alternative design options and building methods is largely being squandered as the same design is used repeatedly, a missed opportunity that is recognized among most building designers (Michelle Ludwig and Tali Bruk). These financial constraints for low-income developments realizing more sustainable and green designs will always be an issue, but are being directly addressed in the Edwards Roads Resident Project through the City providing funding for better design and deliberation over needs. Needs such as close proximity to gang violence, high winds, low soil fertility, energy efficiency, low income inhabitants and sustainably informed green space design are being met with passive security, indigenous landscape, small scale urban agriculture, and rain and grey water systems (Tali Interview 2010).

The Edward Road Residential Project has had the City involved with design considerations for green space, urban agriculture, and passive surveillance in green space allocations (Cindy Jacobs 2010). This will be among the first attempts by the City of Cape Town to provide renewable and green technology to low-income community planning. R65,000 has been allocated for the design and construction of the top structure, which after accounting for design and planning costs, results in R54,000 being spent for a 54

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square meter house, with space for adding onto to the structure. R22,000 is allotted additionally for utility services and connection.

The National Housing Subsidy, used by the disenfranchised to build houses, fails to provide finance for architecture or alternative design considerations, so there is never any change in the design. At Edward Road (Ottery), the city is addressing this and engaging ARG Architects to design the layout and houses in the project. This initiative is among the first of its kind in Cape Town, and will provide City planners with a huge learning opportunity, as the learning curve will be steep. The City will own the designs that come from these projects for future use and alterations.

6.2) Leading By Example

Research on the actual benefits of green roofs are largely unknown, as Cape Town is largely inexperienced in extensive, direct green roof research. It is largely unknown what benefits will be greatest in Cape Town's unique environment, and what indigenous plants will flourish in such rooftop environments while simultaneously maximizing the benefits wanted from such design. Green roof research in other cities in the north and south have shown favorable in the cost benefit analysis of this paper in section 2.2. Barriers such as political will and support, lack of public awareness and acceptance of this new technology, and local supporting industries may be reasons for the absence of green roofs in South Africa and specifically Cape Town. New designs and technologies must be proven to be cost effective and able to provide real and desirable benefits and risks to the tenant, developer, accountants and community at large. Until these benefits are measured, proven and communicated in economic terms that allows them to be measured against the alternatives, new technologies will struggle to become mainstream. Because of the context specific nature of the vegetation and substrate make-up, it is strongly suggested that the City of Cape Town support an independent Green Roof Pilot Project much like the one the City of Vancouver, and the Municipality of EThekwini have undertaken.

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The EThekwini Municipality is currently showing the greatest initiative in South Africa with its ongoing green roof pilot project in Durban. The EThekwini GRPP is evidence that Green Roof design is beneficial in Southern Africa and passing through its initial days of development. The strong initiation and involvement of the municipality may be a precursor to how such design will succeed in Cape Town's development community.

Building designers and spatial planners must not miss the opportunity to respond to climate change through improved building design and layout of cities. Hard engineering solutions such as green roofs, good designs that touch upon multiple benefits will play an important role in Cape Town's adaption to climate change. Biodiversity is claimed to be recognized by the City (Enviroworks 2009) as an important defense against the negative economic and environmental effects of climate change.

Academic and Technicon Colleges also must collaborate or be perceptive and sensitive to future market demands for green-collar workers as a skilled and experienced labor pool is critical of a local industry's success (Connelly Interview, 2010).

Roof contractors and membrane producers in cities such as Vancouver (Connelly Interview 2010) have been reluctant to offer membrane/ roof top warranties past the conventional rooftop's average 20-year lifetime warranty (Carter 2008). Correcting this reluctance is difficult and has been a major obstacle to the industry in Vancouver, Canada. The Canadian Housing and Mortgage Corporation is still reluctant to finance green roofs due to a controversial outbreak of leaky condos in Vancouver almost a decade earlier (Connelly Interview). Such research projects concerning the viability of green roof technology in Cape Town will be needed to overcome institutional barriers, such as acceptance of the benefits. Certification and a quality assurance body such as Agrement South Africa is recommended to avoid inappropriate green roof applications that could increase the perceived risks of incorporating such technologies options into building design, and make the success of green roof developments harder as insurance companies and mortgage lenders become more wary of mistakes made with the initial application of green roofs in South Africa and Cape Town.

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