Perceiving Sustainability and Practicing Community Based Rehabilitation: A Critical Examination of the Western Cape Rehabilitation Centre (WCRC) as a case study

by
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Declaration

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Abstract

Problem Statement: From a sustainability point of view, hospitals offer their services without taking into consideration their impact on the environment, the interplay between various sectors, key elements of sustainable development and interconnectedness. This study represents an attempt to design a "virtual" green hospital facility that does more with fewer resources.

Aims and Objectives: Contribute towards achieving sustainable and better quality healthcare services. To generate evidence and increase our understanding of the sustainability of hospital resource flows. Design a "virtual" green hospital.

Research Method: The research approach consists of a comprehensive literature review, mixed with substantiated field research and interviews. The literature review provided an understanding, recommendations and interventions for the virtual project. These can be used to promote greater sustainability through WCRC's healthcare system, energy efficiency and green hospital buildings. Interviews and questionnaires were used to collect the qualitative data. The interpretive technique was used to analyse the collected data. Consumption statistics of electricity, water and waste were used to collect the quantitative data. It was analysed using the green building rating tool. The rating tool awards points according to incorporated measures, and arrives at a total score after appropriate weighting. The green building rating tool was used to establish the rating of WCRC as it stands and what it could ideally be as a retrofit? The data was presented as demographic information in tables, charts and graphs, drawn from the collected data.

Findings: The findings that emerged suggest that: a) green hospital buildings promote greater sustainability than the current modern healthcare hospital buildings at WCRC and retrofitting would promote greater sustainability; b) the majority of WCRC's current healthcare provision is done in the conventional 'business as usual approach'; c) the greatest weaknesses of the hospital is its heavy dependence (95% average) on non-renewable energy sources of fuel, electricity and water; d) procurement isn't focused in the bio-region; e) sustainability isn't viewed as the cornerstone to influence policy; and f) the flow of resources gets conducted through socio-economic systems.

Conclusion: The current design of the hospital needs to be retrofitted into a green building, which will promote greater sustainability. A higher rated green star building for WCRC would promote greater sustainability. Healthcare provision is done in the conventional 'business as usual approach'. Therefore the healthcare system faces threats in the immediate future, which include the impact of climate change, over dependency on fossil fuels and increasing urban sprawl.

A virtual green hospital is designed to reduce the overall impact of its built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources;
- Protecting occupant health and improving employee productivity;
- Reducing waste, pollution and environmental degradation.

Recommendations: In this sustainability criterion, a paradigm shift is required for WCRC hospital to go green and become sustainable. At a local scale WCRC needs to green the current hospital building by retrofitting. WCRC needs to energy switch from non-renewables to sustainable renewable resources. Bioregional consumption and procurement needs to be practiced whilst establishing a local health movement to engage suppliers and focus on sustainability.

Key words:

Sustainable development

Sustainability

Sustainable hospital

Green building

Sustainable building design

Climate change

Sustainable healthcare

Opsomming

Probleem stelling: Gesien van volhoubaarheids oogpunt, bied hospitale dienste aan sonder om te besin oor die impak op die omgeweing, die tussenspel tussen verskeie sektore, sleautel elemente van volhoubare ontwikkeling en die onderlinge aanknopings. Hierdie studie verteenwoordig ‘n poging om ‘n skyn groen hospitaal te ontwerp wat meer kan doen met minder hulpbronne.

Oogmerk en Doelstellings: Om ‘n bydrae te lewer om ‘n volhoubare en beter kwaliteit gesondheidsdiens te bereik. Om bewyse te genereer en begrip aangaande die volhoubaarheid van hospitaal bronne vloei to verhoog/ Ontwerp van ‘n “skyn” groen hospitaal.

Ondersoek Metode: Die benadering in die ondersoek bestaan uit ‘n omvattende literatuurstudie met ondersteunbare veld ondersoeke en onderhoude. Die literatuurstudie voorsien in die begrip, aanbevelings en tussentredes vir die skyn projek. Dit kan gebruik word om groter volhoubaarheid van die WKRS se gesondheidsisteem, energie effektiwiteit en groen hospitale te bevorder. Kwalitatiewe data was ingewin met behulp van onderhoude en vraelyste. Interpretasie was die tegniek wat gebruik was om data te analiseer. Verbruikstatistiek van elektrisiteit, water en afval was gebruik on kwantitatiewe data te kollekteer. Die analise daarvan was gedoen deur die gebruik van die groen gebou graderingsinstrument. Die graderingsinstrument ken punte toe volgens opgeneemde maatreëls en bepaal die finale gradering na gepaste afwegings. Die instrument was gebruik om die gradering van WKRS te bepaal soos dit is en wat die ideale terugbou sou wees. Die data word in tabelle en grafieke voorgelê soos wat dit verkry was van die gekollekteerde data.

Bevindinge: Die bevindinge wat na vore gekom het dui aan dat:

Groen hospitaal geboue bevorder groter volhoubaarheid dan die huidige moderne hospitaal geboue van WKRS en terugbouing sal groter volhoubaarheid bevorder.

Die meerderheid van gesondheidsdiensvoorsiening deur WKRS geskied volgense die konvensionele benadering van “besigheid soos normal”

Die grootste swakheid van die hospitaal is die swaar afhanklikheid van die hospitaal op nie-hernubare energie (95%) soos brandstof, elektrisiteit en water,

Verkryging is nie gefokus op die bio-streek nie,

Volhoubaarheid word nie beskou as die hoeksteen om belied te beinvloed nie en

Die vloei van hulpbronne word herlei deur sosio-ekonomies sisteme.

Sluiting: Die huidige ontwerp van die hospitaal moet terugverbou word na ‘n groen gebou wat groter volhoubaarheid sal bevorder. ‘n Hoër groenster bougradering vir WKRS sal groter volhoubaarheid bevorder.

Voorsiening van gesondheidsdienste volgens die “besigheid soos normaal” benadering veroorsaak dat die gesondheids-sisteem bedreigiongs in die gesig staar soos die impak van klimaatsverandering, oorafhanklikheid van fosiel energie en verhoodge stadspreiding.

Aanbevelings: Volgens die kriteria is ‘n paradigma verskuiwing nodig by WKRS om groen en volhoubaar te raak. Op ‘n plaaslike skaal is dit nodig vir WKRS om die huidige hospitaal terug te bou om groen te raak. Dit is nodig om energie veranderings te ondergaan van nie hernubare tot volhoubare, hernubare energie bronne. Die Biostreek verbruiking en verkryging moet gepraktiseer word terwyl plaaslike gesondheidsbewegings gevestig word om te onderhandel met verskaffers en te fokus op volhoubaarheid.

Sleutelwoorde:

Volhoubare ontwikkeling

Volhoubaarheid

Volhoubare hospitale

Groen gebou/verbouing

Volhoubare gebouontwerp

Klimaatsverandering

Volhoubare gesondheids-sorg

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List of Acronyms and Abbreviations

Admin	Administration
Agric	Agriculture
APPA	Atmospheric Pollution Prevention Act
AQMPs	Air Quality Management Plans
BBBEE	Broad based black economic empowerment
CDM	Clean Development Mechanism
CEO	Chief Executive Officer
CoCT	City of Cape Town
Co-ops	Cooperatives
CO_2	Carbon dioxide
Cm^2	Square centimetres
Cm^3	Cubic centimetres
DEAT	Department of Environmental Affairs and Tourism
DHET	Department of Higher Education and Training
DME	Department of Minerals and Energy
DNA	Designated National Authority
DOE	Department of Education
DOH	Department of Health
DP’s	Disabled persons/people
DPO’s	Disabled persons/people organisations
EB	CDM Executive Board
EE	Energy Efficiency
ESD	Environmental Sciences Division
G	Grams
HDPE	High-Density Polyethylene
HDR	Human Development Report
HPP	Hydro Power Project
HRDSA	Human Resource Development South Africa
IAQ	Indoor air quality
Kg	Kilograms
Km^2	Square kilometres
LDPE	Low-Density Polyethylene
LED	Local Economic Development
LFSH	Low Flow Shower Heads
LG	Local government
m^2	Square meters
m^3	Cubic meters
Ml	millilitres
MTSF	Medium Term Strategic Framework

NEMAQA	National Environmental Management: Air Quality Act
NG	National Government
NGO	Non-governmental organisation
NMBM	Nelson Mandela Bay Metropolitan
NO_2	Nitrogen dioxide
NSDSIII	National Skill Development Strategy III
O_2	Oxygen
O_3	Ozone
Pb	Lead
PBO	Public Benefit Organisation
PDDs	Project Design Documents
PETE or PET	Polyethylene Terephthalate
PGWC	Provincial Government of the Western Cape
PINs	Project Idea Notes
PP	Polypropylene
PPP	Public Private Partnership
PS	Polystyrene
Prof	Professor
PUrE	Pollutants in the Urban Rehabilitation Environment
PVC	Polyvinyl Chloride
PWDs	People with Disabilities
QoL	Quality of life
QoLC	Quality of life counts
RE	Renewable Energy
Rehab	Rehabilitation
SABS	South African Bureau of Standards
SADC	Southern Africa Development Community
SCI	Spinal Cord Injury
SI	Sustainability Institute
SIEV	Sustainability Institute Eco-Village
SO_2	Sulphur dioxide
SUR	Sustainable Urban Regeneration
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VOCs	Volatile organic compounds
WCRC	Western Cape Rehabilitation Centre
WCRCRSP	Western Cape Rehabilitation Centre's Rehab Service Programme

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Chapter 1 – Introduction

1.1 Introduction

"Designing the 21st Century Hospital through environmental leadership for healthier patients and facilities"

The Center for Health Design's prophecy, 2006:i

In addition to tangible environmental benefits, green buildings have demonstrable social benefits. Various studies have indicated that the quality of the indoor environment in green buildings directly benefits the occupants: on average, students in green schools have scored higher on tests, workers in green buildings have lower absenteeism, they are much productive, and more so "patients in green hospitals have faster healing times" (Jerry Yudelson, 2007:36).

Hospitals are centres of healing and therefore have a responsibility to use materials that are healthy and safe. Safe materials are required not only for the patients they serve, but also for the broader community of which they are part. Increasingly, concern has been expressed about exposures to communities – human and ecological – beyond the walls of the hospitals. At the same time healthcare and hospital construction present a rare opportunity to use the emerging sciences of evidence based design, materials assessment methodologies, and green building tools to build healthier healthcare facilities that benefit occupants, communities, and the global environment in the context of the "climate change challenges" (The Center for Health Design, 2006:iv).

The underlying philosophy of green buildings is that all services have cost implications. The greatest expense for any business is the employee payroll, so greater productivity directly impacts its 'bottom line' (A S I D, nd:10). Similarly, patients who spend less time in hospital save money. Moreover, building owners not only save money in operational expenditures in a green building, but studies from the United States indicate that "certified green office buildings have higher occupancies as well as attract higher rents and sale prices" (British Research Establishment Environmental Assessment Method [BREEAM], 2011:2). Hospitals as businesses' have a corporate social responsibility (CSR) to "contribute to sustainable economic development, working with employees, their families, the local community and society at large, to improve their quality of life" (World Business Council for Sustainable Development, 2004:1).

1.2 Background and motivation

1.2.1 Background

In South Africa, disability has historically been regarded predominantly as a "health and welfare issue and state intervention has, therefore, been channelled through welfare" institutions / Public Benefit Organisations (PBOs) and hospitals. Thus, the responsibility for 'caring' for disabled people has generally fallen on civil society (Independent Living Institute [ILI], 2011:5). There has been little or no commitment to addressing disability in other areas of government responsibility. The medical model of disability implies “organisations for people with disabilities” are usually controlled by non-disabled people who provide services to people with disabilities (Integrated National Disability Strategy White Paper, 1997:9). The vast majority of these organisations were founded by people concerned with creating a more 'caring' environment for different groups at a time when carbon footprint was a term hardly in use.

Under the guise of a disability PBO, the amalgamation of the Conradie Hospital Spinal - General Rehabilitation Units and Karl Bremer Rehabilitation Unit resulted in a brand new, world class custom-built hospital facility known as the Western Cape Rehabilitation Centre (hereafter referred to as WCRC). This was built in the early 2000’s and its doors opened to the public in October 2004. WCRC is a specialised rehabilitation hospital, which accepts appropriate referrals from all levels of health services (i.e. primary level health services, tertiary, secondary, and district). Clients can also refer themselves to the WCRC out-patient clinic (OPC) for one-stop assessments and management purposes.

WCRC provides specialised, high-intensity rehabilitation and community-reintegration programmes for persons with physical disabilities. The focus is outcome-based and the promotion of functional independence. The facility has a maximum capacity of 240 beds, and a daily out-patients department (OPD) clinic. The rehabilitation programmes focus on reducing activity limitations and participation restrictions for persons with:

1. Stroke/Head Injury;
2. Spinal Cord afflictions; and
3. Amputations (post amputation rehabilitation) amongst others (WCRC, 2011).

WCRC also offers a variety of other services such as:

1. Home or work site assessments and
2. Specialised clinics.

WCRC further offers unique research and training opportunities for a variety of health workers, including doctors, nurses, physiotherapists, occupational therapists, speech therapists, social workers etc. It also offers training on request to non-professional health workers such as home-based carers (WCRC, 2011).

WCRC’s focus is on achieving independent social integration, a better quality of life and self-actualisation (WCRC, 2011). Its rehabilitation program includes interventions in the general system of society, adaptations in the environment (including the elimination of physical and attitudinal barriers), the equalisation of opportunities, and the promotion and protection of human rights (United Nations, 1982). All of these are valuable contributions. However, questions need to be asked about the sustainability of such services.

1.2.2 Motivation

As we embark on transforming South Africa's healthcare system in line with national government's service delivery plans, through a National Health Insurance (hereafter referred to as NHI) scheme, the question arises as to how we fund the scheme and support facilities to accommodate the growing demands on the system? Fakir suggests that, South Africa will have to "build new hospitals and other support infrastructure" (Fakir, 2010:2). Learning about sustainable healthcare, ecologically designed communities, energy efficient buildings, waste management, renewable energy, grey water and green buildings, an interesting research question is to explore what a sustainable hospital would look like. More specifically, how could WCRC craft an alternative system that promotes sustainability and to what extent should this be inclusive of design? Research suggests that sustainable hospitals and green buildings reduce costs, increase their revenue, and conserve energy, amongst other human benefits like improved productivity (U.S. Department of Energy, 2005:9). A sustainable hospital "selects products and work practices that eliminate or reduce occupational and environmental hazards, maintains quality patient care and contains costs" (Sustainable Hospitals, 2008:1).

The purpose of this study is to investigate and increase understanding of WCRC's current green building star rating score based on the Green Building Council of South Africa's (hereafter referred to as GBCSA). This is a new office building rating tool, to determine design rating. Green building rating tools set standards and benchmarks for green buildings, and enable an objective assessment to be made as to how "green" a building is. Australia and the United States have seen significant uptake of green building strategies with the adoption of their relevant rating systems, and Green Star certification has virtually become part of the definition of premium office spaces (Jason Buchs, pers.comm.). There after this research makes recommendations for WCRC in terms of ecologically-designed hospitals. Thus the research aims to provide recommendations for a suitable response for the current design, configurations and systems of WCRC to pressing sustainable development challenges (GBCSA, 2008).

1.3 Problem statement

From a sustainability point of view, hospitals offer their services without taking into account or consideration what their impact on their environment is. This research aims to address this challenge.

1.4 Research goals and objectives

The objectives of this research are to investigate the current hospital's design sustainability and green star rating score, and to build an understanding of the design as it currently is. Based on the research conducted, it will then recommend design measures to counteract identified measures. This research is also conducted in order to develop a better understanding of the sustainability of hospitals and the link between resources, energy sources and environmental pollution to ecological design.

Research questions

1. What is WCRC hospital's GBCSA's new building rating score?
2. How sustainable is WCRC hospital's design?
3. What measures are available for sustainable resource flows at WCRC?
4. What would a design of a "virtual" green WCRC hospital look like?

1.5 Significance of the study

In the context of current threats to health, livelihood and environmental security, as well as future challenges of increasing resource demand, climate change and peak oil (Evans, 2010). This study investigates viable alternative health systems in South Africa. The research, in its objectives to investigate the benefits and limitations of WCRC's hospital design, resource flows and local health configurations to promote sustainability, contributes to the current research context of sustainability and specifically fills a much needed gap on health and livelihood security in the South African context. The research aims to move beyond the traditional health sector debate which dominates popular literature to investigate building conventional hospitals as good service delivery, without an emphasis on sustainability through social equality, ecological integrity and community resilience.

On a practical level, this research brings together data sets that have not been previously correlated. It analyses the current hospital design and resource flows of WCRC, which have not previously been studied in this way. It also identifies opportunities for further scholarship. The recommendations made based on this research will further support current healthcare initiatives like the national health insurance and programmes for healthcare provision at hospitals.

1.6 Overview of research design and methodology

The research methodology was designed to meet the research objectives as outlined in Section 1.4 and incorporates both quantitative and qualitative approaches, as well as a combination of research techniques. The research draws on an *intrinsic* case study. The researcher "has an interest in the case" (Stake, 1995:1). The use of case studies is a "widely accepted means of bringing theoretical concepts and practical situations together" (Monash, 2010:2) and appears to be a useful tool in the context of this research. Literature on this topic forms a backdrop to the research and formal and informal interviews were also utilised.

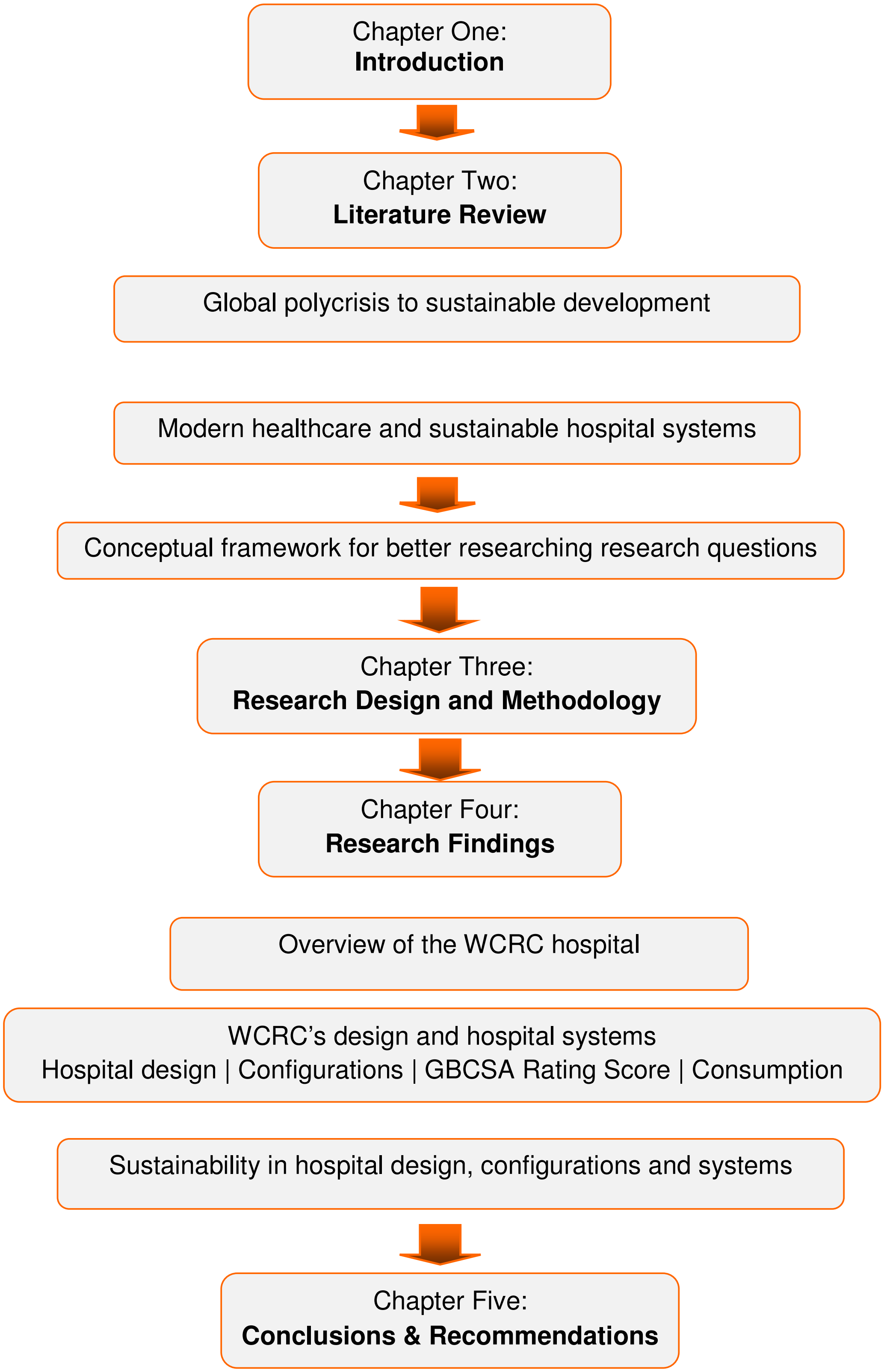
The first objective of the research was to investigate and obtain a GBCSA new office building rating score (star) for the WCRC hospital building. A comprehensive literature review was undertaken to provide a sound theoretical understanding of sustainable development, green buildings, green building rating tools, sustainable hospital configurations, and the sustainable hospital system as a lens through which to assess the building design, resource flows, benefits and limitations associated with promoting sustainability through the WCRC hospital facility. The theoretical approach was informed by the green star framework (Green Star SA, 2011), and a systems thinking perspective (Clayton and Radcliffe, 1996:01-27; Gallopin, 2003:07). The outcomes of the literature review were used to inform the approach taken for the research and as the foundation for informing the recommendations for WCRC hospital in the final part of the research. In order to assess the sustainability of the WCRC, its current status was compared with what could be done differently.

The research design included sourcing empirical data from a variety of bills, surveys, census data, published research and hospital information (secondary data analysis). As well as interviews with various stakeholders in the healthcare service and provision sectors for WCRC and the Western Cape region, to build an understanding of the status of WCRC's hospital design and systems. The research drew on on-going discussions (both formal and informal) with local health professionals (from WCRC's management and the Public Private Partnership management, who are directly linked to the hospital's service providers) and the local provincial health department given their direct role in the hospital and research topic area. Discussions were also conducted with individuals involved in local rehabilitation initiatives in order to better understand the benefits and limitations of the hospital's experiences, in the reality of the WCRC context. Several limitations were experienced with insufficient data availability, which are detailed in Chapter Three, Sections 3.3 and 3.4, and opportunities for further scholarship were identified (Chapter Five, Section 5.4).

The final objective of the research was to provide recommendations for promoting sustainability through WCRC's hospital system. The recommendations made (presented in Chapter Five, Section 5.3) are based on the outcomes of the literature review, the data collected and interviews conducted as well as personal observations both during and prior to the research period. Opportunities for building a more sustainable hospital are identified to facilitate a transition towards greater sustainability for WCRC in a manner which not only serves a selected few patients today, but supports the wider community in the long term through a diversity of locally appropriate programmes.

1.7 Outline of thesis chapters

An outline of the thesis chapters are presented diagrammatically below.
Figure 1: Thesis Outline



Chapter 2 – Literature Review

2.1 Introduction

The literature review aims to investigate the configurations, benefits and limitations of providing healthcare through hospitals to promote sustainability. The research design and methodology for the literature review are presented in Chapter Three, Section 3.3.1. A theoretical framework for this investigation is built by providing the context for the need of sustainability through a review of green buildings, sustainable hospital designs, the current global crisis (including both current and future challenges for our global society) that would then enable the development of a sound definition of sustainable development and sustainability (Section 2.2). A review of the functioning and impacts of the WCRC healthcare system (Section 2.3) provides the context for emerging alternative hospitals (sustainable building practice and sustainable hospital designs), including the healthcare industry (Section 2.4). The green buildings and sustainable hospital design is traced from origin to current functioning and core characteristics (Section 2.4). This theoretical framework provides a foundation from which to assess the configurations, benefits and limitations of providing healthcare to promote sustainability as defined (Section 2.5).

Sustainable Development

The United Nation's Millennium Declaration and the *Millennium Development Goals* (MDG) recognise that global sustainability challenges are interconnected and therefore require interdependent solutions. The global challenges are complex. They affect the rich and poor, the powerful and the powerless – but the latter often disproportionally. They recognise no boundaries. They include poverty, the unequal distribution, access and use of natural resources and land, population growth and reproductive health, migration, malnutrition, food production and food security, greenhouse gas emissions, endemic and pandemic diseases, climate change, energy supply and security, ecosystems, biological diversity, water and sanitation, environmental pollution and toxins (UN, 2000:15; World Health Organization 2005:57). Hospitals are a major contributor towards environmental degradation through their built environment which is responsible for greenhouse gas emissions through construction, operations (like resources they consume like water and electricity amongst other resources) and deconstruction impacts. To prevent the worst effects of global climate change and minimise other negative environmental impacts, it is therefore important to address the environmental impacts of hospital buildings (CIDB, 2011).

In its 1987 report, '*Our Common Future*', the World Commission on Environment and Development, the so-called Brundtland Commission, defined sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their own need (UN, 1987). The 2002 World Summit on Sustainable Development in Johannesburg stressed that the three components of sustainable development – economic development, environmental protection and social development – are interdependent and mutually reinforcing. It underscored the need to "integrate sustainable development perspectives and subsequent action" into all levels and forms of education. According to Johannesburg´s *Agenda 21*: education is critical for achieving "environmental and ethical awareness, values and attitudes, skills and behaviour consistent with sustainable development" and for effective public participation in decision-making (UN, 2002:1).

In December 2002, the UN General Assembly proclaimed 2005 – 2014 as the *United Nations Decade of Education for Sustainable Development* (UNDESD), with UNESCO as the lead agency. UNDESD´s overall goal is to integrate the principles, values and practices of sustainable development into all aspects of education and learning. This education effort will encourage change in behaviour that will create a more sustainable future in terms of "environmental integrity, economic viability, and a just society for present and future generations" (UNDESD, nd:1). Key themes of the UNDESD include biodiversity, fresh water management, environmental conservation and protection, rural transformation, health promotion, sustainable production and consumption, human rights, peace and international understanding, and the crosscutting poverty alleviation and gender equality (UNDESD, nd).

The very basis for human existence on earth is the life-supporting services provided by ecosystems. However, for the present and future generations to keep benefiting from these services, the destruction and over-use of ecosystems have to be overturned and steered into taking account of the existing planetary boundaries (SWEDESD, 2011:1). Iregardless of the lifestyle in a growing proportion of the world today, where economy and consumption are the increasingly overarching philosophies, the earth's natural systems and resources are the fundamental base of all human existence and activities. The services provided by our ecosystems supply oxygen, fresh water and the possibilities to grow or collect food products as well as other life-sustaining functions. It is also the natural systems that, together with human input, provide the constituents for the resources we have available for economic activity. The issue today is however, that we are not only living of the interest from this capital, but are actually consuming resources "faster than they have time to replenish" (World overpopulation awareness, 2011:2). Development like this need to be overturned and the essential importance of the provisions from ecosystems and their services need to be highlighted and assigned the high value they deserve. Hence this is a focal programme area for hospitals in promoting education and learning for *strong sustainability*, where "natural capital must be maintained and enhanced as the functions it performs cannot be duplicated by manufactured capital" (Orindi and Eriksen, 2005:10).

It has been argued that climate change can be managed through "mitigation and adaptation" (Global Mechanism, 2011:6). In the context of climate change mitigation Chandler et al., sees it referring to human interventions "to reduce the 'sources' of greenhouse gases or enhance the 'sinks' to remove carbon dioxide from the atmosphere" (Chandler et al, 2002:20). This in no way ignores what communities have done over the years to adapt to extreme climatic events. Local communities have used a wide range of strategies to deal with climatic hazards such as drought. Coping strategies are short-term responses that are utilised to face a sudden, unanticipated climatic risk while adaptation is a more long-term process that often entails some "soocio-economic and institutional changes to sustain livelihood security" (Orindi and Eriksen, 2005:5). Thus much of sustainable thinking is that hospital construction and healthcare service provision needs to do more with less.

Ecological Design: A pathway beyond sustainability

Van der Ryn and Cowan define ecological design as "any form of design that minimises environmentally destructive impacts by integrating itself with living processes" (1996:18). Ecological design is an integrative, ecologically responsible design discipline. It helps connect scattered efforts in ecological engineering, ecological restoration, green architecture, sustainable agriculture and other fields. Ecological design is both a profoundly hopeful vision and a pragmatic tool. By placing ecology in the foreground of healthcare design, it provides specific ways of minimising energy and material use, reducing pollution, preserving habitat, restoring ecosystems, inventing landscapes, and fostering community, health and beauty. Ecological design provides a new way of thinking about human interventions into the natural world by going beyond many streams of environmentalism, which often merely call for a minimisation of human impacts on the natural world. Ecological design can be defined as a careful and deliberate form of human intervention with the natural environment that attempts to improve natural conditions or reverse environmentally destructive impacts. This view has been supported in the work of SER, who argues that restoration as an ecological practice includes a very wide scope of projects like erosion control, reforestation, removal of non-native species and weeds, re-vegetation of disturbed areas, day lighting streams, reintroduction of native species, as well as habitat and range improvement for targeted species and that the term "ecological restoration" references to the discipline of "restoration ecology" (2004:10). The challenge of ecological design is more than simply an engineering problem of improving hospital efficiency, it is the problem of reducing the rates at which we poison ourselves and damage the world. The revolution that van der Ryn and Cowan propose must first reduce the rate at which things get worse (coefficients of change) but eventually change the structure of the larger system (1996).

Ecological design is the search for a unified approach to the healthcare design of sustainable systems that integrates scales ranging from the molecular to global. How can healthcare design, architecture, city and regional planning, and infrastructure development be woven together with the capacities and needs of specific bioregions in the service of a world that works for all? How can we design in a way that responds to nature, which is continuously exchanging energy and materials and supporting self-organising forms across a dizzying range of scales? Novacek and Cleland articulate that there is consensus in the scientific community that the current environmental degradation and destruction of many of the Earth's biota is considerable, and is taking place on a catastrophically short timescale (2001). Daily et al., articulates that natural ecosystems provide human society with food, fuel, and timber. More fundamentally, ecosystem services involve the purification of air and water, detoxification and decomposition of wastes, regulation of climate, regeneration of soil fertility, and pollination of crops. Such processes have been estimated to be worth trillions of dollars annually (1997). According to Wilson (1988), habitat loss is the leading cause of both species extinctions and ecosystem service decline (Daily et al., 1997). Hence, they are two possible ways to reverse this habitat loss trend: restoration of degraded habitats and conservation of currently viable habitats. According to Schumacher's book 'Small is Beautiful' design is not the attachment or supplement of architectural design, but an integrated design process which is what I deem ecological design to be (1973).

Crane and Swilling argue, for a more "creative way of thinking about innovation and change, we need to synthesize sustainability, dematerialisation and the new institutional economics" (2008: 3). Technically ecologically designed hospitals must incorporate energy efficient landscaping techniques, which are used as a design for the purpose of energy conservation. This further incorporates the use of onsite composting and chipping to reduce green waste hauling, the use of local materials that may involve the use of drought resistant crops in arid areas, the use of hand tools as opposed to gasoline-powered tools and buying stock from local growers and suppliers to avoid transportation energy, and similar techniques. Ecological healthcare designs must have energy using facilities that are primarily, designed to rely more on renewable energy as opposed to fossil fuel driven energy sources. Ecologically designed healthcare systems must be able to supply, and produce their own water, to meet their water needs and demands. Ecologically designed healthcare systems distinguish between dry waste and humid waste, that's biologically inert waste and biodegradable/perishable waste in biological terms (Fehr, M. and Calcado, M. R., 2003). An ecologically designed healthcare system transports humid waste directly to a dedicated composting site whilst dry waste is transported separately to a dedicated sorting site. This implies that they will primarily be two recipients (bins) within the community where one is dedicated for inert (dry) waste whilst the other is dedicated for biodegradable and perishable waste.

This hospital design must incorporate green roofs, which are used as a design for the purpose of adding mass and thermal resistance value to reduce heating in buildings. They also need to promote life cycle building energy consumption and pollutant emission analysis. These hospital's designs need to offer a balance with nature which emphasises the distinction between utilising resources and exploiting them. The design focuses on the thresholds beyond which deforestation, soil erosion, aquifer depletion, siltation, and flooding reinforce one another in urban development, saving or destroying life support systems. Ecological design begins with the creation of places in which the ecology of imagination and ecological attachment can flourish. These would be safe urban and rural hospital places that include biological diversity, wildness, flowing water, trees, animals, open fields, and room to roam--places in which beauty becomes the standard. David Orr supports this view by arguing that "ecological design in its fullest measure is not just smarter management by technicians, but rather a wider awareness and visible manifestation of our awareness that we are part of a larger pattern of order and obligation" (2001:5). Socially, the ecological design goal shouldn't be within the boundaries of carrying capacity, to merely meet needs, but to inform our desires more importantly. Good design instructs a community what they need and the terms of their existence and the designs use on earth.

Finally good hospital design must also meet other standards imposed by the way the physical world works. It must result in systems that are flexible and resilient in the face of changing circumstances. Given the limits to our knowledge and foresight, good healthcare design should never lead us to bet it all, to risk the unforeseeable, or to commit acts that are irrevocable, when the consequences are potentially large. And it would re-orient our sense of time giving greater weight to our future prospects and to long-term ecological processes as well. It would never cause us to discount the future (Orr, 2001). Sim Van Ryn and Stuary Cowan concur with this view in their work and show that thinking ecologically about design is a way of strengthening the weave that links nature and culture. Just as architecture has traditionally concerned itself with problems of structure, form and aesthetics, or as engineering has with safety and efficiency, we need to consciously cultivate an ecologically sound form of design that is consonant with the long-term survival of all species. This integration implies that the design respects species diversity, minimises resource depletion, preserves nutrient and water cycles, maintains habitat quality, and attends to all the other preconditions of human and ecosystem health (2010). Ecological design must become a kind of public pedagogy built into the structure of daily healthcare life. Ecological design is the art that reconnects us as sensuous creatures evolved over millions of years to a beautiful world. That world does not need to be remade but rather revealed. Cowan and Van Der Ryn describes their intentions clearly by stating that, "ecological design occurs in the context of specific places. It grows out of place the way the oak grows from an acorn. It responds to the particularities of place: the soils, vegetation, animals, climate, topography, water flows, and people lending it coherence" (Van Der Ryn, S., and Cowan, S., 1996:39).

2.2 From business as usual to sustainable development

From the recent economic crisis to shifting global climates, there are multiple alarms being raised signalling that our planet is a system in crisis. This "state of *global polycrisis* consists of a multiple set of nested crises that tend to reinforce one another" (Swilling, 2009:14) and that are not reducible to singular cause and effect relationships. A review of several key international sustainability reports will highlight how these challenges are deeply connected and serve as an impediment to both current and future development.
These sustainability reports are important because they articulate that the built environment makes a significant contribution to environmental degradation. An argument will be presented that "our global society cannot afford a path of development that operates without limits, but rather that development can only take place through both environmental and social sustainability" (UNEP, 2007:9). This will provide a theoretical framework for building a definition of sustainability that moves beyond the broadness of

the commonly accepted Brundtland Report definition of sustainable development and to frame the analysis within the context of the current sustainability discourse (UN, 1987).

Sustainable development is a difficult concept to define. It is also continually evolving, which makes it doubly difficult to define. One of the original descriptions of sustainable development is credited to the Brundtland Commission; sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987:43). Sustainable development is generally thought to have three components: environment, society, and economy. The well-being of these three areas is not separate but intertwined. Many governments and individuals have pondered what sustainable development means beyond a simple one-sentence definition (Rosalyn McKeown, Charles A. Hopkins, Regina Rizzi and Marianne Chrystalbridge, 2002).

Shelley S. Binkley, (2009:25) also argues that Sustainable healthcare is engaging the most successful and cost-effective medical therapies to provide the healthiest population. It includes "treatment and prevention" of environmental degradation. Sustainable healthcare takes a commitment on everyone's part to bring to the public the best, most cost-effective treatments. Skinner et al, of 7 Feb 2006, from Health Affairs argues that the most effective treatments are not necessarily the most costly (Skinner et al, 2006). Sustainable healthcare is "a complex system of interacting approaches to restoration, management and optimisation of human health that has an ecological base, that is environmentally, economically and socially viable indefinitely, that functions harmoniously both with the human body and the non-human environment, and which does not result in unfair or disproportionate impacts on any significant contributory element of the healthcare system" (Alliance for Natural Health Europe, 2009:1).

Too often than not, flourishing health systems have been destroyed by mismanagement. We have to rethink what we mean by health infrastructure (New Statesman, 2005 and SAGov, 2011). The old 'business as usual' healthcare/hospital model is not suitable now, nor for the foreseeable future. As cited by Emerald, Haines argues that 'we need to support the institutions that are outstanding'. Hence sustainable healthcare combines three key factors: minimising environmental impact, fiscally responsible budgeting and quality patient care. Although pollution is well understood as a health problem, "…health planners have not fully recognised the need to reduce health-care pollution" (Jameton, A., 2002:1; Emerald Group Publishing Limited, 2002:3). Hence the need to develop and rectify this by implementing more sustainable hospital building "design and construction practices" in developing countries and in South Africa in particular (Gibberd, 2008:6).

Minimising health-care pollution, moreover, requires reducing the throughput of energy and materials. Ultimately, sustaining healthy ecosystems requires that health-care material and energy utilisation is limited. However, traditional conceptions of health-care ethics maintain a philosophy of rescue that makes limiting life-saving resources, except at a patient's request, morally worrisome. Moreover, the media image of health-care as technologically intensive, together with the common medical view that nature is the enemy, render suspect philosophical perspectives respectful of the earth's limits (Emerald Group Publishing Limited, 2002). Some experts argue that the "do least harm" approach is not enough for the healthcare sector and that green hospital buildings should not only aim to "minimise negative impacts" but consciously "encourage positive impacts of building on both the indoor and outdoor environments" (van Wyk, 2008:10).

2.3 Promoting green building rating

The following review will attempt to unpack the development and key characteristics of the Green Building rating tools system in order to provide the context for the emerging green buildings' movement and analysing the configurations, benefits and limitations of green buildings' and rating tools as an alternative approach (thereby meeting the first research objective as defined in Section 1.2). The purpose of this section is to set forth the key issues that will be explored in the later sections, highlighting how these institutional frameworks and market incentives can be adapted to the South African context. In particular, it will investigate how these strategies can be used to address some of the most relevant issues of hospital buildings in South Africa, including the need for low-cost buildings and the use of low-cost building materials for greener hospitals.

2.3.1 Green buildings

Green buildings also known as green construction or sustainable building by definition are buildings designed to be "energy and water efficient, provide healthy productive environments and use non-hazardous materials" (Du Plessis, et al., 2002:5). The Green Building Council of South Africa furthers this definition by articulating that a green building incorporates "design, construction and operational practices that significantly reduce or eliminate the negative impact of development on the environment and occupants" (GBCSA, 2011:1). According to the U.S. Environmental Protection Agency (2009), green building refers to a structure and using processes that are "environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort" (2009:13). Green hospital buildings reduce their energy consumption to less than half of what a conventional building does, with similar reductions in potable water usage, runoff to sewer and solid waste. They can have a really significant impact on "resource consumption and on combating global warming" (Du Plessis, C., 2005:5).

Green buildings have an improved environmental performance (minimised negative environmental impacts and on combating global warming) over standard buildings through all phases of their lifecycle: beginning in design and construction through operations and to the end of life, including deconstruction and demolition. A green building will also have features that make it healthier for its occupants, such as fresh air, increased daylight and non-toxic materials. By reducing the amount of energy and water and other resources they use, green buildings are consistently less expensive to operate and become more valuable in the marketplace than conventional buildings. Green buildings aim to support beneficial social and economic change such as improved health, education and employment in local communities. Green buildings are constructed from Sustainable construction materials. Applied Sustainable Materials define sustainable material as “any material that can be put to effective use in the present without compromising its availability for use by latter generations. A sustainable material's use is within the brackets of a sustainable system, which in turn refers to practices that benefit and replenish the well-being of humans and the general environment” (2011:1). The Center for Sustainable Materials concurs with the latter, defining Sustainable construction materials as “materials from renewable sources that can be produced at high volumes without adversely affecting the environment or critical ecologies” (2010:2). A green building achieves these outcomes by focusing on them from its conception and first stages of design, implementing them throughout construction, and by continually monitoring and measuring its performance in operation. They “minimise resource use, pollution and waste, from the start” (GBC, 2011:1).

In addition to tangible environmental benefits, green buildings have demonstrable social benefits. Studies have indicated that the quality of the indoor environment in green buildings directly benefits the occupants: on average, “students in green schools score higher on tests”, workers in green buildings have “lower absenteeism and are more productive”, and “patients in green hospitals have faster healing times” (UN-HABITAT, 2011:10).

These human benefits have cost implications as well. The greatest expense for any business is its employee’s payroll, so greater productivity directly impacts its bottom line. Similarly, patients who spend less time in the hospital recovering save money.

Box 1: Green buildings improve patient outcomes

A number of international studies have confirmed that green healthcare facilities enable better patient care and reduce the length of stay required in hospital. These Studies include:

- The Mackenzie Health Sciences Centre in Canada found that depressed patients in sunny rooms recovered 15 per cent faster than those in darker rooms.
- The Bronson Methodist Hospital in Michigan, USA found that applying green design principles such as improved ventilation, private rooms, music, light and nature in its redevelopment project led to an 11 per cent reduction in secondary infections and a decrease in nursing turnover rates to below 7 per cent.
- The Inha University Hospital in Korea found a 41 per cent reduction in average length of stay for gynaecology patients in sunlight rooms over patients in dull rooms. The study found a 26 per cent reduction similarly for surgery ward patients.

Source: Green building council of Australia, 2009

Box 2: Green buildings are cheaper to operate

Because they conserve energy and water, green buildings are cheaper to operate. The Ochsner Health System in New Orleans, for example, saved:

- $350,000 a year and reduced the hospital's energy footprint by replacing thousands of pump and suction motors with variable speed motors;
- $3 million a year in electricity by using water directly from the Mississippi River in place of traditional cooling towers for air conditioning;

$1.2 million a year in electricity and reduced energy consumption by 20 percent by replacing 60,000 fluorescent lighting fixtures with newer energy-efficient bulbs.

Source: GBC, 2011

Box 3: Green buildings reduce staff turnover

Green buildings are healthier and happier places for staff, reducing staff sick leave and turnover rates, and boosting morale.

- A study from the Hackensack University Medical Center in New Jersey revealed that the cleaning products we were using before caused the employees to call in sick a lot." After implementing their Greening the Cleaning program, "it all went away, and our workers' compensation claims went down.
- A report by Robin Guenther, Principal at Perkins + Will in New York and author of Sustainable Healthcare Architecture, found a consistent, positive correlation between green building, staff recruitment, retention and performance (Robin Guenther, 2011).

Box 4: Green buildings provide healthier indoor environment quality

Thousands of chemicals and biological pollutants are found indoors. The known health effects of some of these pollutants include asthma, cancer, developmental defects and delays, plus effects on vision, hearing, growth, intelligence, learning and the cardiovascular system. Green construction can greatly reduce the effects of sick-building syndrome, (UN-HABITAT, 2011).

Once more, green buildings can benefit from better ventilation and indoor environment quality, which affects both patient and staff health. For example a study of 17 hospitals in Canada examined tuberculin conversion (a positive tuberculin test result) among employees working in patient rooms. The researchers concluded that tuberculin conversion among health-care workers was strongly associated with inadequate ventilation in general patient rooms. They found a 71% reduction in risk for workers in rooms with ventilation rates greater that two air changes per hour (Gaskill, 2006).

Moreover, the owners of building don't only save funds in operational expenditures of a green building, but studies from the United States indicate that green certified office buildings have higher occupancies as well as attract higher rentals and sales prices (GBCA, 2011).

2.3.2 Green building councils

Green Building Councils (GBCs) are non-profit, member-based organisations that seek to transform building industries towards sustainability by encouraging the voluntary adoption of green building best practices (McHarg, 2008; van Wyk, 2008). Currently, there are some 60 GBCs in various stages of development around the world, with 20 being fully 'established'. While at present there is only one established GBC in Africa – in South Africa – this is slowly changing, with three new councils in their early stages of development in Egypt, Mauritius and Morocco. Their primary methods to achieve their goals are the implementation of green building rating tools, education and advocacy. By engaging directly with stakeholders from throughout the lifecycle of buildings, GBCs can influence the choices made in each phase of the building's life, thereby dramatically improving their environmental performance. However the use of green building techniques is currently voluntary and can be highly variable.

The World Green Building Council is the umbrella organisation and governing body for these GBCs. The World GBC is organised into regional networks: Asia Pacific, Europe, the Americas, and Africa. As yet, only the Asia Pacific and Europe networks have held formal, in-person meetings. The Asia Pacific network is the most advanced, having held a two-week launch and training session in Australia in 2009 (hosted by the GBC Australia and sponsored by AUSAID, a development arm of the Australian government). This network structure facilitates the transfer of knowledge from more mature GBCs to newer GBCs and enables beneficial relationships amongst all parties (GBC Australia, 2011).

According to the USGBC, David Gottfried founded the first GBC in the United States in 1993. The USGBC remains the largest and most successful council in terms of industry influence and absolute numbers. Over 130,000 people have been accredited and trained in using the USGBC's Leadership in Energy and Environmental Design (LEED) green building rating system, with approximately "30,000 buildings registered and several thousand certified" under LEED (USGBC, 2011:2).

There are a number of options of how the GBC model might be adopted to Africa. The traditional model used by all GBCs to date is where by each GBC represents an individual country. However, with smaller markets some countries in Africa may find a sub-regional model more appropriate. There may also be other options for associating with a larger GBC or forming a sub-regional GBC. Going with any of these alternative strategies is uncharted territory and the advantages, disadvantages and practicalities of each of these options will have to be identified and explored (UN-HABITAT, 2011). With the growth and understanding around green buildings and green building rating tools in recent years and due to the success of the first GBCs, each new GBC that starts finds its market acceptance faster than the last. This widespread establishment of GBCs and their mission has impacted government policy as well. It is becoming more common for national (including the US and the UK), subnational/provincial and local governments to require that buildings used for their own accommodation meet the standards set out by the GBCs, and some are beginning to require them for privately owned buildings as well. In order to standardise green building practices and to provide a measure of efficiency of the techniques, different certification and assessment systems have been developed globally and in South Africa, as discussed below.

2.3.3 Green building rating tools

Green building rating tools are voluntary mechanisms used to rate and certify the environmental performance of buildings." Environmental performance is defined by Waste Management (WM) as, "consuming less, emitting less and achieving financial objectives" (WM, 2011:1). For daily operations, Waste Management further defines environmental performance as, "protecting the environment, enhancing the communities where we work and live, and complying with all rules and regulations" (WM, 2011:2). Environmental Performance is the relationship between the organisation and the environment. It includes the environmental effects of resources consumed, the environmental impacts of the organisational process, the environmental implications of its products and services, the recovery and processing of products and "meeting the environmental requirements of law" (ep@w Publishing Company Ltd, 2000:5). Environmental Performance actually has two definitions according to the International Standards Organisation (ISO):

- Firstly measurable results of the environmental management system, related to an organisation's control of its environmental aspects, based on its environmental policy, objectives and targets (ISO 14001: 1996 definition 3.8)
- Secondly results of an organisation's management of its environmental impacts (ISO 14031: 1999 definition 3.7).

By rewarding exemplary building performance, rating tools provide an incentive for building owners to go above what is required by government building codes (which define the baseline level of performance to be a legal building). Building owners can use the ratings to demonstrate the quality of their buildings to a variety of interested stakeholders, including occupants, investors and the public.

The British Research Establishment launched the first commercial green building rating tool in 1990, known as British Research Establishment Environmental Assessment Method (BREEAM). This was followed by LEED in the United States, Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan, Green Star in Australia and several other country-specific tools in Asia and Europe. With a number of successful tools in use around the world, each GBC now has the option to either (1) adopt one of the existing tools that allows its use in other countries with no or minimal changes, (2) adapt one of the existing tools that allows its use in other countries with customisation for the local context, or (3) create a new tool customised specifically for its market (UN-HABITAT, 2011).

The existing green building rating tools that allow the use of their tools and/or customisation of their tools in other countries are:

- BREEAM - BRE will certify a building in any country under BREEAM, using their BREEAM Bespoke methodology (where a tool is custom made for a fee on a project-by-project basis). They also have "agreements (legal and financial) with GBCs and other organisations" in various countries that want to adapt BREEAM for use in their markets. Once the local version of BREEAM is established, the adoptive countries take "responsibility for building assessment and certification" (BREEAM, 2011:1).
- LEED – a building in any country can register for LEED certification using the LEED rating tools, which are based on US standards and codes. The USGBC has "agreements (legal and financial) with several GBCs to use LEED in their countries" (LEED, 2011:1). Early adopters of LEED (e.g. India GBC, Canada GBC) were able to make slight changes to the LEED system for their markets, however LEED tools now instead have options for 'regionalisation' where certain initiatives can be rewarded differently according to the location. The USGBC is considering revising its LEED adoption framework in order to allow for other countries to have some ability to customise LEED. Wherever LEED is used, the USGBC handles all of the "assessment and certification of the projects" (LEED, 2011:1).
- Green Star – the GBC Australia developed the Green Star system and will not certify a building in another country under Green Star, as it was created specifically for Australia. However, they do have agreements (legal and financial) with other GBCs allowing them to customise Green Star for use in their countries (to date, two countries have done so). Once Green Star has been customised for that location, the adoptive GBC is responsible for "assessment and certifications of the projects under their scheme" (GBC Australia, 2011:2).

Several GBCs, particularly in Asia and most recently in Germany, have opted to create their own tools for their markets. Nearly all tools look at similar environmental issues. The differences lie in how the impact issues are categorised within the tool, the performance benchmarks for each initiative, the type of documentation required to prove compliance with the rules of the tool, and the methods by which the buildings are assessed under the scheme. Most systems look at the following issues to some degree: "energy, water, and indoor environmental quality, management of the construction process (including waste), ecological impacts, relationship of the building to its physical context, transportation impacts, and building materials" (UN-HABITAT, 2011:4).

As a rule of thumb, most rating systems start out with tools for new buildings, which apply to new construction and major refurbishments ("buildings with minor refurbishments could also use the tools but would have significant challenges in meeting the criteria put forth in the tools") (UN-HABITAT, 2010:8). Some systems now have rating tools for existing buildings that rate how the building "performs in its on-going operation" (UNEP, 2003:3). Green Building Councils have focused on new building design and construction because "up to 85% of a building's lifecycle costs" might already be determined once just 7% of its up-front costs are spent (GBC Australia, 2011:3). Also owners of new buildings have had the most incentive to pursue certification in order to create a market differentiation for their building.

As some of the more veteran rating systems have matured, they have created suites of tools with specific rating tools for each building type; the tools are specific to the function and form of each particular type of building. For example, a given suite may have tools covering offices, schools, shopping centres', homes, etc. This notion that one tool does not suit all types of buildings will play a role in considering how rating tools can be most useful in the African context, particularly low-cost housing (UN-HABITAT, 2011).

In the South African context, the standards, certification and assessment of green buildings has been driven by the South Africa Bureau of Standards (SABS) which developed the South African National Standards (SANS) 204 [SANS 204] series of standards to provide a framework for energy efficient buildings. The standard will result in minimum requirements for buildings as opposed to best practice. However, it is believed that SANS 204 would result in energy efficiencies of around 40% in commercial buildings. SANS 204 is presently only a voluntary standard but is expected to become mandatory for all new buildings soon, once it has been incorporated into the National Building Regulations. The downside of SAN 204 is that it only looks at energy-efficiency of buildings and nothing else like water efficiency and sustainable materials that makes a green building.

A process of industrial and expert consultations, saw the Green Building Council of South Africa Board (GBCSA-B) deciding to base the South African rating tool on the Australian Green Star system because it was the easiest to customise to a South African context. The Green Star SA rating system is not designed to become regulation, though individual organisations or government departments are encouraged to require it for their own buildings. While regulation sets minimum standards, Green Star SA intends to recognise leadership at the upper end of the green scale (Jason Buchs, pers.comm.). Each Green Star SA rating tool reflects a different market sector (office, retail, multi-unit residential, etc.). The first tool that was developed is the Green Star SA-Office which was published in pilot form for public comment in July 2008. Version 1 (Green Star SA - Office v1) was released in November 2008. The Green Star SA's office rating tool as shown in Figure 8 is for use by new office construction projects and base building refurbishments. It covers issues generally common to all regions and countries of the world. It should be noted that the organisation of two different certifications are awarded through the same tool: Green Star SA - Office Design at the end of the design phase of the project and Green Star SA - Office as built following construction completion, representing a 'best-fit' to guide the selection of this tool. The Green Star SA – office rating tool is "based upon the Green Building Council of Australia's Green Star – office design v3 and Green Star – office as Built v3 rating tools"

(GBCSA, 2010:1). The GBCSA staff, along with technical consultant Arup and a voluntary technical working group made up of industry professionals, evaluated all credits for "adaptation to the South African market" (GBCSA, 2011:1).

The Green Star South Africa office tool now launched as version 1 has embraced all of the "credits from the Australian version" in some form and has brought in five new credits to better address the current South African context (Green Star SA, 2011:2). This doesn't mean that issues should be considered exclusively within only one dimension. The social sub-theme of poverty, for example, has obvious and significant economic, environmental, and institutional linkages. The Green Star framework (Green Building Rating System) in Figure 9, identifies different categories in which a building's environmental performance can be improved; identifies specific initiatives ('credits') that would improve performance, awards points for incorporating the initiatives; totals the points to give a score and award a rating on the basis of the score (GBCSA, 2011:5).

Following the finalisation of the office tool, the Green Building Council recently published a retail rating tool and plans to roll out tools for other building types, for example retail, hotel, multi-unit residential, conference centres and industrial etc. For any given tool, 70 – 80% of the credits are core credits which will be common to all tools (GBCSA, 2011:4).

2.3.4 How green building rating tools work

Green building rating tools put forward optional performance targets for a wide range of building initiatives. These performance targets are known as 'credits'; which are organised into several environmental categories (such as energy, water, materials, indoor environmental quality). Wherever possible, the credits use specific metrics and compliance with international standards to gauge performance and minimise subjectivity (UN-HABITAT, 2010:8).

Each building project team chooses from this menu of credits, deciding which are most appropriate for its particular building with its specific uses and circumstances (buildings are not meant to achieve every credit, nor is it possible to achieve every credit in most tools). Projects receive points for each credit they can prove they have achieved. The aim is to achieve enough points to receive a rating, with more points meaning a higher rating.
As the building moves through the design and construction phases, project teams collect documentation (documentation criteria are clearly spelled out within the credits) demonstrating how the project is meeting its selected credits. At the end of the project, this documentation is submitted to the third-party certification body administering the rating system (typically the Green Building Council that operates the rating tool).

There are multiple of variations in the manner that buildings get assessed through the rating systems. Both LEED and Green Star require project teams to independently collect documentation and submit it all at once, with little interaction with the Council during that time (except to respond to technical queries). Assessors hired anonymously by the GBC review the documentation, which requires several hours per assessor to complete. Whereas, a project hires a BREEAM assessor to work with them throughout the project under BREEAM and this assessor submits the completed project documentation to BREEAM, for quality assurance (GBC Australia, 2011).

In all schemes, where a project is consistent with the rules set out by the body, they are awarded points for each credit achieved and are given a final score based on the project's total number of points. These points translate to a tiered set of awards, which each rating system offering its own variation. For instance, Green Star awards 4, 5 or 6 Stars to high-performing projects; under BREEAM buildings rate as Pass, Good, Very Good, Excellent or Outstanding; buildings can receive Certified, Silver, Gold or Platinum under LEED. Once the project's performance has been certified, it is free to market itself as such, whereas projects that do not meet the lowest point's thresholds are not certified and are not allowed to market themselves as a certified green building (GBCSA, 2011).

2.3.5 Professional accreditation

Most GBCs facilitate the use of their green building rating tools by offering a professional accreditation in their rating tool program. Anyone interested in becoming an 'Accredited Professional' (AP) in the program will take a training course offered by the GBC and then pass an exam (also created by the GBC) to demonstrate their proficiency in using the system. Those passing the exam go into a database on the GBC's website and can market themselves with this accreditation (e.g. LEED AP, Green Star AP). Most of the rating tools themselves also have a credit within them for having an Accredited Professional on the project team from the beginning, as an additional incentive for people to become accredited (GBC Australia, 2011). The Accredited Professional training program is a key part of any educational program that a GBC offers and often provides a "reliable revenue stream" for the council while providing a valuable service to the industry (GBCSA, 2011:3).

2.3.6 Rating systems can address low-cost building and low-cost materials

Perhaps the most pressing building development need in Africa is for low-cost hospital buildings. There is a tremendous opportunity for the uptake of green buildings to encompass the integration of green building best practices into this sector, including slum upgrading projects, hospitals and emergency/post-disaster housing. While all of these areas are important, this section looks specifically at how green building rating tools could address low-cost hospital projects and low-cost materials and whether there are other options better suited to moving this sector towards sustainability (GBC Aus, 2011)?

Green building rating systems must be viewed as indicators. Indicators can provide crucial guidance for decision-making in a variety of ways. They can translate physical and social science knowledge into manageable units of information that can facilitate the decision-making process. They can help us to measure and calibrate progress towards sustainable development goals. They can provide an early warning, sounding the alarm in time to prevent economic, social and environmental damage. They are also important tools to communicate ideas, thoughts and values because as one authority argues, “we measure what we value, and value what we measure” (UN CSD, 2001:2).

There is another practicality to be considered: the use and rating of low-cost building materials in low-cost hospital building. The selection and use of building materials is addressed in every green building rating tool, and with good cause. Most experts estimate that the embodied energy in building materials (the amount of energy required in resource extraction, manufacture and transport of materials) accounts for 15 – 20% of a building’s lifetime energy impact (assuming a 50–year lifespan). The production of building materials consumes large quantities and amounts of other resources as well, including water, and can result in the release of harmful chemicals into the environment and into buildings themselves (UN-HABITAT, 2011). The approach to building materials by a rating tool can have a huge ripple effect on the market as the materials supply chain can stretch around the world for even a single building (GBC Australia, 2011).

Most rating tools try to rely on third-party certification of building materials where possible. For instance, a tool may reward projects for using sustainably harvested timber. To verify compliance with this criterion, projects have to submit proof that a certain percentage of timber used on the project has been certified as sustainably harvested through an internationally recognised third-party such as the Forest Stewardship Council (FSC). Green Building Councils are not in the position to “certify the vast range of available building materials so by relying on third-party standards” they create efficiencies for their own efforts and simultaneously support the work of other organisations that are working towards sustainability (GBCSA, 2011). Where there are no third parties certifying a given material, the rating tool will put forward a performance standard and the project will still be responsible for demonstrating compliance, typically in the form of statements or test results from the manufacturer or supplier.

The majority of low-cost building materials such as adobe bricks, bamboo, compressed earth block, straw bales, and other biomass-based products are not certified under any third-party systems. In order to set performance criteria, the tool will have to look at the key impact of any material and set targets around that impact. Some examples could include determining which types of bricks have the lowest ‘embodied energy’ or rewarding projects for using materials that are sourced and manufactured locally rather than imported (GBC Australia, 2011). Another challenge with materials is how they will demonstrate that they meet the standards used in the tools. It’s easier for large companies to do testing or provide ‘standardised documentation’ to serve large number of projects seeking certification. Any documentation criterion devised by the rating tools addressing these materials will have to make sure they can be readily produced by a small, local operation at a ‘low cost’ or be easily verified in the assessment processes (UN-HABITAT, 2011).

The rating tools used in Africa will also need to be ‘conscious of developing credits’ that have solutions that are readily accessible and affordable in the given country or region, as some materials that are commonly used in green buildings in the developed world may not be affordable or available in countries like South Africa (GBC Australia, 2011).

2.3.7 Other alternatives to promote low-cost green hospital building and materials

Given the systemic challenges of rating low cost hospital building and low cost materials, it needs to be asked if rating tools are the right tool to improve the sustainability outcomes for low-cost hospital building. It is possible that design guidelines supported by prototypes (both design plan prototypes and full scale models) could create the desired outcomes.

Rating tools are meant to create market incentives, but where the government is the primary builder or where there is no competition among private developers, then rating tools are unlikely to be successful. However, in the absence of quality building codes (or building code enforcement) or good green building practices, design and construction guidelines developed by a credible third-party (such as a GBC) could potentially play a positive role. Compliance with the guidelines could be an incentive to private investors or development aid organisations to support the development of green, low-cost hospital building. For whatever strategy is chosen, a producer of a rating tool or guidelines for low-cost, green hospital building will have to "balance the need for rigor and credibility with the practicalities of cost and scalability considerations and the realities of what the market can provide at a reasonable cost" (GBC Australia, 2011).

2.3.8 Section conclusion

This section has introduced the topic of green buildings, green buildings councils, and green building rating tools and flagged the key issues that have been explored in greater depth to promote green building rating in South Africa. Hence, the reason why this research is also using the green building rating tool to meet objective one of this research. The GBCSA's main criteria were to have a tool that represented international best practice and that was "customisable to be relevant to South Africa." Another priority was to choose a "tool as quickly as possible" to get the market using it right away and not to spend an excessive amount of time on making the decision (GBCSA, 2011:10).

2.4 Towards sustainable hospitals and healthcare services

Green building traditionally aims to be sustainable by aiming for lower greenhouse gas emissions typically by being energy efficient. Energy efficiency in green hospital buildings will need to address heating and lighting, ventilation and air-conditioning (HVAC), water heating and cooking methods are also important. The Agenda 21 for Sustainable Construction in Developing Countries (A21SCDC) went as far as to define sustainable construction as "a holistic process aiming to restore and maintain harmony between the natural and the built environments, and create settlements that affirm human dignity and encourage economic equity" (Du Plessis, et al., 2002:4). Thus green building aims to incorporate some of the following principles and concepts in order to achieve the goals discussed and articulated in Section 2.3 above (McHarg, 2008; van Wyk, 2008):

- Sustainable / durable / low maintenance hospital building designs and operations:
  - Building must be sturdy and disaster resistant;
  - Design and build for long service life;"
  - The building must be 'futureproof' – access channels all around the structure to easily upgrade and add future technology (McHarg, 2008);
  - Capable of being 'stand-alone' without connections to gas mains or electric utility.
- Energy efficiency and conservation (van Wyk, 2008):
  - Work towards eliminating dependence on external sources of energy;
- Site/land management, reclamation and conservation (McHarg, 2008);
- Water efficiency, management and conservation (van Wyk, 2008);
- Improved indoor air quality (McHarg, 2008);
- Improved outdoor air quality (van Wyk, 2008);
- Material resource management, recycling and conservation (McHarg, 2008):
  - Maximum use of renewable building materials such as timber, thatch and wool;
  - Minimum use of non-renewable, energy intensive building materials like steel," brick, vinyl, aluminium;
  - Use materials found on site or close to the site;
  - Locally source materials and components in order to minimise transportation impacts and create local jobs;
  - Re-use of building materials and products.

Thus the most obvious way to work towards energy efficiency and carbon neutrality is to employ techniques for temperature control. Comfortable indoor temperatures can be achieved by the use of effective passive heating and cooling systems which harness natural ventilation and shading. Increased solar shading, controllable natural ventilation and high thermal mass significantly decrease energy usage and carbon emissions (Department for Communities and Local Government, 2007:10).

Energy-efficient techniques include (Lark, 2005):

- Passive solar – involves using the buildings elements (such as rock) to collect and store heat;
- Passive cooling – typically involves strategic shading combined with ventilation and evaporative cooling;
- Active solar – captures solar energy in specialised collectors, stores it, and uses it to heat or cool;
- Earth shelter – places a portion of the building underground, reducing its heating and cooling load;
- Super-insulation isolates a building so that body heat will heat it, and summer heat is kept out;
- Energy devices (van Wyk, 2008):
  - Heat pumps – refrigeration technology that moves heat into or out of the earth;
  - Photovoltaic panels – generate electricity directly from sunlight;
  - Domestic hot water solar collectors;

  - Cogeneration – generates electricity and heat in one process.
- Earthen materials – reduce temperature extremes due to their large thermal mass (but should be insulated in colder areas) (Du Plessis, et al., 2002):
  - Cob – earth/straw mix sculpted into walls;
  - Adobe – earth bricks;
  - Rammed earth systems;
  - Ceramic structures;
  - Earthships – earth-sheltered structures made of soil-filled tires.
- Insulative materials include (van Wyk, 2008):
  - Straw bales – used like bricks to build super-insulated buildings;
  - Light clay – clay-straw mixture;
  - Plant materials;
  - Manufactured alternatives to standard construction, eg. Stressed straw panels.
- Green hospital buildings will have measures that include (CIDB, 2009):
  - Ceilings with insulation;
  - Internal and external plastering;
  - Plastic membrane under floor;
  - Sealing the house at ground level; and
  - North-facing roof overhang.
- Green hospital buildings will reduce water consumption in buildings with more conserving fixtures, rain-water recovery systems, and innovative water technologies (Gibberd, 2008).
- Green hospital buildings have a net zero carbon emissions over the course of a year, after taking account of: emissions from space heating, ventilation, hot water and fixed lighting; expected energy use from appliances; and exports and imports of energy from the development (and directly connected energy installations) to and from centralised energy networks. To meet the zero carbon hospitals standard, hospitals should (Department for Communities and Local Government, 2007):
  - be built with high levels of energy efficiency;
  - achieve at least a minimum level of carbon reductions through a combination of energy efficiency, onsite energy supply and/or (where relevant) directly connected low carbon or renewable heat; and
  - choose from a range of (mainly offsite) solutions for tackling the remaining emissions.

Green hospital buildings must have green roofs or living roofs. Green building is no longer merely about technical and practical solutions to energy and carbon emission reduction but has moved towards a philosophy of being in harmony with the natural environment, in terms of form and function. A technique that has gained popularity is that of using living or green roofs. A green roof is a roof of a building that is partially or completely covered with vegetation and soil, or a growing medium, planted over a waterproofing membrane. They are basically an update of the ancient sod roof of Europe. This type of roof has several advantages, including its beauty, its ability to assist the house with blending into the environment and providing climatic stabilisation. A living roof reduces heating (by adding mass and thermal résistance value) and cooling (by evaporative cooling) loads on a building; reduces storm-water runoff; filters pollutants and carbon dioxide out of the air; and increases wildlife habitat in built-up areas, among other advantages. It is believed that if 8% of roofing in the city is green then the ambient temperature in the city can be reduced by up to 2 degrees Celsius. That significantly cuts the effects of global warming and city ‘heat islands’ (Cooper, 2008).

Green hospitals also need to have living walls. Living walls are also called biowalls or vertical gardens. Vertical gardens can be grown on just about any type of wall, with or without the use of soil, and they can be placed both on outdoor and indoor walls. Active living walls' are a new, concept in which the living wall is integrated into a building's air circulation system. These walls attempt to make use of biofiltration and phytoremediation to draw air through the root system of the wall. Beneficial microbes actively degrade the pollutants in the air before returning the new, fresh air back to the building’s interior. Passive living walls do not have any “means of moving the air into the root system” (Landscape Designers and Contractor Philadelphia Main Line, 2011:1).

Hospital building can also innovative and biomimic their building designs. Biomimicry is the concept of copying designs and innovations found in nature. A green hospital can be largely made of a combination of in situ concrete and double thickness brick in the exterior walls that moderates temperature extremes, and generally light coloured finishes reduce heat absorption. It will also have a ventilation system which operates similarly to a termite mound. Outside air that is drawn in is either warmed or cooled by the building mass depending on which is hotter, the building concrete or the air. It is then vented into the building’s floors and offices before exiting via chimneys at the top. The complex also consists of two buildings side by side that are separated by an open space that is covered by glass and open to the local breezes (Doan, 2007).

Lastly hospitals must emulate the cradle-to-cradle design. An emerging concept of cradle-to-cradle design aims to create buildings, communities and systems that generate wholly positive effects on human and environmental health. McDonough & Braungart (2003) foresee a future where instead of inanimate structures, buildings could act as life- support systems embedded in the material and energy flows of particular places. Cradle-to-cradle design is based on the closed-loop nutrient cycles found in nature, in which there is no waste, as opposed to cradle-to-grave design which sees materials as a waste management problem. For example, these hospital buildings would use materials designed as biological nutrients that could biodegrade safely and restore soil after use. There could also be materials that are technical nutrients that are potentially infinitely recyclable. The future may in fact have hospital buildings that function more like trees, in that they may make oxygen, sequester carbon, fix nitrogen, distil water, provide habitat for thousands of species, accrue solar energy as fuel, build soil, create microclimate, change with the seasons and are beautiful (McDonough & Braungart, 2003). The environmental impact of hospital buildings is obviously magnified when looked at the scale of whole cities and countries (SACN, 2004). Hence for cities to become sustainable and thus more liveable they must create the smallest possible ecological footprint and reduce contributions to climate change. This entails powering itself with renewable sources of energy, feeding itself with minimal reliance on the surrounding countryside, producing less pollution, efficiently using land, recycling, converting waste-to-energy, and improved public transport and an increase in "pedestrianization to reduce car emissions" (McDonough & Braungart, 2003:5).

Hospitals face multiple complex challenges amongst them the exposure of humans to biological pathogens, chemical pollutants from medical, building (construction, deconstruction and operational), industrial and human waste, pollution in the air, food, water and soil. Additionally the large consumption needs of hospitals "can cause damage to the ecosystem and other surrounding forms of natural capital in communities" (Urban Age Institute, 2011:1). Governments are simultaneously transferring management administrative and financial responsibilities to local tiers, where levels of management and infrastructure are "weak" (United Nations Economic Commission for Africa, 2005:65). This situation is particularly acute in parts of "Sub-Sahara Africa" where on appearance urban growth is "weakly linked to economic development and growth" (UNDP, 2007/2008:20). In the midst of all these challenges hospitals present a great opportunity to bypass old technologies and shaping development towards more environmentally sustainable futures (Swilling, 2006). Given the urgency of achieving deep and early quantitative cuts in greenhouse gas (GHG) emissions, "well designed cap-and-trade programmes have the potential to play a key role in mitigation" and adaptation (UNDP, 2007/2008:20).

As first defined in 2006 in the UK practitioner journal, *Nutrition Practitioner* by the Alliance for Natural Health Europe (ANH), sustainable healthcare is "a complex system of interacting approaches to the restoration, management and optimisation of human health that has an ecological base, that is environmentally, economically and socially viable indefinitely, that functions harmoniously both with the human body and the non-human environment, and which does not result in unfair or disproportionate impacts on any significant contributory element of the healthcare system" (ANH, 2006:1). Hospitals are meant to be a "clean and safe place" where people go to get well and building hospitals with green building services can further this mission. Greener hospitals provide a safer environment to work and live in, help the environmental issues like the climate crisis and cost less to maintain and operate (ANH, 2006:2). It is estimated in the United States, conservation in hospitals on energy and water can create $100,000 - $200,000 (approximately ZAR850,000 – ZAR1,700,000 at an exchange rate of $1:ZAR8.5) of annual savings in operating expenses. So hospitals nationwide are looking for ways to "conserve as much energy and water as possible" (Eaton, 2011:20).

In addition to dioxin and mercury contamination, there are a variety of other environmental exposures in the hospital environment that can lead to compromised health for both healthcare workers and patients. Some of these issues arise from hospital design and materials used in building healthcare facilities. For example, 75% of Poly vinyl chloride (PVC) is used in construction, which outgases Dioctyl phthalate (DEHP) into the air. Four studies have linked interior PVC exposure to asthma (Thorton, 2002; Jaakola et al., 1999; Jaakola, Verkasalo, and Jaakola, 2000; Wieslander et al., 1999). Other various exposures are tied to 'day-to-day hospital operations', such as the use of toxic cleaners and pesticides in healthcare facilities. According to research conducted by the Massachusetts Department of Health, poor air quality has been identified as the most frequent cause of work-related asthma in healthcare workers (Pechter et al., 2005).

Hospitals are also energy-intensive institutions. After the food-service industry, the healthcare industry is ranked "second in energy-usage intensity" (DOE, 2002:1). In 2005, in the United States of America, each square foot of healthcare space cost an average of \$2.15 (approximately ZAR18.28 at an exchange rate of \$1:ZAR8.5) in electrical and natural gas expenses. Some of these costs can possibly be addressed by "energy-efficiency upgrades and smart design" (CEE, 2005:5). Additionally, many hospitals are located in communities where public transit either does not exist or the hospital is inaccessible to the public transit system. Until recently, hospitals paid little attention to the "energy performance" and "efficiency of their building infrastructure" (CEE, 2005:6-7). As the environmental and health effects of global warming become more pressing, healthcare, like other major sectors, will need to reduce overall energy use and move to cleaner energy sources. Indeed, they have a responsibility to do so. Pharmaceuticals are also emerging as another major environmental and public health threat that until recently was virtually unknown. Many pharmaceuticals contain hormone-disrupting chemicals, which migrate from hospitals and homes to water bodies, negatively impact aquatic life, and wind up in our drinking water (Fox, 2005; Heinzmann, 2005). In addition, most drugs contain compounds that are persistent in the environment or bio accumulates in the food chain. As more drugs are consumed by patients, more of these biologically active agents are building up in our environment (Fox, 2005). "More than one hundred pharmaceuticals or their metabolites have been found in water bodies in Europe and the United States, some of them even in 'drinking water supplies' (Hemminger, 2005; Heberer et al., 1997).

2.4.1 Sustainable hospital design and environmental health science approach

Buildings use about 40% of raw stone, gravel, sand, and steel; 25% of virgin wood; and more than 75% of PVC (Roodman, 1995; HBN, 2006). Buildings also further demand about 40% of energy assets and 16% of water resources, while building construction and demolition generates about 25% of municipal solid wastes. Sick building syndrome has been identified as a frequent contributor to 'short-term' or 'chronic illness' (EPA, 2006a). This is consistent with analysis done in the United States, which found that, people spend 90% of their time indoors and that many common materials emit dangerous compounds and harbour infectious 'melds, fungi, and bacteria'. Thus the consequences are even more severe for people confined to the indoors due to illness e.g in hospital (EPA, 1993).

The challenge intrinsic to healthcare is how to provide high-quality treatment in an ever-changing environment. Technological innovations and new science constantly require healthcare providers to transform the way they deliver services. Over the last 10 years, the new science linking chemical contaminants in the environment and the incidence of disease has created an additional impetus for the transformation of healthcare practice. This section explores the implications of this new science 'linking contaminants and health' and discusses the environmental innovations that hospitals need to implement to not only create more optimal conditions for healing in their institutions, but also to prevent disease in the general public and mitigate climate change (EPA, 1998).

2.4.2 Rising disease burden

In the United States alone, chronic diseases and disabilities now affect more than 90 million men, women, and children, thus more than one-third of their population (CDC, 2005a). Despite of the much advancement in medical practice, the 'best available data' shows an increase in the incidence of acute lymphocytic leukemia, asthma, autism, birth defects, childhood brain cancer, endometriosis, Parkinson's disease, and infertility (Trasande and Landrigan, 2004, Jahnke et al., 2005). In order to get a sense of things, some of the highlights of South Africa's disease burden are summarised in table 1 below. The picture is profoundly troubling and worrisome. The human cost for "families and communities is immeasurable", particularly those already disadvantaged by persistent economic disparities (Goldman, 2001:7). The economic cost of these diseases by 2020 will "exceed $1 trillion yearly in healthcare costs and lost productivity" (Goldman, 2001:25). Evaluating South Africa's disease burden is important for the analysis of the proposed NHI, since it will impact on resource allocation, healthcare demand forecasts, specific programme needs and the like. A heavier burden of disease will demand prudent financial planning, well-planned health interventions and proper structuring of the entire system to cater for specific needs unique to this country and could mean constructing more hospitals. South Africa's one of a kind "quadruple burden of disease" is highlighted, while "further considering what this may signify for a national health system in this country" (Econex, 2009:1).

Table 1: South Africa's country profile of environmental burden of disease

Environmental burden of disease for selected risk factors, per year
Estimates based on national exposure and WHO country health statistics 2004

Risk factor	Exposure		Deaths /year	DALYs /1000 cap /year
Water, sanitation and hygiene (diarrhoea only)	Improved water: Improved sanitation:	88% 65%	**12 300**	**8**
Indoor air	SFU% households:	18%	**3 200**	**1.3**
Outdoor air	Mean urban PM10: 24 ug/m3		**1 100**	**0.2**
Main malaria vectors	*A. arabiensis, A. funestus*			
Main other vectors	None			

Source: World health organization, 2009

Environmental burden of disease (preliminary), per year Estimates based on Comparative Risk Assessment, evidence synthesis and expert evaluation for regional exposure and WHO country health statistics 2004		
DALYs/1000 cap	(World - lowest: 13, highest: 289)	**69**
Deaths		**118 400**
% of total burden		**16%**
Environmental burden by disease category [DALYs/1000 capita], per year		

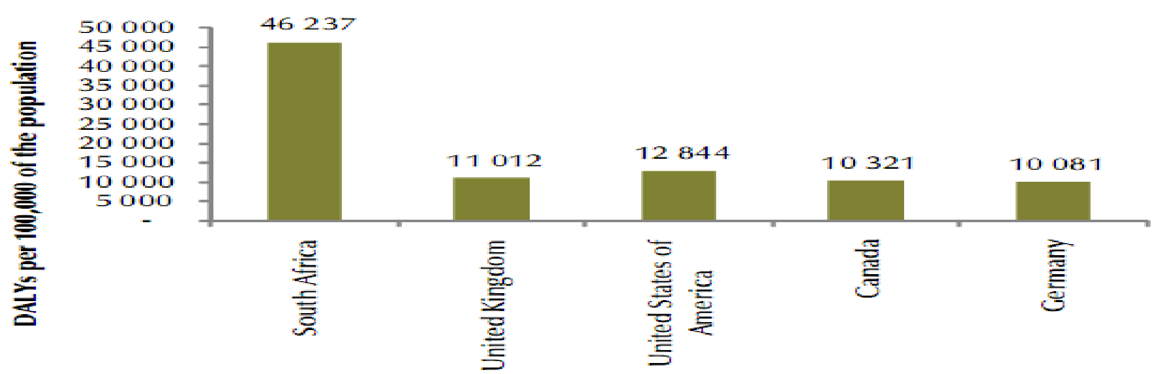
Source: World health organization, 2009

Disease group	World's lowest country rate	**Country rate**	World's highest country rate
Diarrhoea	0.2	**8.1**	107
Respiratory infections	0.1	**3.9**	71
Malaria	0.0	**0.1**	34
Other vector-borne diseases	0.0	**0.0**	4.9
Lung cancer	0.0	**0.4**	2.6
Other cancers	0.3	**1.7**	4.1
Neuropsychiatric disorders	1.4	**2.1**	3.0
Cardiovascular disease	1.4	**3.9**	14
COPD	0.0	**1.2**	4.6
Asthma	0.3	**2.8**	2.8
Musculoskeletal diseases	0.5	**0.8**	1.5
Road traffic injuries	0.3	**4.8**	15
Other unintentional injuries	0.6	**4.3**	30
Intentional injuries	0.0	**4.4**	7.5

Source: World health organization, 2009

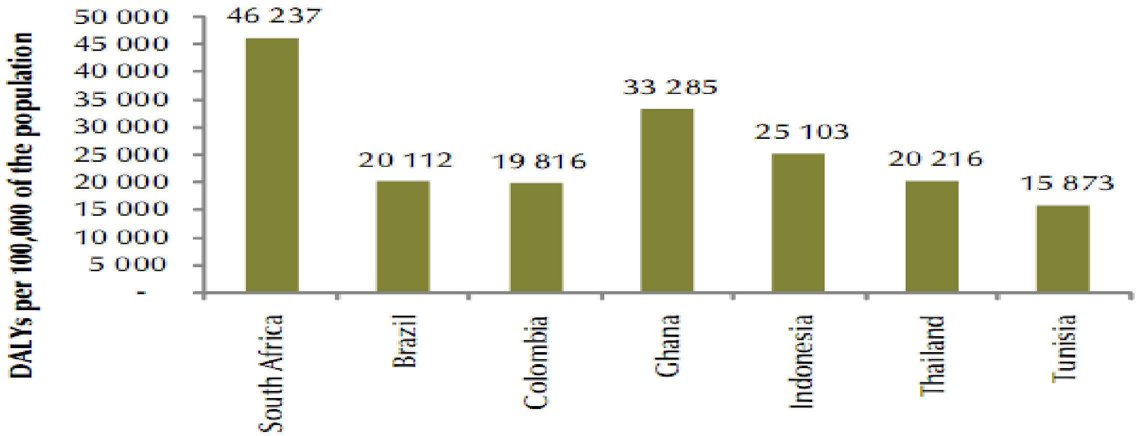
The severity of "South Africa's disease burden can be assessed by comparing the absolute number of DALYs for the selected countries". Figures 2 and 3 present the same underlying data used in the foregoing analysis, but further illustrate the gravity of the various disease burdens, rather than its composition. In addition to the unique composition of South Africa's disease burden, these two graphs emphasise the fact that this country has substantially "higher quantities of sick people who are also sicker than those in other countries" [especially compared with the ill in developed countries] (Econex, 2009:4). South Africa's disease burden is on average "four times larger than that of developed countries", and in most instances almost "double that of developing countries" (Econex, 2009:4 – 5). It is then reasonable to expect also a larger burden on finances, hospital building facilities and human resources in this country, as compared to these requirements in other countries. As stated in the introduction to this section, these graphs underscore the fact that "much thought and careful planning is needed for the design of a national health system addressing South Africa's severe, complex burden of disease" (WHO, 2011:25).

Figure 2: Absolute burden of disease compared with developed countries, in 2004



Source: Econex calculations from WHO, 2009 data

Figure 3: Absolute burden of disease compared with developing countries, in 2009



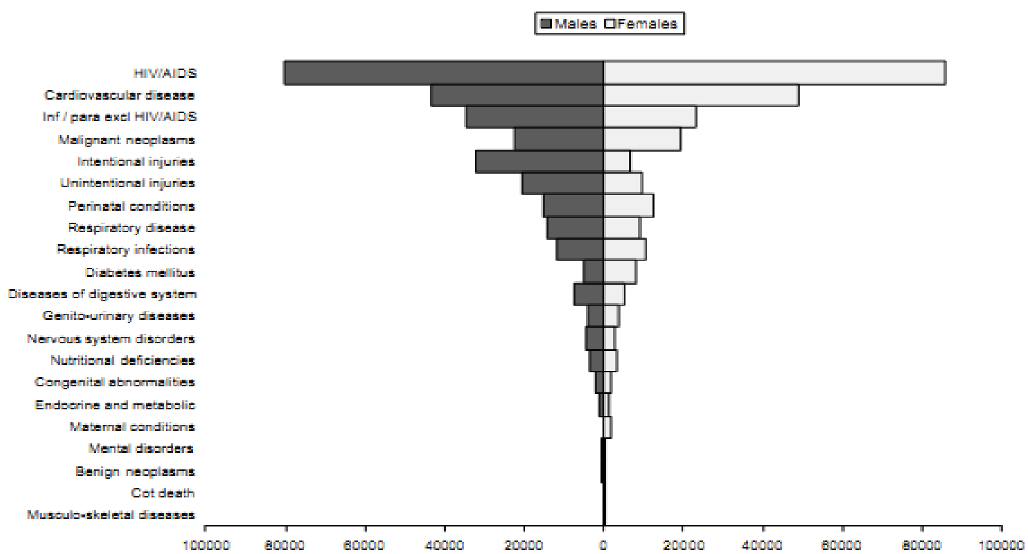
Source: Econex calculations from WHO, 2009 data

While the comparative analysis is presented above, clearly it emphasises the need for some type of national health insurance system in South Africa because they are higher quantities of sick people. And the fact that most people in South Africa can't access healthcare due to two factors, firstly hospital facilities are not available in some case even in residential areas / townships where you find the largest population like Khayelitsha and Mitchell's plain (RAWOOT, 2011). Whilst secondly others just don't have the "economic means" to access health services (Worldbank, nd:25). It also further implies that a South African NHI will have to take into account the specific quadruple burden of disease which South Africa faces. Any expectation that a national health insurance scheme, similar to the NHS of the UK or other advanced economies' national health systems for example, could be introduced within a short time frame is probably overoptimistic. Specifically, the resource requirements, hospital facility requirements and rationing systems of a national health insurance system in South Africa would be unique, given the specific burden of disease that was described above.

South Africa's current healthcare development plans from an infrastructural point of view imply the "construction of new hospitals" as evident in South African Human Rights Commission's (SAHRC) public hearings which suggested that there is a "great need for infrastructural development" and therefore a need to "accelerate development to address the problems with healthcare delivery in South Africa" (SAHRC, 2009:7). The "right to adequate health care" is resource-based and appropriate infrastructure should be put in place for the health care system to function optimally (SAHRC, 2009:8). Now with NHI on the cards, "more hospitals have to be built" so that people easily access hospital facilities otherwise this will add more pressure and strain on the already "distressed healthcare sector" in South Africa (Kautzkyi, and Tollman 2008:19). Given the fact that the hospitals that are under construction are being constructed in the 'conventional business as usual approach', it means that the healthcare sector isn't using the construction of these new hospital facilities to mitigate climate change. This means that even if NHI requires more hospitals, they will still be constructed through the 'conventional business as usual approach' unless a fundamental paradigm shift happens in terms of policy or hospital boards (like you WCRC hospital facility board which runs the PBO hospital facility) themselves adopting green building practices voluntarily for their hospitals. Otherwise the government owned ones like your Khayelitsha and Mitchell's Plain district hospital would be all your conventional hospital facilities and healthcare models whose problem I am trying to address in this research thesis. It's the very same hospital construction/built environment that I am critiquing as it does not conform to green building practices.

Although the quadruple burden of disease has very distinct implications for the supply of healthcare, this also "implies that the demand for healthcare looks completely different here, than elsewhere in the world" (Econex, 2009:3). Hence the supply for healthcare also needs to be different here, than elsewhere in the world. The type of in- and out-patient treatment, medication, primary and other care needed in South Africa, is not like that of other countries. One implication is, for instance, that of more hospital beds (which emphasises the need for better building designs as hospitals' expand in size to take on more patients), and therefore medical as well as other staff, will be required in a country where there is such a high prevalence of communicable diseases, HIV/AIDS, and also injuries. The financial and costing demands will of course then also be different from say, a country with a single burden of disease and where the severity thereof is less than a quarter of South Africa's.

Figure 4: Cause of death by category in South Africa, in 2000



Source: Bradshaw D, et al., 2003:v

In the United Kingdom (UK) a couple of new hospitals were built, known as NHS-run hospitals. To cater for the demand and supply of healthcare in the UK, NHS had to "grow their facilities even more and build more hospitals and buy better equipment and employ more doctors and nurses" (NHS, 2011:2). NHS has been a success but also dogged by massive challenges like cases in the UK where "the private sector will pocket billions from the NHS in profits and interest from new hospitals built" (Daily Mail Reporter, 2010:4). The private sector is also involved in the building and running of NHS hospitals in England under a complex scheme called Private Finance Initiative (PFI). In some areas of the country there are more hospitals' than are actually needed, which is wasteful and an expense the country can't afford (British Medical Association, 2010:1). Given this snapshot of challenges for a country with a single disease burden and whose absolute burden of disease is 4.20 times less than that of South Africa (as shown in Figure 2) is a clear indication what hurdles South Africa has to cross. Its evident South Africa will have to build new hospitals for NHI. The NHS inherited a maldistribution of resources, especially in London where the "main hospitals were concentrated in the centre of the city" (R Klein, 1995:4). London's lack of adequate "primary care coverage and over-reliance on hospitals for treatment has created recurring problems" (R Klein, 1995:5).

It is important at this stage of the debate to understand what the demand side of hospital buildings looks like and also what the current hospital buildings supply constraints are in South Africa and how these can be addressed. This will foster a better understanding of the optimal design of a South African NHI which builds on the sustainable hospital design approach (Modisane, 2005:45). Country-specific estimates of the burden of disease are crucial for targeting health interventions that make a significant impact on the well-being of the population. In South Africa, "an environment where the resource envelope is limited," the information in this report provides an excellent framework for the prioritisation of such health interventions (Bradshaw D, Groenewald P, Laubscher R, Nannan N, Nojilana B, Norman R, Pieterse D and Schneider M., 2003:i). Bottlenecks exist in the healthcare service provision as in towns and cities, some 15% to 20% of the population have excellent access to health services, while 75% to 80% of South Africans have limited or no access (Modisane, 2005).

The new field of environmental health is linking each of these diseases and disorders to exposure to toxic chemicals (CHE, 2006; Heindel, 2003). The old way of looking at chemical risk and safety would have missed these links, as they are not as simple as single cause and single effect. But through the new lens of environmental health science, we are learning that exposure to toxic chemicals, at previous levels thought to have been safe, is increasing the "chronic disease burden of millions of people" (Heindel, 2003:10). The new findings in environmental health science show that:

1. Chemical exposure at "...incredibly small levels can impact the hormonal system and disrupt the body's normal development, including interacting with genes that can damage the delicate balance in the human body. New science is revealing that genes and chemicals work together to contribute to disease onset…" (The Centre for Health design, 2011:6).
2. Babies in the "…womb and young children are more vulnerable to chemical exposure than average adults…" (CHE, 2006; G Cohen, 2006:6).
3. Chemical exposure at "…important windows of human development can set in motion changes that only manifest themselves as health impacts later in life" (Cohen, 2006).

4. Chemicals can "…interact in a synergistic way in our bodies to contribute to a health impact or exacerbate a health problem…" (G Cohen, 2006:6; Modisane, 2005).

This new science is coupled with the increasing understanding that hospital chemicals are present in our "food, air, soil, water, homes, schools, workplaces, and even in our bodies" (EPA, 2004:10). Our exposures come from "…food, cleaning and disinfection products, personal-care products, pesticide and herbicide applications, emissions from chemical manufacturing and disposal sites, pharmaceuticals," and a multitude of other sources, some known and some unknown to us (The Centre for Health design, 2011:15). In South Africa where NHI will come with the construction of new hospitals, chemical production will rise and the resulting waste will mount. According to the EPA, US industries reported manufacturing 6.5 trillion pounds of 9,000 different chemicals in 1998 alone. In 2004, major US industries reported "dumping 4.2 billion pounds of 650 industrial chemicals into our air and water" (EPA, 2004:13). Since most toxic releases are not reported, this only represents "less than 9% of the total toxic releases" (NET, 2004:10).

As a result of toxic products and pollution, today every child born already carries toxic chemicals in his/her body that have passed through the mother's placenta. We have minimal to no toxicological data on most of these chemicals. Additionally, there is almost "no scientific research about the synergistic effects of exposing human beings to this complex cocktail of toxic compounds" (G Cohen, 2006:3). Sadly we also don't know how this body burden of chemicals interacts with on-going exposure to emissions from hospital buildings, hospital incinerators, hospital food, hospital air pollutants, and other hospital sources, as well as other environmental stressors and genetic dispositions.

2.4.3 Healthcare's contribution to environmental chemical contamination

The health sector is a major source of dioxins and mercury in the global environment primarily as a result of medical waste incineration and the breakage and improper disposal of mercury-containing devices such as thermometers and sphygmomanometers. I argue that hospitals must give priority consideration to waste treatment processes, techniques and practices that avoid the unintentional formation and release of persistent organic pollutants (POPs), such as dioxins. However, many countries lack the "ability or resources to comply with these obligations" whose ultimate goal is to protect public health and the global environment from the impacts of dioxin and mercury releases (UNOPS, 2011:1-2). Focus must primarily be on activities such as waste minimisation (e.g zero waste), promoting the use of non-burn waste treatment technologies, improved waste segregation practices and the use of appropriate alternatives to mercury-containing devices, creating model healthcare building facilities or programs through collaborations with hospitals, smaller clinics, rural health and/or central waste treatment facilities within a community or bio-region. Mercury and Dioxins are two chemicals that "new environmental health science has shown to be unsafe at levels previously thought" to be safe (Mahaffey, 2000:10; Keitt, Fagan, and Marts, 2004). Thus green hospitals buildings must not use mercury or dioxin containing products to reduce their materials impact on the earth.

According to the US Environmental Protection Agency (EPA), in 1995 alone, medical waste incinerators were the largest source of dioxin air emissions and "contributed 10% of the mercury air emissions in the United States" (EPA, 1995:6). Processes such as combustion, chlorine bleaching of pulp and paper, certain types of chemical manufacturing and other industrial procedures that include the combustion of chlorine produce dioxin as a by-product. The EPA estimates that "humans receive more than 95% of their dioxin intake through food" (FDA, 2006:1). People eat dairy products, meat, and fish and take the dioxin into their bodies, where it is stored in fatty tissue for years and builds up over time. The global distribution of dioxin's, means that every member of the human population is exposed. This is especially problematic for childbearing women, who pass dioxin to a child in "utero and when breastfeeding" (EPA, 2005). Being a green building goal, hospitals need to reduce such impacts which arise during occupancy.
Intimately linked to the "dioxin issue is polyvinyl chloride (PVC)", widely used in the production of IV and blood bags, plastic tubing, and an array of other hospital products (FDA, 2002:3). PVC (because of its high chlorine content) contributes to dioxin formation when it is manufactured and incinerated. Flexible PVC often contains a chemical, DEHP [Di (2-ethylhexyl) phthalate] that can leach out of products and enter the bodies of patients receiving fluids through PVC tubing. In 2000, new environmental health science led the National Toxicology Program to conclude that DEHP is a reproductive toxicant and that infants in hospitals are at risk from exposure to this chemical (NTP, 2000). The US food and drug administration followed with a health advisory to hospitals, urging healthcare facilities to seek safer alternatives, especially for vulnerable populations (FDA, 2002). Thus green hospitals must reduce the impact of their materials on the earth.

According to the EPA, medical waste incinerators are also a source of mercury and other heavy metal emissions into the environment, although their numbers have been drastically reduced (EPA, 1995). Mercury is a toxic metal that affects the human nervous system, liver, and kidneys; mercury-contaminated fish eaten by pregnant women can affect foetal development. In addition to dioxin and mercury contamination, there are a variety of other environmental exposures in the hospital environment that can lead to compromised health for both healthcare workers and patients. Some of these issues arise from hospital design and materials used in building healthcare facilities. As both the environmental effects and health effects of global warming become more and more pressing; hospitals, just like other major sectors, will need to reduce the overall energy use and move to cleaner energy sources. Indeed, they have a responsibility to do so. The dawn of a new 'corporate social responsibility' (CSR) is seen as "…becoming an even more important part of business practice five years from now, and will make crucial and necessary contributions for the betterment of people' and the environment" (Business for Social Responsibility and Dutch Ministry of Economic Affairs, 2004:12).

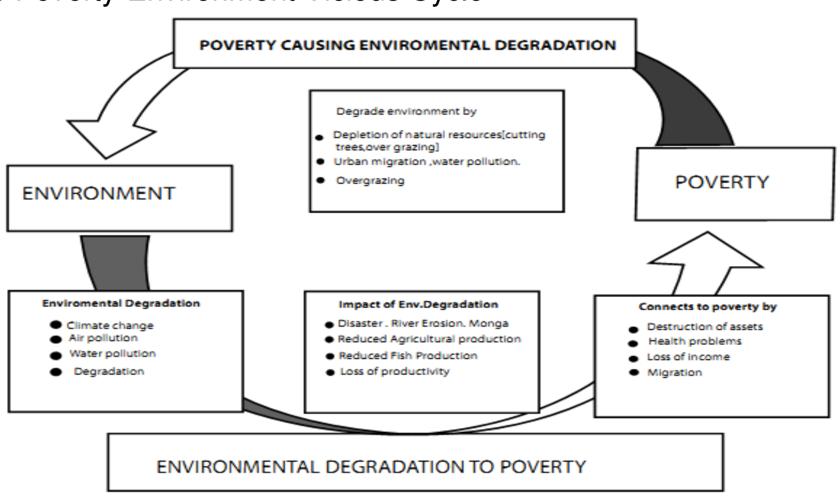
For hospitals to become sustainable and thus more environmentally friendly they must create the smallest possible ecological footprint and reduce contributions to climate change. This entails powering themselves with renewable sources of energy, feeding themself with minimal reliance on the surrounding countryside, producing less pollution, efficiently using land, recycling, converting waste-to-energy, and improved public transport and an increase in pedestrianization to reduce car emissions. A sustainable hospital facility will also foster human well-being by creating a sense of community. There will be more open spaces, green centres and gathering places. This requires a radically different approach to hospital design planning, with integrated green building aspects.

2.5 Resources flows and natural resources

Sustainable design is driving both "market transformation and organisational change" (Healthdesign, 2011:1; Robin Guenther, FAIA, Gail Vittori, and Cynthia Atwood, 2006:6). Each is necessary for the healthcare industry to sustain itself (Hamilton DK., 2004:6). There "are many reasons the industry is overburdened and slow to change, but this section begins with the notion that the industry is increasingly recognised as an out-moded system that pollutes. In fact, when viewed in this particular light, the system not only pollutes, it potentially participates in creating the very same illnesses that it is trying to cure" (Hamilton DK., 2004:10). Sustainable construction, or *green building*, calls into question the purpose of the healthcare system. Does it treat sickness or promote the conditions of health? Does it create sickness and prevent health? Is it a paradoxical situation that can be resolved and, if so, how? Do healthcare organisations that undertake green building recognise this paradox, and, if so, are they acting on it?

In most African countries, some of the key environmental issues are: "declining soil productivity, soil erosion, rangeland degradation, bush encroachment, salinization, desertification, agrochemical pollution of water, siltation, water supply and shortages, loss of habitats and biodiversity and overexploited forests" (UNECA, 2002:35).

Figure 5: The Poverty-Environment Vicious Cycle



Source: Chowdhury and Ahmed, 2010

These issues are agriculturally related and thus can be linked to challenges in the attainment of the Millennium Development Goals (MDG) 4 – 6 which target healthcare provision. In some instances healthcare goals translate to the construction of hospitals and the question is what type of hospitals will ensure environmental sustainability and speak to MDG 7? Environmental degradation also threatens all aspects of human well-being including health. In most African countries, persistent poverty means that growing populations depend on mostly, appalling hospital infrastructure and inadequate local natural resources for survival. In their studies of healthcare and land management in Uganda, Nkonya et al., found strong linkages between poverty, poor healthcare provision and land management as investments in hospital standards and management was associated with household income levels and productivity (Nkonya et al., 2004).

In order to promote sustainable healthcare systems, hospital planners must take into account the interplay between the various sectors (ecosystems, water supply, energy supply, sanitation and waste management, building construction, traffic and transport, the environment, security, social structure, etc.), and place this in the geographical context (district, town, city, surrounding area). Figure 6 shows this interplay between sectors. Only then can solutions actually be effective, rather than giving rise to new problems somewhere else bearing in mind the "cost-cutting parallel measures in the health sector (hygiene campaigns, shared gardens for medicinal plants, pharmacies for traditional cures, health education in primary schools) and Cooperation in urban development" (Deutsche Gesellschaft für Technische Zusammenarbeit [GTZ] GmbH, 2005:13).

Figure 6: Interplay between the various sectors

Source: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, 2005

The earth is made up of ecosystems whose existence heavily depends on the availability of each single species that forms a part of that ecological system (ecosystem). The extinction of a single species distorts the cycle and threatens the survival of the other species dependent on that system, and the need to conserve and safeguard biodiversity to boost ecosystems. A lot of biological processes depend on "ecosystems whose overall impact is environmentally friendly" (FAO, 2010:22). Divergent groups within central business district (CBD) systems have expanciated some principles like the ecosystem approach (Shepard, G., 2004). The earth's natural resources need to be used 'prudently', thus trying to minimise and curb the exhaustion of non-renewable resources. Water needs to be used sparingly and recycled via an efficient waste management system. The water can be recycled and reused to flush toilets to reduce on water consumption. Solid waste can be used to generate biogas for cooking and the other waste slug can be used to water fields. Waste packaging like plastic, paper and glass can be recycled for future re-use especially in hospitals where large amounts of it are generated (Kibert et al., nd).

Natural resources are intricately linked to the livelihoods of most countries in Africa and elsewhere. They are the basis of subsistence in many poor communities. Natural resources account for "26% of the wealth of low-income countries" and are the mainstay of many developing economies (UNEP, 2007:88). The world's ecosystems are 'capital assets'. If properly managed, they yield a flow of vital services, including the production of goods such as food, fibre and timber as well as life support processes such as pollination and water purification. They also confer other life-fulfilling conditions such as anaesthetic appeal and serenity. Moreover, ecosystems have value in terms of the conservation of options such as "genetic diversity for future use" (Gretchen et al., 2000:19).

2.6 Evolving the Hippocratic Oath

First, Do No Harm (Institute of Medicine [IOM], 2004:25)

Since physicians and other healthcare professionals take an oath to "first, do no harm", healthcare institutions and the industries that support them have a special responsibility to ensure that their operations are not major sources of chemical exposure and environmental harm (healthybuilding.net, 2011:1). But, until recently, healthcare professionals and hospital administrators were unaware of their contribution to climate change, pollution, environmental degradation and broader societal disease burdens and some are currently still unaware (Robin Guenther, Gail Vittori, 2008; James A. Johnson, Carleen Harriet Stoskopf, 2010). The educational curriculum for physicians, nurses, and hospital administrators does not provide the latest scientific information on the "environmental consequences of healthcare delivery", neither sustainable development nor climate change (Margaret F., Schulte, DBA, Fache, 2008:24). Hospitals don't have this as a focus area on their agenda neither do they have it on their development plans – they don't even have sustainability statements to mention the least. Hospitals and healthcare companies may not be "judged today by their sustainability policies, but that day is coming" (OgilvyEarth and Ogilvy Public Relations Worldwide, 2011:4). The flow of resources gets conducted through socio-economic systems in hospitals and they are separate units/systems' in place in the healthcare system like procurement, purchasing, personnel, stores etc. and to make the hospital sustainable these systems need to be aligned in a sustainability driven manner.

Clark articulates that "hope for the future lies in 'active engagement of civil society with governments' to make sure that community rights are respected and responsible corporate conduct is carried out" (Clark, 2003:8). Sustainable development can only be realised in the 21st century by "resuming the overt state responsibility" for the regulation of economic development and social welfare as a response to organised civil pressure in a bid to rescue abandoned valuable objectives from the vagaries of the supposed 'free' market (Clark, 2009:17). Rita de Cássia Guedes argues that government needs to identify the "political, economic, and social forces" because "…companies gain new power notions: [...] increasingly stressed command of transnational corporations that – deprived of sovereignty, unacquainted with frontiers and nationalities – have in fact an upper power in relation to many national States [...]. (Oliveira, 1997, p. 55)", (Rita de Cássia Guedes, nd). Genuine CSR needs to recognise the interrelated links between the following aspects which make CSR holistic:

- Community
- Education
- Environment
- Governance
- New Product Development
- Strategy
- Supply Chain
- Workplace

This further *calls for hospitals to* strike *a balance between* their economic profit maximisation agendas with the participation in community social projects and activities to encourage the regeneration of depleted environmental resources. In the last ten years, however, the information gap has begun to close. The healthcare industry has begun to expand its definition of health to include environmental health – the body of scientific evidence that links the health of the environment to the incidence of human disease. With the emergence of Health Care without Harm (HCWH), hospital leaders have learnt about their industry's contribution to chemical exposure issues and made steady progress to solving some of their environmental problems. For example, due to the rising costs of complying with dioxin emission regulations and the educational work of HCWH, more than 5,000 medical-waste incinerators have closed since the mid-1990s in the US alone.

In response to the changing regulatory climate, hospital administrators "chose to reduce waste and adopt safer waste-disposal and treatment technologies" (Robin Guenther, Gail Vittori, 2008:14). For example mercury elimination in the American healthcare sector, although not yet complete, is a powerful success story about how hospitals can collectively use their enormous "purchasing power" to reduce their environmental and public health footprint and also drive markets for safer "alternatives to problematic chemicals and technologies" (H2E, 2005:2). There are additional components to this success story. Firstly, "healthcare leaders occupy a highly respected place as trust-holders in society" (healthcaredesignmagazine, 2007:1). If hospitals eliminate mercury from their operations, it creates the political momentum to eliminate mercury from other sectors and other products in our economy, thus improving the safety of the food supply and public health. Since hospitals began moving to remove mercury from their operations in 1998, more than 29 US states have passed laws "restricting mercury-based products in their states" (EIA, 2005:9). Hence hospitals have a role to play in the sustainability era.

2.7 Green healthcare spaces

Whilst they are changing green space definitions, greenspaces are the “green lungs” of our towns and cities which contribute to improving people's physical and mental health by providing places for informal recreation - walking, cycling, sitting, socialising and children's play - and “breathing spaces” to take time out from the stresses of modern life (Greenspace Scotland, 2011:1). Greenspaces also create safe and attractive places where people want to live and businesses invest. Greenspaces are 'multi-functional' and they are used in many different ways (Maidstone Borough Council, 2003:2). They include not only areas to which the public have physical access, but also visual access, for example, in the way greenspaces provide settings for buildings, communities and everyday activities (Evergreen, 2004:31). The standard of these spaces must range from 0.7 to 6 hectares/1,000 people, with an average of 2.79 hectares/1,000 (Evergreen, 2004:9). The built hospital environment isn’t the only one that needs to be a green building but its surroundings too, need to be green spaces. A green hospital building must provide the much needed *space* for people to take part in “organised or informal sports and provide recreational opportunities for those unable or unwilling to” (Green Space, 2010:1). There is mounting research evidence which backs up the case that the foresting the healthcare sector and hospital building spaces will help sites to realise the following, proven health, social, environmental and financial benefits:

2.7.1 Accelerated patient recovery

Research has shown that patient recovery rates improve even if they can only view trees from their hospital window.

- Studies of cholecystectomy patients in hospital found that they recovered more quickly with a view of trees and nature from their windows (Ulrich, R.S., 1984).
- Hospital gardens can provide the following (Cooper, M. C., 2005; CABE, 2009):
- Facilitate stress reduction which helps the body reach a more balanced state.
- Help a patient summon up their own inner healing resources.
- Help a patient come to terms with an incurable medical condition.
- Provide a setting where staff can conduct physical therapy, horticultural therapy, with patients.
- Provide staff with a needed retreat from the stress of work.
- Provide a relaxed setting for patient/visitor interaction away from the hospital interior

2.7.2 Improved community health

The health of patients, staff and local communities can be dramatically improved by providing opportunities to exercise outdoors and access green spaces including woodlands but the question is how much of the South African population have access to local woodland within 500 meters of their home?

- Researchers from the Universities of Bristol and East Anglia found that people living closer to green spaces were more physically active, and were less likely to be overweight or obese, and people who lived furthest from public parks were 27% more likely to be overweight or obese (E. Coombs, A. Jones, & M. Hillsdon, (in press)).

- Greater opportunities for exercise provided by close proximity to a park reduced weight gain in teenagers by five kilograms over a two year period (Janice F. Bell, PhD, MPH, Jeffrey S. Wilson, PhD, Gilbert C. Liu, MD, MS. Am J Prev Med, 2008;35(6):547–553).
- A University of Glasgow study found that, for England as a whole, people living closer to green spaces had lower death rates and less heart disease. Amongst lower income groups, 1,300 extra deaths occurred each year in areas where the provision of green spaces was poor (Lancet, 2008; 372: 1655-1660).
- Regular physical activity contributes to the prevention of more than 20 conditions including coronary heart disease, diabetes, and certain types of cancer, mental ill-health and obesity (Department of Health, 2005).
- Trees and woods can have a restorative and therapeutic effect on the mind (Hartig, T., Evans G.W., Jamner L.D., Davis D.S., and Gärling T., 2003:109).
- Recent studies have looked at the beneficial effects of natural surroundings on children with Attention Deficit Hyperactivity Disorder (ADD) and proved that they is a surprising Connection to Green Play Settings for kids Coping with ADD (Taylor, AF et al, 2001:60).
- Trees have been found to enhance mood, improve self-esteem and lower blood pressure. Research in the Netherlands and Japan indicated that people were more likely to walk or cycle to work if the streets were lined with trees and live longer and feel better as a result (Van den Berg, A.E., Koole S.L., and van der Wulp N.Y., 2003).
- Two reports, sponsored by RSPB, published in 2004 and 2007 outlined the benefits to physical and mental health arising from contact with the natural environment. These included the reductions in obesity, heart disease, diabetes, cancer, stress, ADHD, aggression and criminal activity, amongst others (Bird, W., 2004).
- Environmental volunteering, including tree planting, can be as effective as aerobics in improving fitness. Independent evaluation of BTCV's Green Gym concluded that overall the physical health status of volunteers significantly improved, with 99% of participants reporting enhanced health and confidence (Yerrell, P., 2008).

Thus sustainable healthcare systems need to have green spaces apart from green hospital buildings as they are great rewards that the researches above have proven when hospitals focus on tree planting, community engagement and the health benefits of the green space. The evidence above suggests that they are significant healing properties of the creation of green spaces on hospital estates.

2.8 Chapter summary

Climate change is one of the "greatest challenges of our time" argues the United Nations Framework Convention on Climate [UNFCCC] (UNFCCC, nd:1). It has elicited action at local, national and global scales. Climate change is predicted to exacerbate the intensity and magnitude of extreme weather events like flooding, cyclones and droughts. These will negatively affect natural and social systems. Human livelihoods, especially those of nature-based economies, will be adversely affected. Changing precipitation and temperature patterns and trends will affect ecosystems' productivity and thus the availability and distribution of goods and services. Understanding, mitigating and adapting to climate change is urgent if ecosystems are to continue providing critical goods and services. This includes focusing on the improvement of the resilience and adaptive capacity of natural and human systems. An important question is, how can this be realised? The answer partly lays in the way local level initiatives and decisions (like managing hospital environments') are undertaken now and in future. Several sections in this chapter argue that the management of hospital environments' and hospital resources should include the full participation of local residents and cooperation with government to ensure socio-environmentally sustainable hospital systems and resource management.

This lies in how hospital resource management is viewed and undertaken in the light of climate change responses at global, regional and national levels. It is expected that with climate change, hospital resource management at different levels will dynamically facilitate the design and implementation of mitigation and adaptation strategies that will enhance resilience and adaptive capacities of economic, natural and social systems. In order to bridge global, regional, national and local level divides, climate change science is critical. Appropriate tools, approaches and methodologies are, therefore, critical in advocating for mitigation and adaptation strategies. It has been argued that the physical science basis of climate change is fairly well settled. Greenhouse gases are major contributors of climate change.

Controversies persist on precipitation and temperature patterns and trends and quantification of their impacts on natural resources. However, questions abound, for example, on how plausible the glacial melting rates in the Himalayas are the connection between severe weather storms and climate change? As regards mitigation of climate change, an array of measures, including financing mechanisms, have been piloted and scaled up in different landscapes. Questions on environmental justice and adequacy of payments to sustain smallholders' interests have been raised. Some of the mitigation mechanisms, Reduction of Emissions from Deforestation and Degradation (REDD) are seen as excuses not to reduce emissions from industry (like hospitals). These controversies are likely to be addressed as the frontiers of knowledge get expanded. Universities, especially graduate students, have a role to play in addressing these knowledge gaps and controversies. Further opportunities of research lie in areas like green water, blue water, grey water and rain water harvesting for example in the healthcare contexts. These are research lines worth exploring.

Healthcare's path to ecological medicine

Once the link between hospital design, healthy people and a healthy environment is made, wonderful opportunities present themselves for hospitals that want to "model environmental responsibility" (EPA, 2006:1). Some opportunities are discussed below.

Design for health

As discussed in Chapter 2 (Chapter 2.4.1: Sustainable Hospital Design and Environmental Health Science Approach), hospital associations need to respond by issuing "strongly worded directives advising their building professionals to acknowledge sustainable design as basic and fundamental to standard quality practice" (healthybuilding.net, 2011:1). In addition, local, state, and provincial public policy makers need to start adopting green building guidelines and hospitals need to establish environmental building standards. These strategies once emerging, redefine the way hospital buildings ought to be "designed, built, and operated" (Vittori, 2002:2). Such policies extend the conventional notion of hospital building performance to include "human health and environmental quality as essential cornerstones of quality and value" (AIA, 2005:3).

In the US for example, about eight and half years ago, the Centre for Maximum Potential Building Systems convened a group of leading architects and designers from around the country to develop a green building tool that would be appropriate for the healthcare sector. The result of that project is the "Green Guide for Healthcare" (www.gghc.org). The Green Guide for Health Care (GGHC) is modelled on the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standard, but it goes beyond LEED and includes a more robust framework based on environmental health considerations aligned with healthcare system priorities. Specific guidance on materials selection is given and it addresses some of the chemical issues raised in this thesis. Each recommendation in the guide is accompanied by a summary of its impact on health – either "patient health, worker health, or the health of the environment" (HCWH, 2008:9).

In the first 18 months of its existence, GGHC has attracted enormous interest from the healthcare design community. By June 2006, more than one hundred hospitals around the country, representing more than 40 million square feet of construction, had agreed to pilot the GGHC in their construction projects. Kaiser Permanente, the nation's largest non-profit health maintenance organisation (HMO), has committed to use the GGHC as a framework for its entire system's building plans. During this same period, several building materials and furniture companies that service the healthcare sector have launched new products to capture the rapidly growing interest in healthcare to build 'green and healthy'. At the policy level, the City of Boston has agreed to recommend the GGHC to the city's hospitals that are engaged in expansion plans. The healthcare sector's eager acceptance of the GGHC is encouraging. If hospitals help redefine green building to include environmental health as a key component in overall building projects, this could trigger a number of important new directions in healthcare 'construction and design' (GBC, 2011).

Firstly, it creates the possibility that healthcare can be a leading sector in "going beyond first-cost building expenses" (The Planning Report, 2011:2). If we account for the health and environmental 'services' of the building over its entire life, we can save on life-cycle costs in designing the building. This broader way of estimating costs of new construction can help marry construction and operations expenditures in cost calculations and "link construction and design teams with operations teams" (Gaskill, 2006:15). Secondly, if hospitals evaluate their buildings along the environmental health criterion, it creates the possibility of an entirely new chapter in "evidence-based design" research in healthcare (McCullough, 2010:212).

The healthcare sector can play a leading role in society in implementing a research agenda that documents how healthy buildings contribute to healthier people and greater productivity. Hospitals can lead society towards building schools, homes, and office buildings that also promote occupant health and consider the environmental and public health implications of the building materials and systems themselves. This will further influence some spin offs on the consumption side of things and influence resource flows (UN-HABITAT, 2011). Hospitals will do more with fewer resources consumed.

Healthy food in healthcare

The dominant industrial food system in South Africa is currently a leading factor in a host of preventable health and environmental problems. For example, poor nutrition is a risk factor for four of the six leading causes of death – heart disease, stroke, diabetes, and cancer. “Pesticide drift, field runoff, waste burning, and diesel exhaust from transporting food over long distances are all factors of food production that contribute to air and water pollution” (Robin Guenther, Gail Vittori, 2008:13). Additionally, the expansion of “large-scale animal feedlot operations” has contributed significantly to the demise of independent family farms, contaminating “groundwater with nitrates, hormones, and other products of untreated animal waste” and creating the conditions for virulent pathogens to spread (FAO, 2006:22). Rather than fresh fruits and vegetables, whole grains, and other high-fibre foods important for health being consumed, our current healthcare food system favours the production of “feedlot-raised animal products and highly refined calorie-dense foods” (Michael Martine, 2009:3). This is not only a food system misaligned with dietary guidelines: it is also a food system that is largely reliant on production and distribution methods that undermine public health and the environment in which we live in of resource constraints (Koc & Dahlberg, 2004).

Being places of healing, hospitals have an “incentive to provide food that is healthy” for people and the environment in which we live (UNC Center for Health Promotion and Disease Prevention & Center of Excellence for Training and Research Translation, 2010:2). Yet many healthcare facilities are increasingly trying to save costs by buying inexpensive and pre-processed food. Part of the reason this food is inexpensive has to do with the agricultural subsidies that have brought down the cost of certain commodities, like corn for corn syrup, soya-beans for partially hydrogenated oil, and mass-produced grains that are often highly processed before they reach our plates. However, cheap production has come with a very “steep price in terms of our environment and nutritional needs” (IATP, 2006:4). For hospitals, it presents a particularly ironic position: How can we expect the larger society to understand the links between good food and human health if our “healing spaces” are filled with products that are part of the problem (Gaskill, 2006:2).

Hospital leaders need to begin to rise to this challenge. Several large healthcare systems need to begin to promote better health and responsible farming practices by purchasing fresher, better tasting, and nutritious food for their patients, staff, and broader community. Hospitals need to pass overarching food policies that clearly align their institutions with both healthy food choices for their patients and sustainable agriculture practices. In the US for example, the Catholic Healthcare West’s (CHW’s) policy states that “CHHW recognises that food production and distribution systems have wide ranging impacts on the quality of ecosystems and their communities, and so; CHW recognises that healthy food is defined not only by nutritional quality, but equally by a food system which is economically viable, environmentally sustainable and which supports human dignity and justice, and so; CHW aspires to develop a healthy food system" (CHW, 2006:1).

From sponsoring farmer's markets to adopting better procurement guidelines, hospitals can make a difference. And by supporting food production that is local, humane, and protective of the environment, healthcare providers can lead the way to more sustainable agricultural practices in their communities. These sweeping changes help redefine the term *community benefit* and allow the hospital system to expand its health promotion mission beyond the four walls of its facilities. Kaiser Permanente healthcare in the United States has established farmer's markets in the past six years, "at the majority of its hospital campuses" (healthdesign, 2011:1). "In some locations, the Kaiser Permanente lobby is the only place to get fresh and organic produce in the community" (Kaiser Permanente, 2006:4). Large GPOs, which purchase supplies for 72% of the healthcare market, are developing specifications to buy meat without the use of nontherapeutic antibiotics in the production process (Knowledge Source, 2006:16). This one incremental change alone could potentially help ensure that essential antibiotic drugs are not rendered ineffective by agricultural overuse of antibiotics (Shea, 2004; Huffling, 2006). Healthcare's position on this critical issue sends an important message to the market-place that the overuse of antibiotics for meat production is a problem for healthcare providers.

Sustainable building materials, chemical materials and safer chemical policies

The operations of green hospitals must be based on sustainable materials. Sustainable materials from a green hospital building's operations don't need to cause occupational health risks indirectly/directly related to physical, biological and "chemical factors" in the environment and related behaviours (Prüss-Üstün A., and Corvalán C., 2006:24). Green hospitals' must use environmentally friendly building materials. Building materials often emit (out gas) "volatile organic chemicals (VOCS) into the air" (Eco Building, 2010:1). Chemically injured (or the resulting state of chemically sensitive) people must wisely choose materials which have low or no VOCS. Selecting poplar or oak as hardwood, over pressed wood products which contain formaldehyde in the glue, is an example of a wise choice. Selecting zero VOC paint, preferably one which not only contains no formaldehyde but also is capable of sealing in harmful VOCS emitting from the substrait (sheetrock), is wise (Eco Building, 2010).

About 75% to 90% of the waste of health care providers is general waste, whilst between 10% and 25% are hazardous health care waste, which may create a variety of health risks (GTZ, nd:1). South Africa still engages in extremely "hazardous chemical waste disposal practices" and this occurs in "municipalities, hospitals" and other places (Khumalo-Seegelken, 2008:7). Thus at this point of the debate it's important to note that chemicals are a key component in the operations of hospitals and green hospitals need to use chemicals as a source of sustainable materials and make their chemical policies environmentally friendly. In some of the sections to this chapter, I articulated how chemicals have invaded every aspect of our lives, including our bodies. These chemicals are “linked to a wide variety of preventable diseases, including cancer, birth defects, immune-related diseases, learning disabilities, and asthma” (CHE, 2006:10). Clearly, if our society could eliminate these chemical exposures, a great deal of disease could be prevented, thus avoiding the enormous burden on the healthcare system (Shea, 2004).

In 1994 and again in 2005, the US general accounting office reported that the US chemical policy regime does not properly assess or control the public health impacts of chemicals from hospital buildings. In the last 27 years, only five chemical classes or chemicals have been restricted due to their impact on public health via the Toxic Substances Control Act, yet thousands of new chemicals have entered the market-place without “comprehensive toxicity testing” (Wilson, 2006:11). To address this lack of federal leadership on chemical policy, as well as to address its own contribution to a chemical-dependent economy, healthcare systems have begun to develop their own chemical policies to purchase safer chemicals. This far-reaching framework is a powerful signal to the marketplace that healthcare is “planning to use its purchasing power to drive markets for safer products” (Robin Guenther, Gail Vittori, 2008:88). If manufacturers want to provide products within this new framework, they will need to reform their production processes and replace potentially dangerous materials with safer ones (EPA, 2008).

Kaiser Permanente’s hospital chemical policy for example, states the following: Kaiser Permanente “…aspires to create an environment for its workers, members, and visitors that is free from the hazards posed by chemicals that are harmful to humans, animals, and the environment. Kaiser Permanente’s mission is to provide affordable, high-quality healthcare services to improve the health of our members and the communities we serve. Our concern for the health of our communities extends to the air we breathe and the water we drink” (Kaiser, 2005:1). Other healthcare systems and GPOs are also adopting chemical policies to guide their overall procurement. Since healthcare accounts for “about 15% of the US gross domestic product,” the impact on the overall economy could be profound (OECD, 2004:10). Acting in unison, the healthcare sector can provide the much needed leadership in its purchasing to demonstrate to other sectors that replacing dangerous materials with safer ones is not only good for the South African economy, but good for the health of the South African people. Given that according to a recent report in the SA medical journal, about 8.5% of South Africa’s gross domestic product (GDP) is spent on health. About 5% of this GDP goes towards the 7 million people in private healthcare, while 3.5% caters for the other 41 million people (Campus health service, 2011:2). Moreover, healthcare influentials can assume leadership as spokespeople for broader sustainable material policy changes in our society, for example your sustainable materials for green hospital buildings. Indeed, in the US this is already occurring. Leaders from Kaiser Permanente, Consortia, the American Nurses Association, and CHW have testified before state legislatures about the need for policy reform. This expanded role for healthcare reflects the growing awareness that healthcare leaders can play a role in transforming not only their own institutions, but also the society at large.

2.9 Conclusion

The built hospital environment is without doubt a major contributor to global carbon emissions and has large impact on the natural environment and on human health. The uptake of 'green building' concepts and techniques is largely focussed on eco-efficiency. Green hospital buildings clearly reduce negative environmental impact by being designed to reduce the quantities of energy and water used by the hospital building and to reduce the negative impacts on ecology and human health. It should be noted that simply reducing negative impacts by a certain percentage is not going to solve the world's environmental problems, though it can certainly help if it becomes standard practice. In conclusion, I would like to argue that whilst the practical applications vary amongst disciplines, hospitals need to be ecologically designed, and be sustainable green buildings that sought to meet the following sustainability principles and criterion:

1. Low-impact materials: "…use and choose non-toxic, sustainably produced or recycled materials, which require little energy to process…" (Huncke, M.D., et al., undated:1).
2. Energy efficiency: "…use manufacturing processes and produce products, which require less energy…" (Schneider Electric, 2010:1).
3. Quality and durability: "…longer-lasting and better-functioning products which will have to be replaced less frequently, reducing the impacts of producing replacements" (Chapman, 1992:12). It is argued that the public interest requires high quality long-life construction which is 'conservant' with respect to energy and materials. This can be achieved through quality, durability, maintainability, and the ability to adapt, dismantle, relocate, or recycle.
4. Design for reuse and recycling: "…products, processes, and systems should be designed for performance in a commercial afterlife…" (Anastas, P. L. and Zimmerman, J. B., 2003:1).
    - Design impact measures for total carbon footprint and life-cycle assessment for any resource used are increasingly required and available. Many are complex, but some give quick and accurate whole-earth estimates of impacts. One measure estimates any spending as consuming an average economic share of global "energy use of 8,000btu per dollar and producing CO_2 at the average rate of 0.57kg of CO_2 per dollar" (1995 dollars US) from DOE figures (US DOE, nd:31).
    - Sustainable design standards and project design guides are also increasingly available and are vigorously being developed by a wide array of private organisations and individuals. There is also a large body of new methods emerging from the rapid development of what has become known as 'sustainability science' promoted by a wide variety of educational and governmental institution (US DOE, nd:31).
5. Bio mimicry: "…redesigning industrial systems on biological lines ...enables the constant reuse of materials in continuous closed cycles..." (Paul Hawken, Amory B. Lovins, and L. Hunter Lovins, 1999:4).
6. Service substitution: "…shifting the mode of consumption from personal ownership of products to provision of services which provide similar functions, e.g., from a private automobile to a car sharing service. Such a system promotes minimal resource use per unit of consumption…" [e.g., per trip driven] (Ryan, Chris, 2006:1).

7. Renewability: "…materials should come from nearby (local or bioregional), sustainably managed renewable sources that can be composted (or fed to livestock) when their usefulness has been exhausted…." (Ecosign, nd:21).
8. Healthy buildings: "…sustainable building design aims to create buildings that are not harmful to their occupants nor to the larger environment. An important emphasis is on indoor environmental quality, especially indoor air quality" (Levin, Hal, 1995:11). It is clear that human society needs to reduce the absolute burden on the environment of all construction activities, while at the same time "maintaining or even increasing material welfare and services provided to customers…" (Bringezu, 2001:1).

The typical ecological design benefits of green buildings as: "reduced operational costs; community involvement and benefit to local economies; healthy buildings; higher occupancy rates; improved productivity of work spaces; better sales with retail; improved learner-ship in education; lower environmental impacts; improved marketability and sustainability" (Horn A. R., 2010:1). Bernstein's definition of 'sustainable buildings' comes close to the definition of adaptable buildings. As discussed by industry and academic leaders during the CERF/CIB symposium, 'sustainable' means "being able to meet the multiple requirements of society through the life cycle of a building or structure" and hospitals need to live up to this (Bernstein, 1999:2). If a hospital building is not suited to changing circumstances, it is vulnerable to becoming poorly utilised, "prematurely obsolete and unable to accommodate changing technology that could make the building better able to meet contemporary user needs, as well as increasing the efficiency of building systems" (Grammenos and Russel, 1997:19). Obsolete buildings are evidence of wasted natural resources and inadequate use of land. This may be avoided if buildings are adaptable. While traditional building design has been based on the ergonomic requirements of an average, healthy adult, ignoring other human conditions, more recent architectural design aims towards '*differentiation'*, not uniformity in designing the built environment (Preiser *et al.,* 1991). Hospital building design needs to consider the "entire human lifespan, including special needs". It is also argued that the universal design approach – simply designing all products, buildings and exterior spaces to be usable by all people to the greatest extent possible – is a sensible and economical way to reconcile the integrity of a design with human needs in the environment (Mace *et al.,* 1991).

The fact that about "56% of the energy consumed, both nationally and internationally, is used in buildings," shows the opportunities and responsibilities for designing energy efficient buildings (Harvey and Ashworth, 1996:10; U.S. Department of Energy, 2008:29). In the construction industry energy is used for the extraction and manufacture of building materials and components, their transportation to the building site, the construction process, the running of the building, maintenance, adaptations, deconstruction and disposal. Energy conservation of buildings pertains to all these phases of building life.

The complexity of factors influencing sustainability of the building industry demands a holistic approach in analysis, assessment and development of policies. Research efforts focus on two main areas: the development of an integrated sustainability assessment method, and the deepening of knowledge about individual factors that affect the sustainability of buildings. With regard to the specific building design features which affect the sustainability of buildings, it is necessary to examine whether the improvement of some building features might have an adverse effect on others. Therefore, the following points need to be examined:

i. the relationship between the factors that influence the sustainability of buildings such as the durability, adaptability and energy conservation;
ii. possible conflicts between them; and
iii. strategies for their reconciliation.

This thesis further argues that it's not just about 'greening' but designing the built hospital environment within ecosystems, celebrating the context, seriously taking the 'mixed communities' approach into consideration, neighbourhoods becoming producers beyond consumption neighbourhoods and the reclamation of our right to make our own communities and our own living environments. In conclusion ecologically designing hospital's begins with the belief the world is meaningful and not meaningless, coherent in ways that are often mysterious to us (Souki, 2011). Our task is to discern, as best as we are able, the larger patterns and scales in which we live and act faithfully within those boundaries. Design, in this larger sense, is not simply the making of things but rather a striving for wholeness. Ecologically designed hospitals' at their best are "the ultimate manifestation of love – a gift of life, harmony, and beauty to our children" (David Orr, 2011:1; Postman Neil, 1982:1). "…sustainable development is not a fixed objective but a moving target. Within this perspective sustainable hospitals and communities need to be flexible entities that are able to evolve in accordance with increased understanding of the complex interrelated issues of sustainable development" (Boulogne, FA., 2010:3; Fleur Boulogne, 2009:5). Whilst 'business as usual' issues can be directly addressed on individual building projects, dealing with 'greening' issues requires considering the building and its supply chain over its life-span. Thus, hospital building projects must move more and more towards community-scale solutions rather than building-scale solutions and contribute to sustainable development as listed below (UNEP SBCI, nd).

○ Consumption of non-renewable fuels ○ Water consumption ○ Materials consumption ○ Land use ○ Impacts on site ecology ○ Greenhouse gas emissions ○ Other atmospheric emissions ○ Solid waste/liquid effluents ○ Indoor air quality, lighting, acoustics ○ Longevity, adaptability, flexibility ○ Operations and maintenance	Green Building	Sustainable Building
○ Social and cultural issues ○ Economic considerations ○ Urban planning/transportation issues		

Source: UNEP SBCI, nd:10

Chapter 3 – Research Design and Methodology

3.1 Overview

The purpose of Chapter Three in outlining the research design, methodology and process is to motivate the research approach that was taken and contextualise the research findings presented in Chapter Four. Given the complexity of the research case study (a hospital), the research design was built on several research methodologies, both empirical and non-empirical, in an attempt to provide a more holistic and multi-dimensional perspective to the research findings. A sustainable development approach informs this approach (Bartelmus, 1994; Gallopin, 2003:07; Mebratu, 1998) which places a strong emphasis on the importance of both quantitative and qualitative understandings of complex systems (Clayton and Radcliffe, 1996:1-27; Harding, 2009:35). A summary of the ideal research approach, the actual approach taken within the limits of the study and the research outcomes as well as opportunities for further scholarship are presented in Table 2 in the Chapter Summary (Section 3.5).

3.2 Introduction

The research design aimed to meet the research objectives which have been outlined as:
The research objectives can be clearly defined as the following set of research questions:

ii. What is WCRC hospital's GBCSA's new building rating score?
iii. How sustainable is WCRC hospital's design?
iv. What measures are available for sustainable resource flows at WCRC?
v. What would a design of a "virtual" green WCRC hospital look like?

3.3 Research design

The research design aimed to meet the research objectives mentioned above (Section 3.2). A literature review was selected as the most appropriate means of investigating and establishing the benefits and limitations of hospitals in promoting sustainability. The green building new office rating tool was then used to obtain a current green star rating score of WCRC's hospital building and thereby meeting the first research objective, outlined in (i) above. The aim of the literature review is to provide a sound theoretical understanding of sustainable development and the sustainable healthcare system against which to assess the benefits and limitations of local hospitals in promoting sustainability. The findings also informed the research sourced in meeting the second and third research objectives and the recommendations made in meeting the fourth research objective. The research process and methodologies employed for the literature review are outlined in detail in Section 3.4.1 below. Based on the findings of the first research objective (that green buildings tend to promote greater sustainability), a core finding from the literature review was to promote a greener hospital building and healthcare environment at WCRC. The next objective of the research (refer to (ii) and (iii) above) was to build an understanding of the current status of healthcare provision, systems and consumption trends at WCRC hospital in order to make recommendations to promote sustainability through WCRC's healthcare system [and meet the final research objective (iv)].

The final aspect was then to compare resource flow figures (i.e. to obtain data and statistics of food consumption, electricity usage, water consumption, waste generation etc. for the years 2009 and 2010 respectively) in order to establish whether WCRC has the capacity to do more with less in its healthcare system and meet hospital consumption demands through local bio-regional production (i.e., what is currently being produced) in order to inform the recommendations presented in support of the final research objective.

Secondary data analysis (SDA) was selected as the primary research design to build an understanding of the status of WCRC's healthcare system and hospital building. SDA is defined as "using existing data (mostly quantitative) ... [and] aims at reanalysing such data in order to test hypotheses or to validate models" (Mouton, 2001:164). The secondary data used in the research included census data, survey data and market analyses. The strength of the research design is that it allows a large body of extensive and often thorough data to be analysed but it does limit the study in that errors and constraints of the original research are carried through (Mouton, 2001:165; Boslaugh, 2007:03-04).

The research also drew on on-going discussions (both formal and informal) with hospital management, staff (from various hospital departments) and the local health department, given their direct role in the research topic area. Discussions were also conducted with individuals involved in leadership and management, in order to better understand the benefits and limitations of the hospital's experiences in the reality of the WCRC hospital context. The aim of the research was to establish current practices, challenges and opportunities for promoting sustainability of the hospital given the value of local hospitals in promoting sustainability as established in Chapter Two through the second research objective. The research processes and methodologies employed to meet the second and third research objective are detailed in Sections 3.3.2 and 3.3.3 below.

The final objective of the research, refers to (iv) above, was to provide recommendations for promoting sustainability through WCRC's healthcare hospital system. The recommendations that have been made (presented in Chapter Five, Section 5.3) are based on the outcomes of the literature review, the data collected and interviews conducted as well as personal observations both during and prior to the research period.

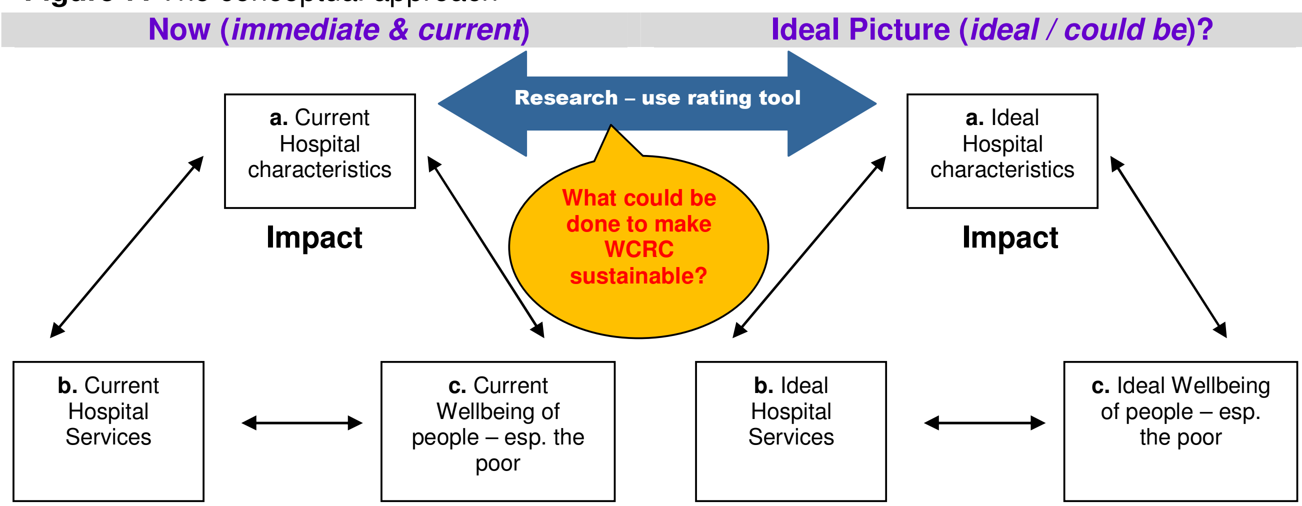
3.3.1 Focus

The central focus of the questions asked in each phase of the research related to the various stages of the research's main conceptual approach and sub-research themes as shown in Figure 7. This framework together with the Green Star SA's office rating tool core set of indicators will be used, as summarised in table 2, below. According to the Institute for Healthcare Improvement, "hospital flow can be measured at five levels:

patient and community; hospital throughput; hospital activity; hospital performance; and unit performance". Each level provides a portion of the total measurement picture and this research is measuring the resource flows of the hospital activity. Once the links between a healthy environment and healthy people are made, wonderful opportunities present themselves for hospitals that want to model environmental responsibility (GBC, 2011).

I also attended the Green Star SA accredited professionals' course in Cape Town on the 18th of April 2011. This essential one-day course provides a detailed overview of the Green Star SA green building rating system and provides an excellent introduction to green building; training participants on each category and credit in the rating system. This course also "offers an introduction to the use of the Green Star SA tool which is a useful guide to greening buildings and a means to gain certification of building projects. The course is also a gateway to registration as an Accredited Professional" (GBCSA, 2011:3).

Figure 7: The conceptual approach



Source: Author's own elaboration

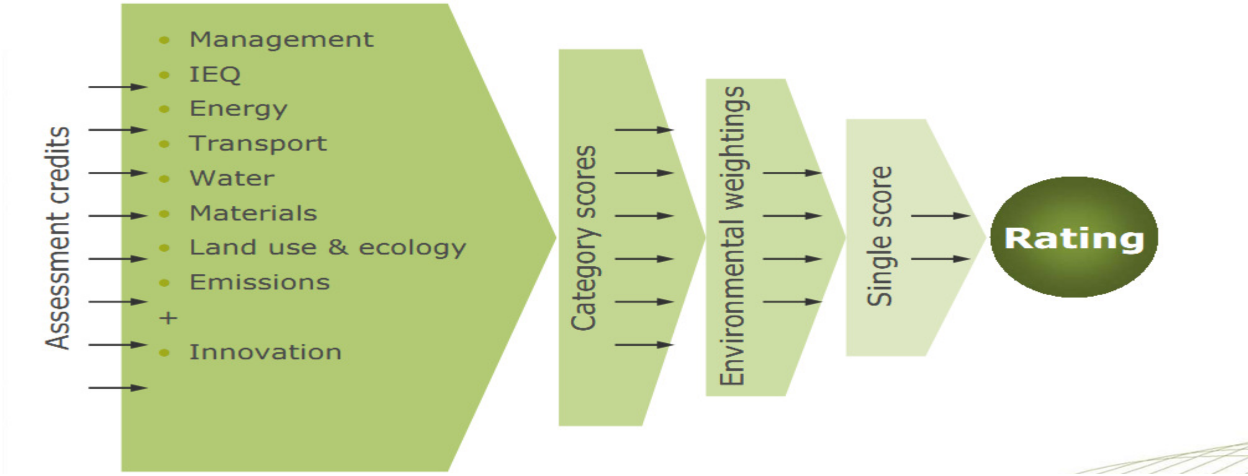
The following is a complete inventory of all credits in the proposed GBCSA pilot tool with notations on any changes from the original Australian versions.

Figure 8: Green Star SA Ratings

Rating	Score	Represents						
One Star	10	Minimum practice	☆	★	★	★	★	★
Two Star	20	Average practice	☆	☆	★	★	★	★
Three Star	30	Good practice	☆	☆	☆	★	★	★
Four Star	45	Best practice	☆	☆	☆	☆	★	★
Five Star	60	South African Excellence	☆	☆	☆	☆	☆	★
Six Star	75	World Leadership	☆	☆	☆	☆	☆	☆

Source: Green Star SA, 2011

Figure 9: Green Star Framework



Source: Green Star SA, 2011

Table 2: The Green Star SA Office Rating Tool Categories Guide (8 Categories, plus Innovation)

Theme	Theme description
Management	Ensures sustainable development principles from project conception through design, construction, commissioning, tuning and operation.
Indoor Environment Quality (IEQ)	Addresses occupant health, comfort, and productivity issues in terms of thermal comfort, lighting and contaminants.
Energy	Targets an overall reduction in non-renewable energy consumption, to achieve an impact on greenhouse gas emissions.
Transport	Reduction of individual use of cars and encourages alternative forms of transport.
Water	Targets reduction of potable water consumption, and encourages the use of recycled and rain water.
Materials	Aims to minimise life cycle impacts of materials by reducing natural resource consumption, reusing materials that can be reused and recycling whenever possible.
Land Use & Ecology	Addresses impact on the immediate ecosystem; encourages preservation and restoration of flora and fauna.
Emissions	Addresses negative emissions from development to the atmosphere, watercourse and local ecosystems.
Innovation	Rewards pioneering in industry transformation, exceeding Green Star SA benchmarks, and addressing impacts not currently targeted by Green Star SA credits.

Source: Green Star SA – Office v1, 2010

As determined by the Green Star SA - Office v1 tool, which validates the environmental initiatives of new commercial office buildings or base building commercial office refurbishments, this research intends to deduce whether or not WCRC as an institution is sustainable? The technical sustainability assessment will comprise of the GBCSA green building rating system's eight categories including innovation. Within the context of the Green Star South Africa - Office version1 tool for the assessment and evaluation, I'll adopt and use this set as a starting point for the technical assessment of the WCRC hospital building. This framework will be used in assessing the WCRC hospital building. As shown in Figure 6 (interplay between the various sectors), WCRC will be assessed in distinct categories drawn from the correlations and interconnections.

This interdisciplinary research focused on the environmental impacts associated with sustainable management of WCRC's hospital in resource consumption and flow scenarios. The study included an exposure assessment of the WCRC hospital building from the knowledge and experience gained at the sustainability institutes eco-village (SIEV) and the comprehensive literature review on sustainable development, ecological design, green buildings, energy efficient buildings, land use, ecology and others that were found relevant as the literature review progressed. Taking into account waste, pollution, heat sources (the study entails pollutant sampling), human behaviour (human capital development i.e. education, civil society organisations' etc.), recycling, local agriculture (i.e. gardening, and grounds) and building characteristics, such as cemented building rates, insulation, and the provision, conservation and use of energy in buildings.

A range of quantitative exposure assessment techniques and selected research methods have been explored, tested and deduced. This involved literature surveys, the use and development of mathematical models, and statistical analysis of datasets. This research has been designed to develop a better understanding of the sustainability of WCRC's hospital building and the links between resources, energy sources and environmental pollution links from the hospital in the light of South Africa's carbon footprint.

3.3.2 Action research / Praxis approach

The action research methodology has heavily influenced and further informed the design of this research process. It is a process that "supports the voices from the margins in speaking, analysing, building alliances and taking action" (Hall, 1992:22). WCRC's network of organiser and leaders has been leveraged by this research in order for them to engage further in a process "reflection and action" (Hall, 1992:23). A collaborative consultation process between outside researchers acting as catalysts and facilitators is fostered by action research, and inside stakeholders are engaged with in the process, addressing issues of immediate significance to their lives. According to Franklin this approach is "participatory and grounded in conducting research with the intention of supporting action among those directly involved and impacted" (Franklin, 1996:1).

Action research and praxis methodology are connected. The praxis methodology however places an emphasis on the dialectical relationship between practice and theory where the each inform the other. This creates a whole that conceptually is not possible with the simple summation of its parts. However the praxis concept is one that "encourages an on-going relationship" between theories which further informs practice, and practice which then further informs new theory (Hall, 1992:01). Praxis is a process that creates a "space for empowerment through its participatory nature" and it is also an approach that recognises participants as co-researchers (Arsenault-May, 2003:41). The design of this research was based on a praxis approach, where by the research participants' have been invited to share their feedback to influence the final outcomes and further provided with on-going project reports.

The research is not designed to only understand the contextuality of the hospital's systems, but it is also intended to strengthen and support the effectiveness of existing efforts. Participants have been engaged with in thinking about strategies of change, and discussions have been conducted regarding the sustainable action framework with various groupings that will be able to use it as an underlying basis for future sustainable hospital system's decision making. There is a mixed variety of praxis-oriented methodologies such as the contextual action research method [CAR], which engages a broad range of stakeholders and groups with in a particular domain, and the participatory action research method (PAR) which offers "ways of facilitating processes" by which spaces are created where people are encouraged to think about how to improve some aspect of their lives, either in their community or work places (Arsenault-May, 2003:49).

While the design of this particular research was greatly influenced and informed by the principles of various forms of action research, there were limitations as well in the implementation process. The process involved facilitation of inputs through an online consultation for example, but due to timing constraints participation was very limited to a small number of people. Furthermore, whilst the internet as a medium has its advantages, this research process could have been more enriched had management research participants been able to come together and reflect on their experiences, discuss the framework for Action and its relevance to their lives in a face-to-face setting.

Lastly, non-management stakeholders could have been more engaged in the research process to discuss the issues along with strategies for change. Having said this, the research process was also influenced by the people who can directly benefit from the research outcomes – practitioners in health, who are leading initiatives and projects, and in hospital management at the hospital. This increases the chances/possibility of impact. We're most likely to modify our own behaviours when we participate in problem analysis and solutions. We are further likely to implement the decisions we have helped to make.

3.4 Research process and methodology

In order to meet the research objectives outlined above, four research methodologies were employed. The research processes that followed are described in detail below. The research processes undertaken are described, including the methodologies employed and justification for the choices made as well as considerations taken about alternative methodologies. The research processes are summarised in Table 3, in Section 3.5.

3.4.1 Case study methodology

Case studies according to Soy, Susan K. (1997), are "complex because they generally involve multiple sources of data, may include multiple cases within a study, and produce large amounts of data for analysis" (1997:01). Researchers form many disciplines, however use the case study methodology to explain a situation, to challenge or dispute theory, to produce new theory, to provide a basis to apply solutions to situations, to describe or explore a phenomenon or an object or to build upon theory. They are advantages of using the case study method as it's contemporarily, applicable to real-life, human situations and its publicly accessible through written reports. The results of case studies directly relate to the common reader's everyday experiences. They facilitate an understanding of complex real-life situations. This WCRC research explains a complex situation and involves multiple sources of data and this justifies the researcher's choice of this methodology.

Feagin, Orum, and Sjoberg argue that a case study approach is an ideal method to use when a holistic, in-depth investigation is required like in this case. Case studies have been more oftenly used in varied investigations, in particular "sociological studies, but increasingly, in instruction" (Feagin, et al., 1991:1). Yin, Stake, and others that possess wide experience with this methodology have developed robust procedures. When these "procedures are followed", the researcher will be following methods tested and as well developed as any other in the field of science (Stake, 1995:02). Whether the study is quasi experimental or experimental, the data collection and analysis methods are known to hide some details. On the other hand case studies are "designed to bring out the details from the viewpoint of the participants by using multiple sources of data" (Feagin, et al, 1991:1), of which multiple data sets are being looked at in this case and multi-perspectival analyses being sort. Case studies offer multi-perspectival analyses. Implying that the "researcher considers not just the voice and perspective of the actors, but also of the relevant groups of actors and the interaction between them" (Feagin, et al, 1991:4). Case studies possess this aspect in their characteristics as a salient point. Case studies further give voice to the voiceless and powerless. Many studies of the powerless and homeless when presented by sociological investigations, do so from the 'elites' viewpoint.

3.4.2 Literature review methodology

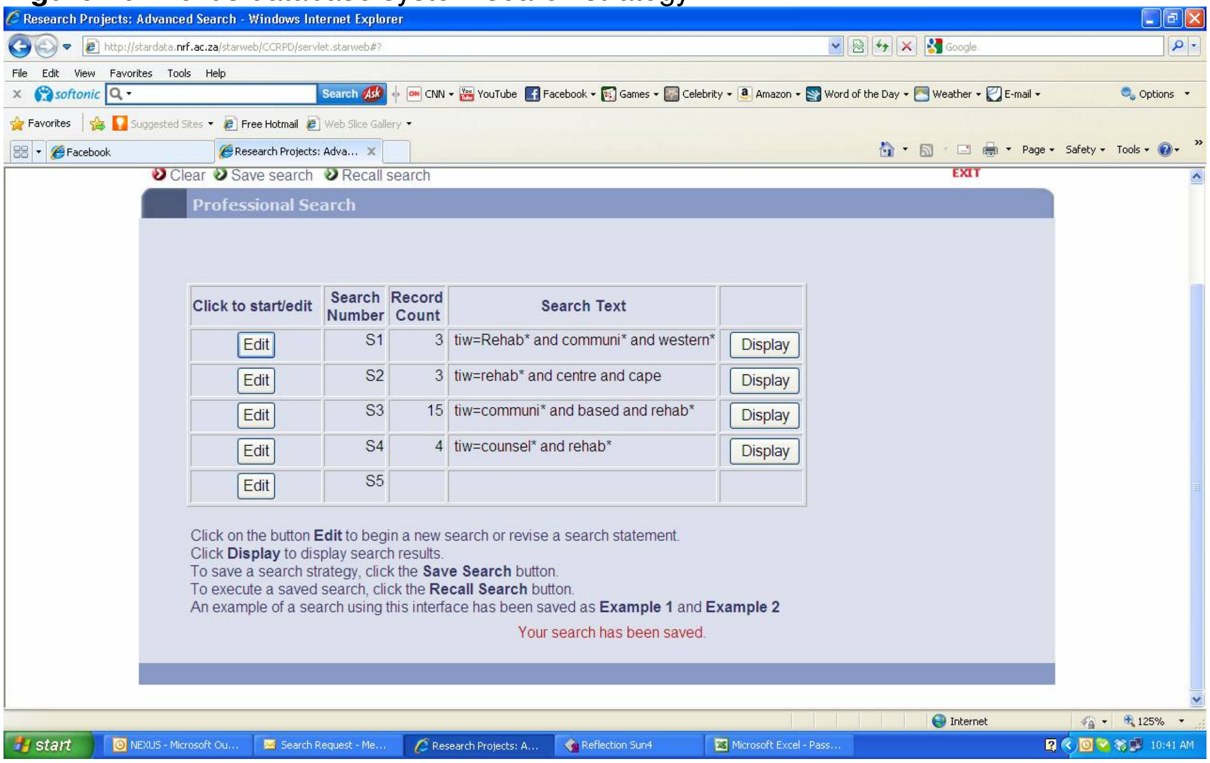
According to Mouton, a literature review can be defined as a "research design type that provides an overview of scholarship in a certain discipline through an analysis of trends and debates" (2001:179). A series of key internationally accepted reports were taken as the departure point for building an argument for sustainable development through a review of the current global polycrisis and included the UN-HABITAT Report of 2003 on the Challenge of Slums (critical in identifying the scope and magnitude of growing urban poverty) and the United Nation's Development Programme's Human Development Report from 1998 (signalling a shift in the global focus beyond poverty into issues of inequality as well). Key reports in assessing Sustainable Buildings, Promoting policies and practices for the built environment included the UN-HABITAT Conference Report on Promoting Green Building Rating Systems in Africa, "UNEP-FI / SBCI'S financial and sustainability metrics report" ("An international review of sustainable building performance indicators & benchmarks") and UNEP's report on redesigning metropolis (the *built environment* and waste diversion). Key reports in assessing the state of the natural environment included the Millennium Ecosystem Assessment Report of 2005 (which drew on over 1300 scientists globally to assess the consequences of ecosystem change for human wellbeing (MA, 2005: v), the World Wildlife Fund's Living Planet Reports for 2006 and 2008 (WWF, 2006; WWF, 2007; WWF, 2008), the business case for the global compact *environmental* principles (UNEP, 2004) and towards a green economy: buildings, investing in energy and resource efficiency (UNEP, 2011).

Further key reports included the 2007, Intergovernmental Panel on Climate Change (IPCC) findings on climate change, the Stern Report by Sir Nicholas Stern (commissioned by the British government to assess the costs of climate change globally). A growing body of literature around peak oil led by Campbell of the Oil Depletion Analysis Centre (Bentley, 2002:189; Campbell, 2002; Edwards, 1997:1292). The 2008, international recognition of the end of cheap oil by the International Energy Agency (IEA, 2008:14). Other key reports drawn on for the review of the modern healthcare systems and green buildings include the Centre for Health Design (CHD) findings and Health Care without Harm, which can be considered as a comprehensive global review of the state of healthcare, having been compiled by a coalition of 440 international groups in 55 countries, all working to transform the healthcare sector so that it's no longer a source of harm to the environment and people and ecologically sustainable (HCWH, 2006).

The first data search criterion for investigating the local green building ratings was set to *local green buildings* literature based on the South African and African experiences. Searching both online databases and contacting several departments at the University of Stellenbosch (as well as meeting with several subject librarians at the University Library) revealed that very limited literature was available on hospital building experiences in South Africa in general, apart from the GBCSA's literature, limited case studies in international texts and none were found specifically for WCRC's hospital, or South African hospitals. The search strategy used to search the Nexus database is shown below in Figure 10. The Nexus current and completed research projects database was searched using the following relevant keywords, terms, concepts, phrases and synonyms:

1) Rehabilitation and Community and Western Cape
2) Rehabilitation and Centre and Cape
3) Community and Based and Rehabilitation
4) Counselling and Rehabilitation
5) Health
6) Healthcare
7) Green buildings
8) Green hospital buildings
9) Green rehabilitation buildings
10) Green Building in South Africa

Figure 10: Nexus database system search strategy



Source: National Research Foundation, 2011.

The literature searches outcome of South Africa on the Nexus database that emerged was not helpful for this research. Hence none of it was used due to its irrelevance for this study. The search criterion was then widened to include '*sustainable hospital systems'* in the international context. The majority of findings from searching online databases focussed on articles on waste (UNEP, 2010), ventilation and indoor air quality debate (California Energy Commission, 2009) and carbon foot printing of transport costs, in some cases extending to analysis of the carbon footprint for the entire product lifecycle (Edward-Jones *et al.*, 2008: 265). The predominant finding from these case studies (with the results varying greatly) was the importance of "green buildings, sustainability and context" in each example (Peters *et al.*, 2008:3). The literature on waste, ventilation and indoor air quality and carbon life cycle assessment was felt to fall far short of addressing the complexity of the healthcare systems by focussing only on embodied energy. It was increasingly found that literature analysing a rich diversity of impacts of healthcare systems considered the flow of multiple types of resources within a local healthcare system, often being termed the local healthcare economy. Within the healthcare literature, new perspectives that were not considered at the formulation of the research title were uncovered, including the links between healthcare and bioregionalism/eco-regions set of views based on naturally-defined areas and building community resilience on multiple levels. The principle authors whose work dominated the healthcare literature on bioregionalism and were continuously referred to in other case studies included Peter Berg (1978), Morgan and Terrey (1992), (Thackway and Cresswell, 1995), Michael McGinnis (1998), Environment Australia (2000), Dick (2000) and Kirkpatrick Sale (2000).

Key authors in the sustainable healthcare or green buildings literature that made reference to eco-regions included Gary Snyder (1995), Doug Aberley (1998), Robert Thayer (2003) and Patel (2007).

Interesting linkages began to emerge across different research fields, including the links between 'green buildings, healthcare, food', energy, water, waste, 'livelihood and environmental security' through the health system and the role that healthcare potentially has to play within that. These linkages were affirmed by the findings of key international reports (UN-HABITAT, 2003; United Nations Environment Programme [UNEP] and the World Resources Institute [WRI], 2003; The Center for Health Design, 2006; UNDP, 2011), and interesting papers on "building connections": "promoting partnerships to achieve sustainable building and construction", healthcare sovereignty, sustainable technology and development, community healthcare security, built environment sustainability, healthcare systems, green buildings, sustainable facilities and infrastructure (SFI) and sustainable healthcare. Several case studies were of special interest, including the "thriving healthcare system of Dominican Hospital in Santa Cruz, California and Boulder Community Foothills Hospital in Colorado" (Gaskill, 2006:13).

The literature review can be considered a comprehensive review that included a holistic approach to green buildings, sustainable hospitals and healthcare systems by considering the impacts from the healthcare side through to patterns of resource flows, waste generation and management, operations and consumption. An attempt was made to strike a balance between quantitative data as well as the more qualitative findings that I considered to be of equal importance. The literature review was limited in that several case studies that may have been of relevance were not included due to the scope of the study coupled with time and other constraints that did not allow all possible literature to be reviewed. Main sources of error may be derived from the types of literature that were drawn on, as a result of personal potential bias towards community driven solutions and opinions on the importance of environmental sustainability. An attempt was made to substantiate these views through key international reports and published case studies.

3.4.3 Empirical data collection methodology

Empirical data was sourced to build an understanding of the current status of the hospital's building, service, design, distribution and consumption patterns at WCRC and thereby contributed to meeting the second and third research objective (as outlined in Section 3.2, ii, iii). Further empirical data was sourced in support of understanding the implications of realising optimal consumption and the potential capacity to do more with less of the hospital in order to make recommendations for the hospital system in the third and final research objective.

The aim of the research was to provide a broad overview of WCRC's healthcare system (service, design and consumption) through an analysis of existing data. As recognised by Peters *et al.*, in their review of system analysis methodologies, "tools are needed to determine how the environmental impact and vulnerability of the system are related to where resources are produced in relation to where they are consumed" (Peters *et al.*, 2008:01). To this end, a consumption analysis of electricity, water, waste, foods, the resource flows that feed the hospital system, can provide useful and unique insights. Primary data collection was undertaken due to the small size of the research boundary (the entire WCRC hospital) and time limitations, several recommendations are made in Table 3 (below) on opportunities for further scholarship that include primary data collection for certain areas of the research (Peters *et al.*, 2008).

The departure point was to establish whether any existing research had been undertaken on WCRC's hospital building and healthcare system? Several departments within the University of Stellenbosch and other local research institutions (including the Department of Health) were contacted. Several interviews revealed that no study had previously been undertaken to assess the sustainability of the entire hospital building and healthcare system of WCRC including its hospital building. The research was broken down into (1) WCRC's hospital building GBCSA rating score, (2) current healthcare system and (3) ideal sustainable healthcare system, optimal consumption, and the research methodologies for investigating each are described and summarised in Table 3 below.

Several limitations were encountered during the research which is also outlined in the sections below. As a result inferences or estimations were made in order to provide a broad overview for the rating score of the hospital building and WCRC's healthcare system and to meet the first and second research objective. Table 3 outlines the original research aim, the actual research approach and findings (due to limitations encountered) as well as opportunities for further research that were identified as a result.

3.4.4 Ethnographic research methodology

Ethnography is defined by Geertz and Philipsen as "a qualitative method aimed to learn and understand cultural phenomena which reflect the knowledge and system of meanings guiding the life of a cultural group" (Geertz, 1973:1; Philipsen, 1992:2). Given the complexity of the research case study, it was imperative to investigate beyond the empirical data through ethnographic case study methodologies in order to gain at first hand, a better understanding of the functioning of the current healthcare system and perceptions around green hospital buildings, sustainable hospitals and greening healthcare.

Ethnographic research was undertaken to meet both the second and third research objectives as outlined above. The interviews were semi-structured in that a set of questions were planned and presented during the interviews, but adapted and developed as the interview progressed in response to the issues being raised by the interviewee. Whilst most of the interviews were carried out in person, some of the interviews were electronic and telephonic when the interviewees were not available for personal interview. Interviews with the hospital management, the private party and independent service providers were conducted in order to better understand the current healthcare system of WCRC and its building structure. Further interviews were undertaken to document local innovative initiatives that also formed part of the current healthcare system.

Secondly, interviews were carried out with the objective of better understanding opportunities and barriers of promoting a sustainable hospital at WCRC as part of meeting the third and final research objective: (iii) to recommend measures which can be taken to promote greater sustainability through WCRC's hospital and healthcare system. Various experts on green buildings were spoken to, including representatives from the local municipality, GBCSA, department of Health and University of Stellenbosch as well as local health practitioners' (both private practitioners and public practitioners), departmental managers from the hospital departments and local service providers to ascertain their perceptions around hospital sustainability. Non-formal interviews were carried out continuously through my professional work at WCRC. These non-formal interviews and daily experiences of working across sectors at WCRC hospital have been critical in shaping an understanding of the key sustainability challenges and opportunities for WCRC hospital.

The strength of the ethnographic research employed is the extent to which it provided a deeper context to the empirical research and assisted in the identification of potential barriers and opportunities for promoting greater sustainability through WCRC's healthcare system. The case studies of local hospital initiatives that were documented provided meaningful examples of the key characteristics of a sustainable hospital (moving beyond service delivery to promote sustainable healthcare, community resilience and green building). Experts from a range of sectors (community services through to health economics) were able to provide valuable insight to the research.

The limited number of interviews that were carried out during the research, mostly due to time constraints, can be considered a limitation of the research. Whilst several resources and consumed resources were documented, there were other resources that were not investigated fully (including hospital grounds agricultural inputs or practices) that warrant further investigation and research. Also, perceptions from patients on healthcare systems were not fully represented by the interview selection, again due to time constraints. Main sources of error can be attributed to the potential bias in the interview questions and the potential misinterpretation of the interviewees' responses to the interview questions. Conscious efforts were made to ask open questions and ask for clarity when the answers were unclear to avoid guiding the research or misinterpreting the findings.

3.5 Chapter summary

The research design was built to meet the research objectives as outlined in Section 3.2 and produce the research findings presented in Chapter Four.

Sufficient literature was available to complete a comprehensive literature review in order to meet the research objectives. Despite extensive investigation, the absence of comprehensive and accurate empirical data on resource consumption, the functioning of the current WCRC healthcare system and a dedicated hospital green building rating tool in South Africa resulted in estimations and inferences being made in order to create an overview for the sustainability of the current WCRC hospital building and healthcare system. The case studies documented highlighted the importance of healthcare institutions like WCRC in promoting sustainability. The research findings brought together previously uncorrelated sectors and broad inferences were established within the limitations of the available data to provide an overview of the current sustainability status of WCRC (in order to meet the research objectives) as well as potential of the hospital, in support of making recommendations to make hospitals and health systems even more sustainable. These research findings provided a platform for making recommendations to promote sustainability through WCRC's healthcare system and thereby meet the research objectives. The research identified several opportunities for further scholarship that would strengthen the findings of this research and are described further in Chapter Five, Section 5.4.

Table 3: Research ideal, actual, outcomes and opportunities

Research design		Ideal research methodology	Actual research methodology	Research outcomes	Research opportunities
Literature review		Comprehensive literature database with documented case studies of sustainable healthcare initiatives and experiences.	Substantial literature found on international experiences. No formal literature found on WCRC hospital but this created an opportunity for documenting the findings and relevant case studies.	Representative literature review.	Documenting further WCRC's healthcare system and opportunities in greater detail (such as greening, bioregionalism, partnerships etc.).
Empirical data collection	GBCSA Green Star office rating score	GBCSA rating score with the Green Star SA – Office tool specific values for building rating score and actual green star.	Data used from the following category weightings: - Management – 9% - IEQ – 15% - Energy – 25% - Transport – 9% - Water – 14% - Materials – 13% - Land Use & Ecology – 7% - Emissions – 8%	Estimation of the hospital building rating score and actual green star rating.	Developing a hospital building rating tool. Detailed surveys and mapping of both actual and potential hospital building rating scores and green star rating. Explore how waste can be used as a category weighting for hospitals.
	Design and operations	Detailed surveys of who the hospital offers its services to and how it offers these services.	Data available from the hospital of who they offer their services to. General statistics aggregated by gender and type of injury available.	Broad overview of hospital design and distribution patterns for parts of the distribution's chain through inferences and estimations.	Detailed surveys of how the hospital offers its services. Research developing & sustaining best healthcare waste management practices in a way that is both locally appropriate and globally replicable.
		Accurate accounting systems from the hospital on where they source their food from.	Estimates from the hospital on percentage of food locally sourced.		Systems for the hospital to account where food is sourced from.
		Detailed surveys of alternative healthcare waste treatment technologies appropriate to conditions in	Estimates of typical alternatives from the GEF project "demonstrating and promoting		Detailed surveys of alternative healthcare waste treatment technologies appropriate to conditions

		much of sub-Saharan Africa.	best techniques and practices for reducing health-care waste to avoid environmental releases of dioxins and mercury".		in much of sub-Saharan Africa.
	Consumption	Representative profile of typical consumption patterns across multiple hospital department's at WCRC hospital. Locally suitable optimal resource flows across hospital departments.	Hospital department's consumption reports (2009) compared with department's consumption reports (2010).	Estimated consumption patterns for the hospital. Optimal resource flows in hospital depts. from studies.	Detailed surveys on typical consumption patterns for multiple hospital departments at WCRC hospital. Locally suitable optimal resource flows in hospital departments.
Ethnographic research	Local healthcare system trends interviews	Personal interviews with a wide representation of stakeholders to ascertain their perceptions of local healthcare system, barriers and potential for sustainability.	Limited number of formal interviews due to time constraints. Continuous discussions and investigation.	Increased understanding of local healthcare system trends, as well as opportunities and barriers for strengthening the healthcare system.	In depth market analysis research on further opportunities for local healthcare system initiatives within different sectors, e.g., creating model healthcare facilities or programs through collaborations with hospitals, smaller clinics, rural health and/or central waste treatment facilities etc.
	Local healthcare and hospital system case studies	Personal interviews with selected case study subjects.	Personal interview with selected case study subjects	Descriptive case studies of current green hospital buildings and local healthcare initiatives.	Further case study documentation. Focusing primarily on activities such as green hospital buildings, waste minimisation, promoting the use of non-burn waste treatment technologies, improved waste segregation practices and the use of appropriate alternatives to mercury-containing devices etc. It must delve into evidence on the financial performance of green office buildings like in the USA (GBCSA hopes to compile their very own local version this year!). Insights must include the following: despite increases in the number of green buildings, and the recent downturn in property markets, green premiums have been maintained; and Energy Star-certified buildings command rents that are 2.1% higher compared to similar, non-certified properties.

Chapter 4 – Research Findings

4.1 Introduction

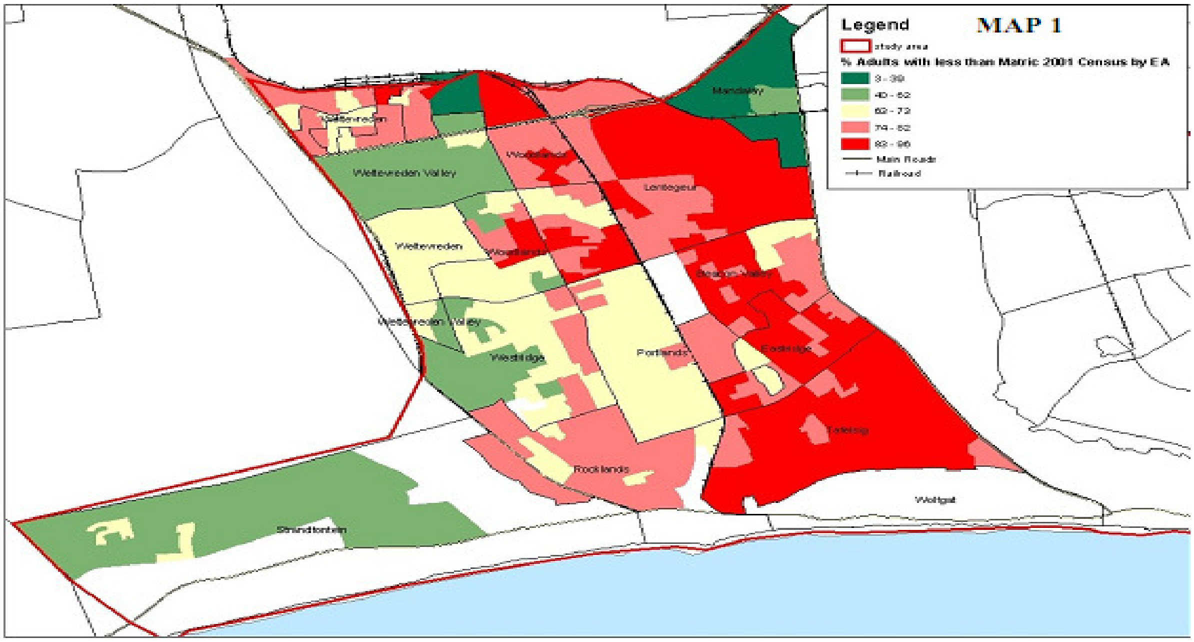
This section aims to provide research findings in support of the first, second and third research objectives as identified in Chapter One, Section 1.2. An overview of the context of WCRC hospital (Section 4.2) and core findings on the current status of hospital design, resource flows and consumption (Section 4.3) are presented in support of the second research objective and in order to provide a baseline for the final research objective, some intervention were relevant are also suggested alongside the findings.

In the context of sustainability and the dynamics of green building, the design requirements for a sustainable hospital and optimal consumption are put forward (Section 4.4) and the capacity of the hospital to meet both current and sustainable optimal resource demand presented (Section 4.4 and Section 4.5). These research findings are presented in order to make recommendations to promote a stronger local healthcare system and hospital facility (based on the findings of the first research objective in Chapter Two) and thereby promote greater sustainability through WCRC's hospital system (in support of the final research objective). A selection of case studies are presented throughout to provide context to a growing green building and sustainable hospital movement, and highlight some of the challenges and opportunities for promoting sustainable healthcare through hospitals, also in support of the final research objective.

4.2 Overview of WCRC and Background to Mitchell's Plain

The Western Cape Rehabilitation Centre's (WCRC) hospital area covers a total of 71 square kilometres and is situated within the greater Mitchell's Plain municipal district under the Cape Town municipality of the Western Cape Province in the Republic of South Africa (refer to Figure 11 below). A number of human settlements ranging in size from the large Mitchell's Plain town centre to the western half which includes "Westridge, Rocklands, Strandfontein, Portland, Westgate, Woodlands, Colorado Park, and Weltevreden. The eastern half includes Tafelsig, Eastridge, Beacon Valley, and Lentegeur, lie within" the area, with a spread of housing lands and natural lands falling beneath the False Bay coast that pass through coastal region. Housing and residential activities are responsible for over 90% of land use in Mitchell's Plain and "housing between 1.2 million - 1.9 million residents (although the city of Cape Town estimates it's about 1.8 million), it comprises a number of sub-sections which reflect the diverse class" backgrounds of the population (Statistics South Africa, 2006). The undeveloped spaces surrounding the human settlements of Mitchell's Plain are under increasing pressure from developers attracted to the region. Beneath the charm of Mitchell's Plain lies deeply rooted social inequality as a legacy from the Apartheid era and increasing resource based challenges. Mitchell's Plain is "located 20 kilometres" from the city of Cape Town. It is bordered by Philippi to the north, Philippi Horticultural area to the west, the False Bay Coastline to the south, and Khayelitsha to the east (Statistics South Africa, 2001).

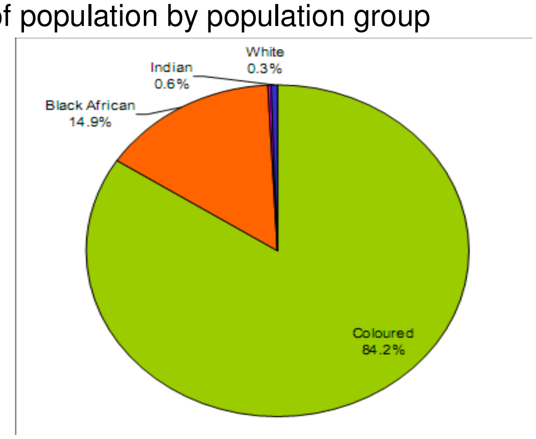
Figure 11: Boundaries of the research location – Mitchell's Plain municipal area



Source: Mitchell's Plain Municipality, 2010

The area is characterised by very low residential densities with an excess of open space, there is also a lack of quality urban public places in strategic locations. "Mitchell's Plain CBD is a thriving economic centre with a significant informal trading sector" however, the presence of gangs and high crime levels are problematic in the area. The Mitchell's Plain population is constituted of mostly Coloured residents: "84.2% of the population indicated their population group as Coloured." "Only 14.9% indicated their population group as African/Black and 0.6% as Indian and 0.3% as White" (Statistics South Africa, 2003:10). Figure 12 below indicates the current and projected population estimates for Mitchell's Plain. Mitchell's Plain was built to "accommodate 250,000 people" but the current population of the area far exceeds this number (Statistics South Africa, 2001; URP, 2006).

Figure 12: Distribution of population by population group



Source: Statistics South Africa, 2003:10.

The 2001 Census recorded the size of the Mitchell's Plain population "at 305 343 people living in 67 746 households." This compares to the 1996 figure of "257 578 implying a growth rate of 3.4 per annum" between 1996 and 2001 (Statistics South Africa, 2003:45).

Table 4: Comparison of 1996 and 2001 Census Figures

	1996 Census	2001 Census	Average Growth
Nº of People	257 578	305 343	3.4%

Source: Statistics South Africa, 2003

Whilst Mitchell's Plain is experiencing the "sharp urbanisation" characterising the larger cities of the developing world, the informal settlement areas of Mitchell's Plain continue to grow on the urban periphery and remain under serviced (City of Cape Town, 2008:89). As recognised in the Integrated Development Plan (IDP) of the City of Cape Town [here after referred to as Mitchell's Plain Municipality for municipality sub-directorate clarify] (2007/8), the faster growth of the African population is changing the demographic composition of greater Mitchell's Plain, requiring targeted intervention to ensure adequate land for residential and other purposes as well as infrastructure and service delivery. Furthermore, the demographic profile of the Mitchell's Plain municipality indicates that approximately a third of the population are younger than fifteen years old, suggesting a strong dependency ratio. This has implications on the need for healthcare, educational facilities and job creation to support this growing population (Nodal Economic Profiling Project Business Trust & DPLG, 2007).

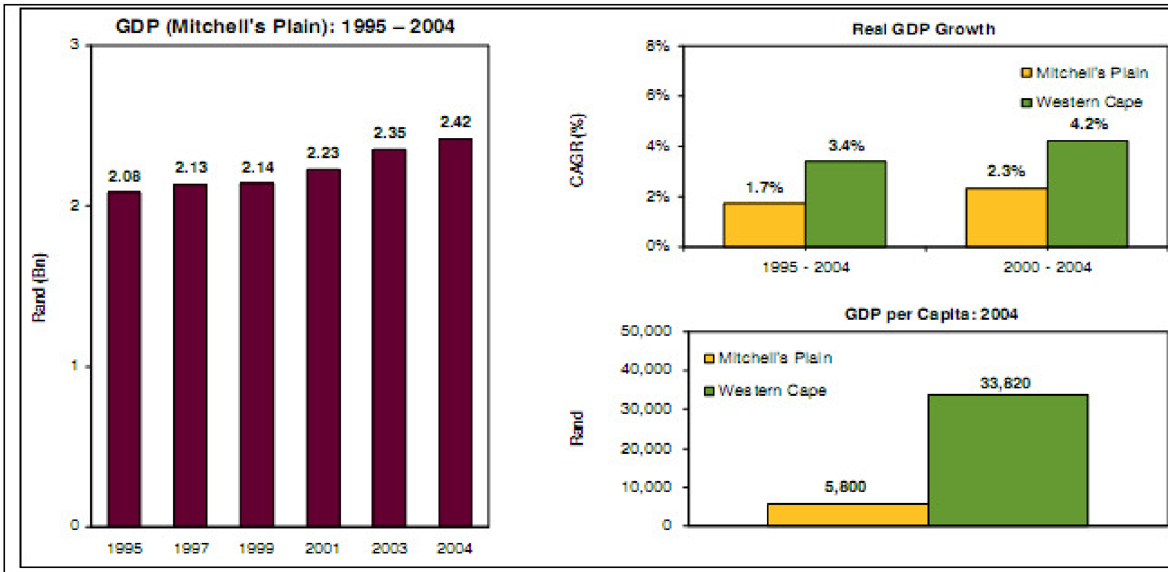
Mitchell's Plain was a residential area planned as a new settlement in the 1970s. It was built to alleviate housing shortages in the so called coloured community of Cape Town at a time when these communities were being forcefully removed in terms of the apartheid legislation. The town was then planned as a segregated, self-sufficient dormitory town far from the white areas of the city, and it was also isolated from its black and Indian neighbours. All manufacturing and industrial activity was "excluded from the planning for the area in order to promote Atlantis, 45km to north of the city, as a coloured decentralisation point" (Nodal Economic Profiling Project Business Trust & DPLG, 2007:15). The main economic activities of Mitchell's Plain CBD is a thriving "economic centre with a significant informal trading sector", which indicates that whilst residential housing is the largest sector by land use, the main revenue streams are derived from informal trading and other sectors through formal employment of the residents', including finance and business services and manufacturing (WCPG, 2007:8). Manufacturing is the largest employer in Mitchell's Plain residents followed by wholesale and retail trade, and community, social and personal services (shown in Table 5 and Figure 13 below). Manufacturing is closely linked to the health sector, which itself is not a large employer but indirectly supports a number of other sectors in Mitchell's Plain. The proportion of most people "living in Mitchell's Plain work outside the" area - few people who live in "Mitchell's Plain actually work there; the railway lines and taxi routes feeding these areas are among the busiest in Cape Town" [Nodal Economic Profiling Project Business Trust & DPLG, 2007:71; Integrated Transport Plan for the City of Cape Town, 2006; Shand, 1998] and this is discussed further in Section 4.3.1. The city of Cape Town recognised that making an effort to integrate Mitchell's Plain both spatially and socially was the most relevant and potential source of economic growth in both the short and long term for growth in the Mitchell's Plain economy (Economic and Human Development (EHD) Strategy, 2006).

Table 5: Employment by economic sector (2001)

Private Households	Construction	Transport / Communication	Financial and Business	Trade	Community, social & personal	Manufacturing	Other
2.8%	8.7%	6.3%	11.5%	21.8%	20.5%	26.0%	2.3%

Source: DPLG, nd

Figure 13: Mitchell's Plain contribution to Regional Mitchell's Plain GDP: 1995 – 2004



Source: DPLG, nd: 7

The mean monthly incomes for the African and Coloured residents of Mitchell's Plain as a share of total mean for all population groups have increased marginally over time, indicating decreasing inequality in a region with arguably 'one of the highest levels of inequality in the world'. Mitchell's Plain currently has some of the "greatest discrepancies between poverty and wealth" (Mitchell's Plain Municipality, 2009:20) in a country with a "gini co-efficient of 0.72" (Statistics South Africa, 2008:03), which is considered to place South Africa in the top ten most unequal countries in the world (UNDP, 2008; CIA, 2008).

Major challenges recognised by the Ward Councillors for Mitchell's Plain include housing, unemployment, crime and poverty alleviation in the Coloured communities, law enforcement, urban growth and conservation in the Coloured and African communities and crime and cleansing in the African communities. The key challenges facing Mitchell's Plain are "spatial marginalisation, overcrowded living conditions, HIV/AIDS, crime and lack of access to public amenities" (DPLG, nd:12). The majority of the population found in Mitchell's Plain is poor; many people are economically inactive or unemployed; and most of the people earn less than the household subsistence level (DPLG, nd:14). The issues raised by the Ward Councillors point to challenges of poverty at multiple levels (that need to be addressed alongside with deep inequality) through targeted growth that values social upliftment, greater social integration and community building above economic growth alone. A key finding presented in Chapter Two (Section 2.2) is the failure of the economic growth model to "realise improvement in quality of life" (Ayres et al, 1996:02). In the context of growing resource constraints, there is increasing pressure to realise development through equitable and sustainable development.

These social challenges will only be compounded further by the resource based challenges that Mitchell's Plain is already facing. Water shortages are common place during the dry summer months and are expected to worsen as population growth puts increasing demand on dwindling water supplies as a result of climate change (Hewitson, 2006; City of Cape Town, Mitchell's Plain Municipality, 2008; Smit, 2009). This will impact directly on the local economy of the region (in sectors such as health, agriculture or tourism), as well as the "quality of life for its residents" (Ayres et al, 1996:04).

The national energy provider, Eskom, has placed "limits on growth and expansion" through electricity restrictions (Mitchell's Plain Municipality, 2008:37). The Visserhoek landfill is full and "has been capped" (City of Cape Town, 2011:5) and the Mitchell's Plain sewerage treatment plants are at capacity, with overflow common place in the wet winter months. In the context of both climate change and peak oil coupled with population growth, Mitchell's Plain cannot afford to continue down an energy-dependent and waste intensive path of development given the possible exception of Mitchells Plain Treatment Works which has very high running costs. Should it be possible to reduce the running cost of the works by more than 10%, then according to the model, it will be "more beneficial to retain the works" (Smit, 2009:3). According to the Cape Metropolitan Council political, social and/or environmental considerations might still justify rationalisation which could test the feasibility to close works simply to rationalise the number of treatment works and the possibility of "transferring sludge and excess flows from the Mitchells Plain to the Cape Flats Treatment Works" was planned, (Cape Metropolitan Council, 1999:13 – 14).

Mitchell's Plain lies within the Cape Floristic Kingdom, an internationally recognised biodiversity hotspot and less than 10% of the critically endangered Renosterveld endemic to the region remains today, with less than 1% under formal conservation (Von Hase, Ragout, Maze & Helme, 2003:2). As discussed in Chapter Two (Section 2.2.2), basic ecosystem services (such as biodiversity) are continuously providing humanity with a clean and healthy environment that sustains life, whilst protecting communities from threats such as flooding, and providing resources, such as food or energy. Furthermore, a degraded environment "severely limits our capacity for development and the extent to which poverty and inequality can be successfully overcome" (Ayres et al., 1996:5 – 6). Whilst Mitchell's Plain Municipality's IDP (2007/8 – 2011/12) places great "emphasis on local economic development and community participation", the natural environment is considered mostly in terms of parks or services, and not as a limiting factor to development (Smit, 2009:023). It therefore is proposed that Mitchell's Plain adopts a more holistic approach to environmental management which takes responsibility for Mitchell's Plain's contributions to both local and global environmental degradation. An approach such as this has potential to increase the quality of life for all citizens, present and future, through investing in a "clean and healthy environment" (Von Hase et al, 2003:1).

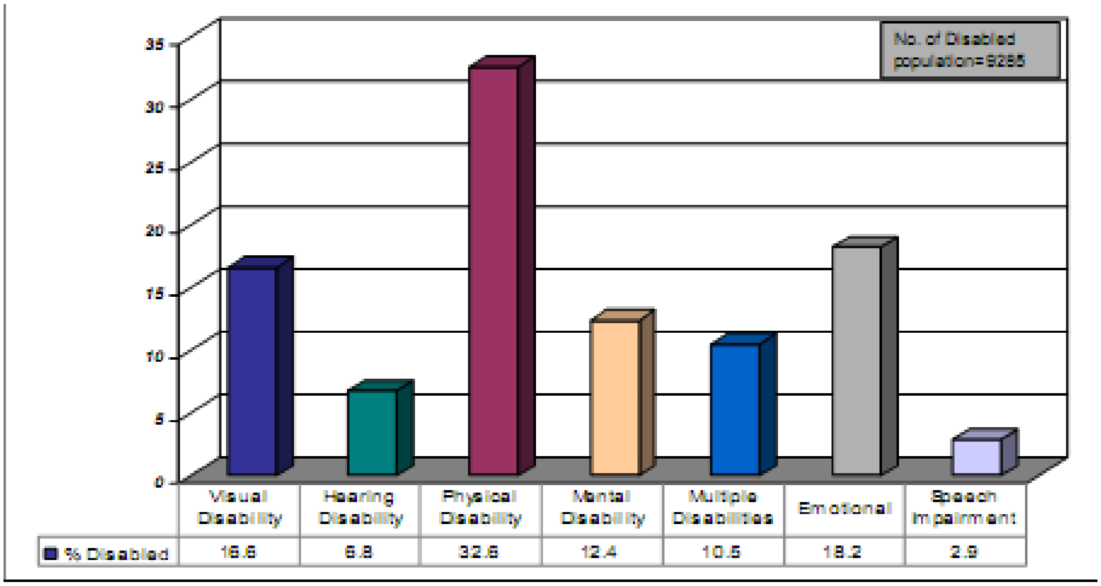
In the latest integrated development plan for Cape Town 2008/09 Review, the City of Cape Town's Municipality, Mitchell's Plain (2007/8 – 2011/12) has committed itself to:

i. Fight against drug and substance abuse;
ii. Eradication of poverty through empowerment;
iii. Sustainable economic development and the creation of employment opportunities in the commercial, industrial and agricultural sectors (with special reference to land reform);
iv. Building civic pride and a united town;
v. Spatial, regional and transport planning for sustainability;
vi. Integrated sustainable human settlements, in particular solutions to homelessness and overcrowding;
vii. Sustainable resource use, including energy efficiency/renewable energy, zero waste, secure water supplies and biodiversity conservation;
viii. Access to social security programs;
ix. Crime prevention and victim support;
x. Health provision, including the promotion of healthy living;
xi. Youth and Gender issues.

Furthermore, the formal Programme of Action for Building Productive and Sustainable Nodal Economies which was developed by the URD Branch in September 2005 recognises that addressing the problems and optimising the opportunities of Mitchell's Plain can best be done by adopting the core principle of sustainability in all spheres of activity, whether that be educational, social, economic, technological, infrastructural or economic and further commits to "a vision of Mitchell's Plain as a Sustainable residential township" (DPLG, nd:13).

The current challenges being faced by the Mitchell's Plain community (both social and environmental) and the formal commitments to address these in a sustainable manner provides a context for investigating the current healthcare system of WCRC hospital and healthcare facility and an opportunity to draw up a set of recommendations to promote sustainability through a sustainable healthcare facility. According to the incidence of disability by type of disability, the "most common form of disability was physical disability; affecting 32.6% of the disabled population" in Mitchell's plain (Statistics SA, 2003:10).

Figure 14: Prevalence of disability in Mitchell's Plain



Source: Statistics South Africa, 2003 and Statistics South Africa, 2001

4.2.1 Analysis of WCRC's founding philosophy, principles and history

From the interviews it was found that WCRC formed through the amalgamation of the Conradie Hospital Spinal (CHS) - General Rehabilitation Units and Karl Bremer Rehabilitation Unit (KBH) as opposed to founding it as new Rehabilitation Unit(s) in addition to the two in order to "increase efficiencies by pooling resources (budgets and staff and expertise). They was no allocated funding for establishing additional rehab centres – this was not part of the Department of health's priorities and strategic plans." WCRC opened its doors to the public in October 2004.

During the interviews, it was also found that the consideration(s), reason(s) and factor(s) that influenced, caused and resulted in the amalgamation are as follows:

(a) The MEC for Health made a decision to sell the Conradie hospital site in 2003. The hospital infrastructure was very old and dilapidated, all underground utilities were "past their sell by date" and way too expensive to try and repair, fix, or refurbish. Building a complete new hospital was required and seen as a solution.

(b) Prior to this a top management decision was made in 2001 to amalgamate KBH Rehab (the "model" the current WCRC CEO had developed for National Health and the University of Stellenbosch Medical faculty), and to "expand" this model to Conradie's Spinal and Neuro-rehab Units.

(c) In the Departments Strategic Health Plan (CSP or Comprehensive service plan) services needed to be situated at appropriate levels. Based on this, the acute services of Conradie were relocated to Eerste River Hospital. This was a brand new facility purchased by the Department of Health (DOH), and gave this community their first District Hospital.

(d) The acute tertiary services of the Spinal Cord Injury Unit (ICU and High Care) were relocated to Groote Schuur Hospital (tertiary facility).
(e) The rehab components of the service were then amalgamated and relocated to the newly built WCRC in Mitchells Plain.
(f) The WCRC was custom-built for persons with physical disabilities (PWD) at a cost of R100m.
(g) There were four PWD's appointed as Consultants to the DOH, to assist with the design and planning of the new facility.

It was also found that the current management still thinks that the amalgamation was a good notion and still an appropriate, relevant and worthwhile move even today because:
(a) It gave WCRC a brand new, world class custom-built facility.
(b) It is situated in an area with the highest prevalence of physical disability in the Western Cape.
(c) They were many additional positive "spin offs" for the community. For example: "the Lentegeur and Mandalay train stations were completely refurbished to conform to universal accessibility design (wheelchair accessible); the route from the WCRC to the nearest two shopping centres were upgraded (street lighting and pavements etc.)"

4.2.2 Analysis of WCRC's leadership and management

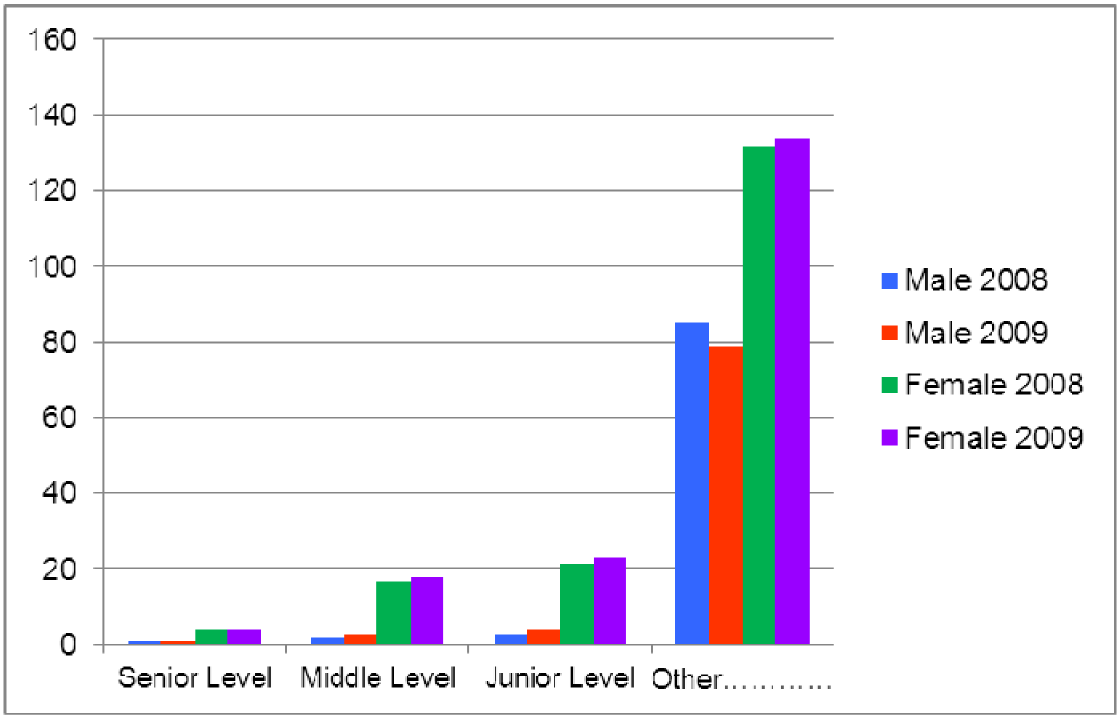
During the interviews, it was also found that:
(a) WCRC is under a government department/body: Department of Health.
(b) It is governed and managed through: Directives; Regulations; Legislation and Bylaws.
(c) Policies that influence and affect WCRC's governance come into effect through national legislation.
(d) It is run through the Public Private Partnership (PPP) where Mpilisweni is the name of the Consortium (a Special Purpose Vehicle formed for the PPP) and comprised of three companies: Drake and Scull, Folang medical and Vuya Investments.
(e) 266 employees constitute WCRC current staff members as illustrated in Fig 28 - 30.

Table 6: Ethnicity demographic units (n°) of the WCRC employees

Ethnicity	African Black				White				Coloured				Indian			
Year	2008		2009		2008		2009		2008		2009		2008		2009	
Sex	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
n°	17	19	16	19	8	40	6	39	65	112	65	116	1	3	-	5

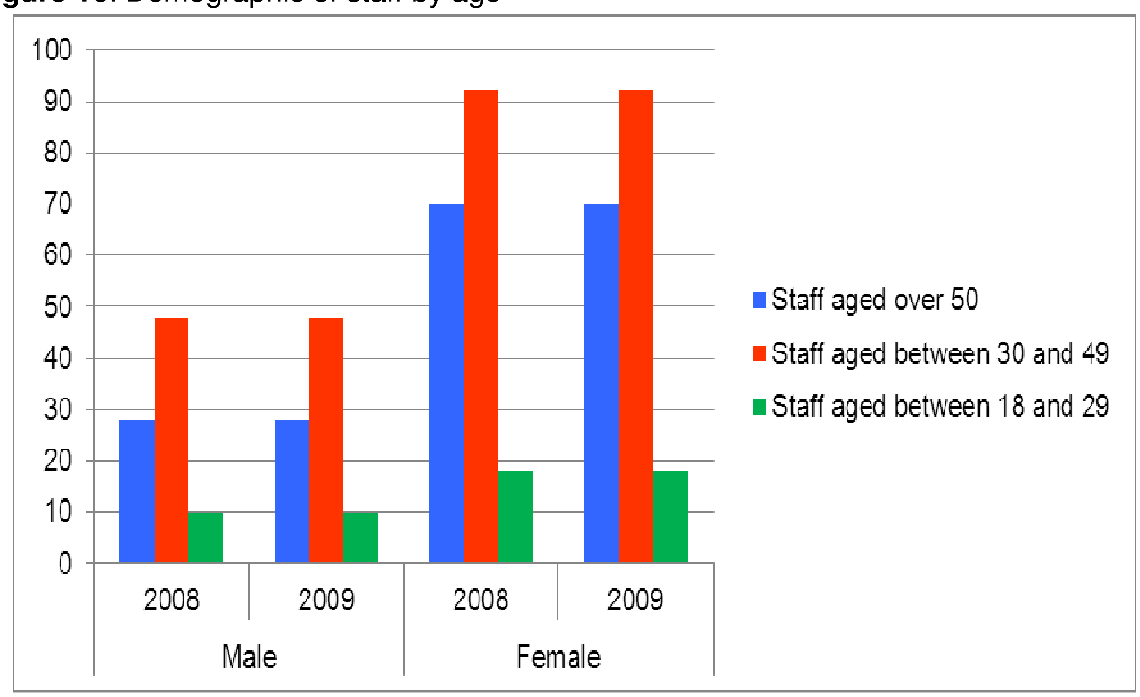
WCRC current staff members by staff by hierarchical levels are disaggregated as follows:

Figure 15: Demographic of staff by hierarchical levels



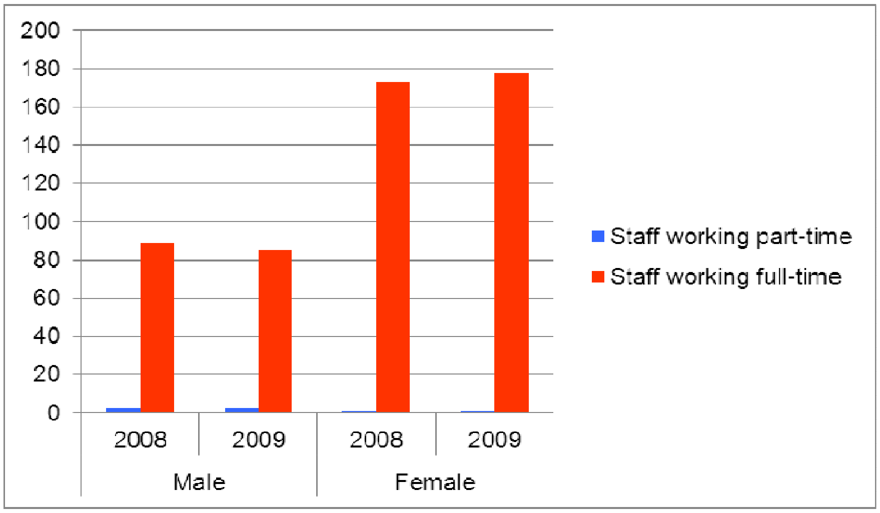
WCRC current staff members by staff by age are disaggregated as follows:

Figure 16: Demographic of staff by age



WCRC current staff members by staff by working time are disaggregated as follows:

Figure 17: Demographic of staff by working time



WCRC trains its own staff and develops their knowledge, skills, capacity and expertise.
Figure 18: Demographic of specialist training area and training duration

Specialist training area	Training Duration
Improvement of clinical skills (Continuous professional development)	1 – 15 days
Computer training (Per module)	1 day
Leadership and Management	1 – 5 days
Information Management (research)	1 day
Communication skills	1 – 3 days
Personal Development	1 – 2 days
Nurse training	1 – 5 days
Quality of care	1 – 3 days
Labour relations	1 – 3 days
Emergency care	1 day

During the interviews, it was found that WCRC serves the entire Western Cape Province and neighbouring Northern and Eastern Cape provinces. It also receives referrals from other provinces such as Gauteng / Kwazulu Natal but this is rare.

It was also found that WCRC as an organisation does not have/use any of the following:
(a) A Sustainability / Sustainable Development policy or plan;
(b) A Corporate Social Responsibility (CSR) policy;
(c) An environmental policy (EP);
(d) A Human Social Protection (HSP) policy;
(e) A Sustainability Matrix (SM);
(f) A Development Plan (DP).
The absence of either of the documents listed above highlights how WCRC doesn't think of sustainability at a policy level. Having a sustainability policy is one thing and abiding to

it is another. Though having it is a sign that atleats sustainability is being though about form an organisational policy level. It's none existence indicates otherwise.

It was also found that WCRC as an organisation has a Strategic Plan (SP) which is developed by all of its staff members, which is reviewed and redrafted quarterly. WCRC does "not monitor and report on its performance in sustainable development." WCRC as an organisation are not "sustainable development champions, i.e. they do not have any dedicated staff members whose role is to promote SD or who receive or offer training in SD." "They are no particular features of SD leadership and management which they would identify as good practice."

It was also found that WCRC isn't implementing any national or international environmental management systems like:
(a) EMAS;
(b) BS 8555;
(c) ISO14001;
(d) Green Mark; or
(e) Any other

4.3 Analysis of the current hospital systems and practices

An analysis of the current healthcare system is presented as the baseline for making recommendations on sustainable hospital design and healthcare system based on the findings of the first research objective and in support of the final research objective. For the purposes of the research, the healthcare system is considered in terms of (1) hospital building green star SA rating, (2) hospital building design, (3) consumption and (4) waste management. An overview of the building green star SA rating describes the current hospital building's green star SA rating. The hospital system component of the WCRC hospital is described through a series of examples to highlight current practice and complexities. Consumption patterns are inferred for the hospital's needs which represent the population. As emergent from the findings above, when WCRC hospital was built, the main focus to build a new state of the art hospital to meet health care needs without any consideration being put into key design issues like:

1. **Alternative infrastructure technologies** (National Center for Small Communities, 2004:2)
   - Water: new sources (rainwater, and recycled water, etc.), efficiencies
   - Sanitation: zero-waste approach, localised treatment to cut long-distance transport
   - Energy: efficiencies, local sources, mix of inputs, not just a carbon focus
   - Transport: massive investments in public transport, with conventional transport modes being the key spin offs

2. **Buildings** (Green Development Services, 2001:1)
   - Orientation
   - Solar performance – overhangs, windows

- Thermal performance
- Ventilation
- Lighting – natural through design
- Energy efficiency
- Energy generator
- Zero waste
- 'greened' via landscape, function, flows
- Embedded in local economy – procurement etc.

3. **Eco-system G&S** (Tertog Change, 1998:33)

- Local food supplies – the big one, but also
- Productive re-use of wastes as reinvestment in the eco-system
- Harnessing of eco-system G&S – worms, bees, animals, birds, planting for cooling & food supplies, storm water management
- Cultural & spiritual value for community building, healing, child learning

4. **Know-how, learning, community** (Atkin, J., 1999:18)

- Innovation is key
- But innovation dependent on social cohesion
- Community building as driver of change for sustainability and local economy

5. **Energy** (Green Development Services, 2001:1)

- "Grid-supply from fossil fuel-based sources, long-distance transmission (11% losses), from sub-stations to buildings, metered";
- "Transport as a mix of rail (grid-supplied) and road fuelled by a mix of imported oil and 'oil-from-coal'" – up to 50% of the energy mix of the city – user fees

Figure 19: Impact per KWh in SA

Water consumption	1.29l/kWh
Coal consumption	0.5kg/kWh
Ash produced	142g/kWh
Ash emitted	0.28g/kWh
SO2 emissions	8.22g/kWh
NO emissions, NOX	3.62g/kWh
CO2 emissions	0.9kg CO2/kWh
Transmission and distribution losses	11%

Source: Swilling, 2010

Figure 20: Green star SA weight scores of WCRC's hospital office building as built

Green Star category	Weight Score	Findings of what is/has been done at WCRC (as built)
Management	0.0	○ Building was tested to achieve airtightness levels,
Indoor Environment Quality	7.0	○ Windows and doors ○ Open able windows or trickle vents ○ Blinds as is to control glare ○ LED fluorescent light tube who's Luminance: ≥400 Lux/1.5m ○ Windows above 720mm and below 2400mm to view outside grounds etc. ○ VOC paint for all walls ○ Use composite wood products with formaldehyde ○ Full natural ventilation to prevent moulds ○ No establish dedicated photocopying and printing area with exhaust riser non-smoking regulation in the hospital building
Energy	1.7	○ Comply with SANS 2004: 2008 ○ Single metering for lighting & no developed effective mechanism for monitoring energy consumption and data from all energy meters ○ Single light switch per room ○ Peak Energy Demand Reduction
Transport	2.6	○ Provision of Car Parking ○ No Fuel-Efficient Transport ○ No cyclist facilities ○ Commuting Mass Transport ○ Local Connectivity
Water	7.5	○ Conventional city of Cape Town water ○ Borehole water ○ Single main water meter
Materials	3.5	○ Recycling bins with no dedicated storage area for the separation and collection of recycling materials ○ No integrated fit-out ○ PVC ○ Ordinary certified timber ○ Design for without disassembly ○ Locally sourced materials' used
Land Use & Ecology	0.0	○ Site in municipally approved urban edge
Emissions	0.5	○ Peak storm water flows ○ All discharge to sewer ○ No cooling towers servicing the building
Innovation	0.0	○ None
Total points	**23**	**Equates to 2 star rating score for WCRC as it is**

4.3.1 WCRC's hospital building green star SA rating score

Table 7: Green star SA rating score of WCRC's hospital office building as built

Green Star SA - Office As Built v1							**Credit Summary**		
WCRC Hospital building currently WCRC Now (immediately and currently)									
Category	**Title**	**Credit No.**	**Points Available**	**Points Achieved**		**Points to be Confirmed**	**Percentage of Available Points Achieved**	**Weighting**	**Weighted Score**
Management									
	Green Star SA Accredited Professional	Man-1	2	0		0			
	Commissioning Clauses	Man-2	2	0		0			
	Building Tuning	Man-3	2	0		0			
	Independent Commissioning Agent	Man-4	1	0		0			
	Building Users' Guide	Man-5	1	0		0			
	Environmental Management	Man-6	2	0		0			
	Waste Management	Man-7	3	0		0			
	Airtightness Testing	Man-8	1	0		0			
		TOTAL	**14**	**0**		**0**	0%	9%	**0.0**

Indoor Environment Quality						
	Ventilation Rates	IEQ-1	3	2		0
	Air Change Effectiveness	IEQ-2	2	1		0
	Carbon Dioxide Monitoring and Control	IEQ-3	1	0		0
	Daylight	IEQ-4	3	1		0
	Daylight Glare Control	IEQ-5	1	1		0
	High Frequency Ballasts	IEQ-6	1	0		0

Electric Lighting Levels	IEQ-7	1	0		0				
External Views	IEQ-8	2	1		0				
Thermal Comfort	IEQ-9	2	1		0				
Individual Comfort Control	IEQ-10	2	1		0				
Hazardous Materials	IEQ - 11	1	1		0				
Internal Noise Levels	IEQ-12	2	1		0				
Volatile Organic Compounds	IEQ-13	3	1		0				
Formaldehyde Minimisation	IEQ-14	1	0		0				
Mould Prevention	IEQ-15	1	1		0				
Tenant Exhaust Riser	IEQ-16	1	0		0				
Environmental Tobacco Smoke (ETS) Avoidance	IEQ-17	1	1		0				
	TOTAL	**28**	**13**		**0**		46%	15%	**7.0**

Energy									
Conditional Requirement	Ene-	0	Not Achieved		0				
Greenhouse Gas Emissions	Ene-1	20	0		0				
Energy Sub-metering	Ene-2	2	1		0				
Lighting Power Density	Ene-3	4	1		0				
Lighting Zoning	Ene-4	2	0		0				
Peak Energy Demand Reduction	Ene-5	2	0		0				
	TOTAL	**30**	**2**		**0**		7%	25%	**1.7**

Transport									
Provision of Car Parking	Tra-1	2	1		0				
Fuel-Efficient Transport	Tra-2	2	0		0				
Cyclist Facilities	Tra-3	3	0		0				
Commuting Mass Transport	Tra-4	5	2		0				
Local Connectivity	Tra-5	2	1		0				
	TOTAL	**14**	**4**		**0**		29%	9%	**2.6**

Water								
Occupant Amenity Water	Wat-1	5	0		0			
Water Meters	Wat-2	2	1		0			
Landscape Irrigation	Wat-3	3	3		0			
Heat Rejection Water	Wat-4	4	4		0			
Fire System Water Consumption	Wat-5	1	0		0			
	TOTAL	**15**	**8**		**0**	53%	14%	**7.5**

Materials								
Recycling Waste Storage	Mat-1	2	1		0			
Building Reuse	Mat-2	0	na		0			
Reused Materials	Mat-3	1	0		0			
Shell and Core or Integrated Fit-out	Mat-4	1	0		0			
Concrete	Mat-5	0	na		0			
Steel	Mat-6	0	na		0			
PVC Minimisation	Mat-7	1	0		0			
Sustainable Timber	Mat-8	2	0		0			
Design for Disassembly	Mat-9	1	0		0			
Dematerialisation	Mat-10	1	0		0			
Local Sourcing	Mat-11	2	2		0			
	TOTAL	**11**	**3**		**0**	27%	13%	**3.5**

Land Use & Ecology								
Conditional Requirement	Eco-	0	Not Achieved		0			
Topsoil	Eco-1	0	na		0			
Reuse of Land	Eco-2	2	0		0			
Reclaimed Contaminated Land	Eco-3	0	na		0			
Change of Ecological Value	Eco-4	4	0		0			
	TOTAL	**6**	**0**		**0**	0%	7%	**0.0**

Emissions							
Refrigerant / Gaseous ODP	Emi-1	1	0	0			
Refrigerant GWP	Emi-2	2	0	0			
Refrigerant Leaks	Emi-3	2	0	0			
Insulant ODP	Emi-4	1	0	0			
Watercourse Pollution	Emi-5	3	0	0			
Discharge to Sewer	Emi-6	5	0	0			
Light Pollution	Emi-7	1	0	0			
Legionella	Emi-8	1	1	0			
Boiler and Generator Emissions	Emi-9	0	na	0			
	TOTAL	**16**	**1**	**0**	6%	8%	**0.5**
			Sub-total weighted points achieved:				**23**

Innovation						
Innovative Strategies & Technologies	Inn-1	5	0	0		
Exceeding Green Star SA Benchmarks	Inn-2	5	0	0		
Environmental Design Initiatives	Inn-3	5	0	0		
	TOTAL	**5**	**0**	**0**	(Innovation is not weighted)	**0**
			Total weighted points achieved:			**23**

Two Star (Average Practice) Green star SA rating score.

Hence WCRC's hospital building as it is (as built) has achieved a 'Two Star' Green star SA rating score which implies average practice which means that the Minimal standards for Green Star accreditation are not met.

4.3.2 Buildings and estates: hospital building design

From the building inspections and interviews with hospital management, it was found that the hospital undertakes audits of its consumption and management of the following resources:
(a) Energy (electricity): this is metered separately for each ward and area.
(b) Water: this is metered separately for each ward and area.
(c) Waste: they are waste bins for each ward and area.

It was also found that all of WCRC's buildings were constructed using red common bricks and brown face bricks. Cement was used as the building binding material and no other binding material types were used. The hospital building is predominantly south faced and there are no specific features of construction and estate management practices that were identified which influenced the direction faced by the building. No building design features or various design techniques like the ones listed below were used:

- Tree planting for the purpose of providing shade to reduce costs;
- Building or planting windbreaks to slow down wind near buildings to prevent heat loss;
- Use of shrubby and wines as wall sheltering to create windbreaks directly against a wall;
- Green roofs to cool buildings with evapotranspiration and extra thermal mass;
- Minimising paved areas, reducing the heat island effects with previous paving, shade and high albedo paving;
- High efficiency fixtures light level sensors and full cut off fixtures site lighting.

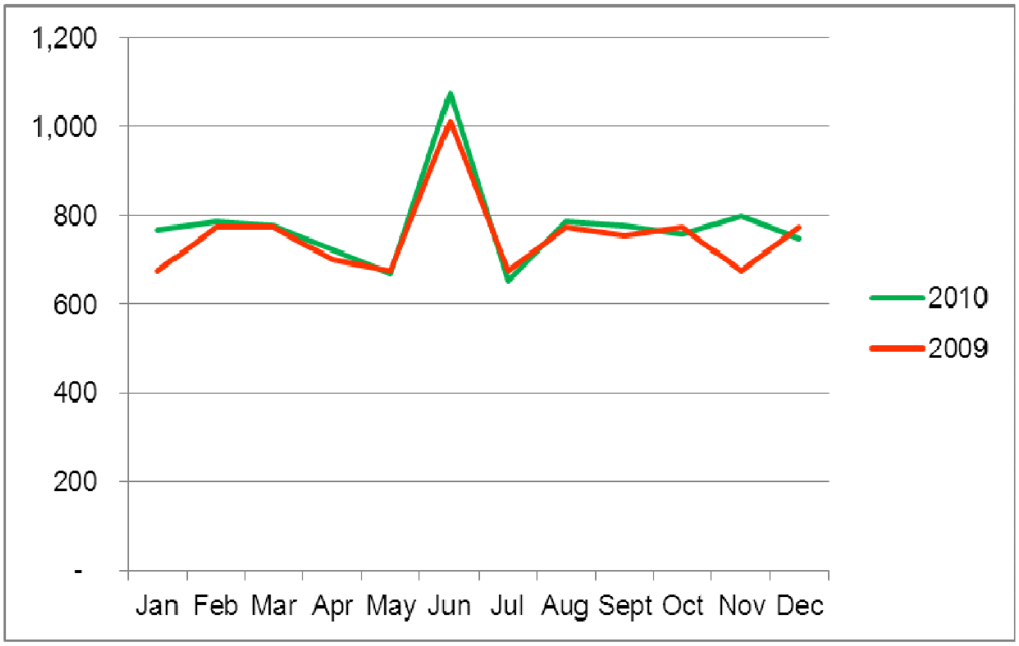
There were no indoor air quality and air tightness features/properties that were particularly identified for the hospital building. These building features were not considered in great detail but the standard government statutory building requirements of South Africa were met during the construction of the hospital. Apart from air vents no particular features of ventilation and thermal insulation were identified from the hospital building. During the interviews the only design, construction and operational feature that respondents identified as demonstrated good practice in sustainable development is the "easy access of the hospital even to handicap persons".

4.3.3 Waste and recycling

From the interviews conducted with the hospital management and data collated from the hospital's waste management and recycling reports, it emerged that the hospital promotes the efficient use of resources i.e. waste minimisation and resource efficiency. The hospital doesn't have a policy on this but their staff members for example do double side printing as opposed to single sided prints. Their staff reuses scrap paper and don't use disposable cups but reusable mugs and glasses for tea and drinks.

In terms of waste, the hospital produces agricultural waste products, sewage waste products, medical waste products, hazardous and other special waste products such as fluorescent bulbs containing mercury. The medical waste is taken from the respective ward areas to one central point in ward F. When in ward F, a service provider named Hlomani collects the medical waste from ward F for disposal as a 'pig swill'. Hlomani is directly contracted by the department of health and provincial government to deal with the medical waste. Hlomani transports the waste from the hospital premises for incineration at an undisclosed location. The sewage waste from the hospital all goes down into the city of Cape Town's sewerage system and like the rest of the sewer from residential homes in the area, it goes to the closest city of Cape Town's waste treatment plant in Mitchell's Plain (Mitchells Plain Wastewater Treatment Works shown in Appendix B). No sewage sludge and bio solid waste is produced from the hospital. Waste products from the hospitals kitchen are taken to a pig farm in Kraaifontein were they are fed to the pigs.

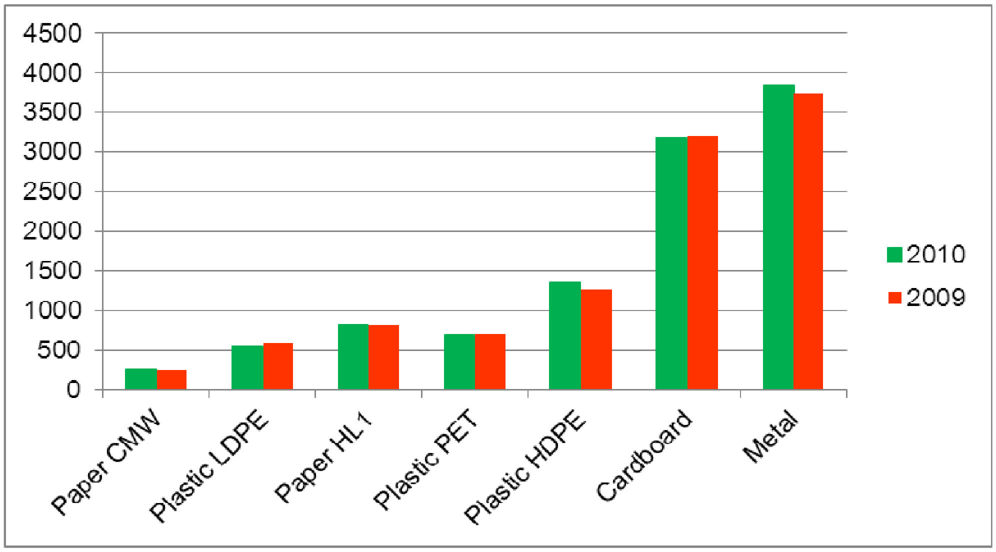
Figure 21: Pig swill waste annual figures analysis in kilograms



From the interviews conducted, it emerged that they is an increase in pig swill in June because the hospital has its highest number of patients between May and July – it's the peak admission period for the hospital.

From the interviews conducted with the hospital management, it emerged that the hospital has a recycling policy in place. Waste products like paper, boxes, plastics, rubber, glass and tin from the wards are all taken for recycling by waste man. Metal, steel and foam products from the hospital stores and workshop are also taken for recycling. Waste is collected from site and dumped into the skip in the waste area. The skip is taken to the waste separation area at the airport industria site by waste man. Various recycling companies come and collect the recyclable products from there. No e-waste products are recycled by the hospital. The following amounts of recycling have been done by the hospital for the years 2009 and 2010 respectively:

Figure 22: Recycling statistics – annual figures in South African Rand



From the interviews conducted with the hospital management it emerged that they were convinced that all their hospital staff members know how to use the recycling system in place and they don't have any difficulty in finding a recycling collector as waste man has a satellite office base at the hospital's premises.

4.3.4 Consumption and resource flows

The data of WCRC's electricity and water consumption is presented in the figures below. A heavy reliance and consumption of electricity from the Eskom grid and portable water from the city of Cape Town's water supply is evident for the years 2009 and 2010.

Figure 23: Electricity consumption from the Eskom grid

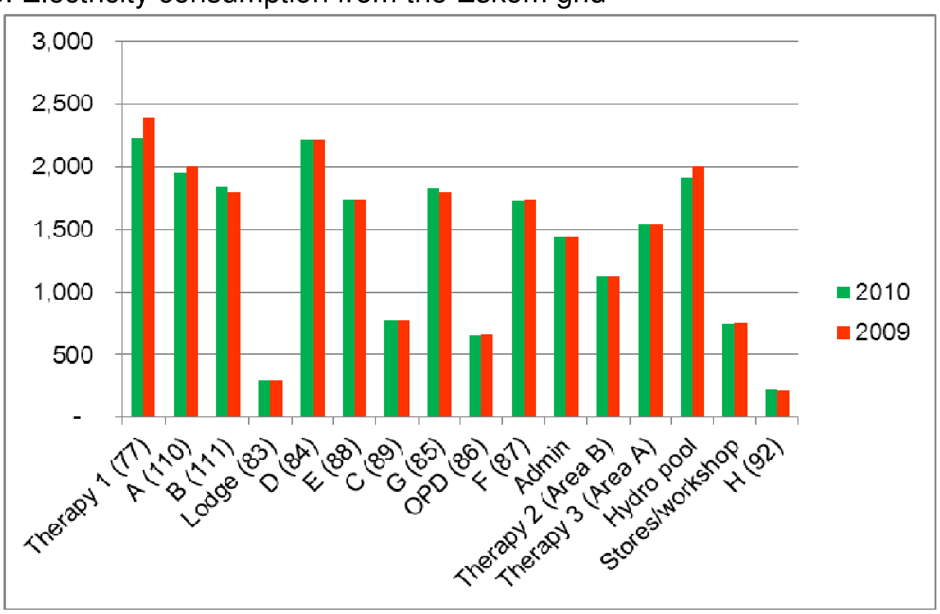
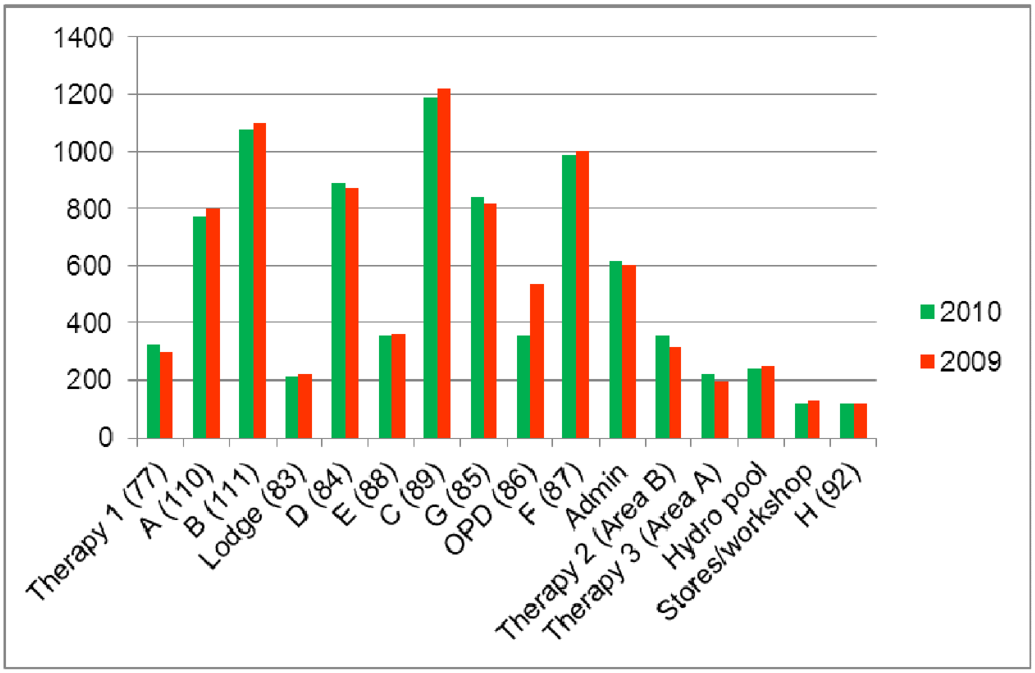


Figure 24: Portable water consumption from the city of Cape Town's water supply



The data of WCRC's patients and human resource flows is presented in the figures below. The data is disaggregated by gender and then by ethnicity to get a clear picture of who the beneficiaries' of this hospital's service are.

Figure 25: Patients admitted and consulted into WCRC by gender

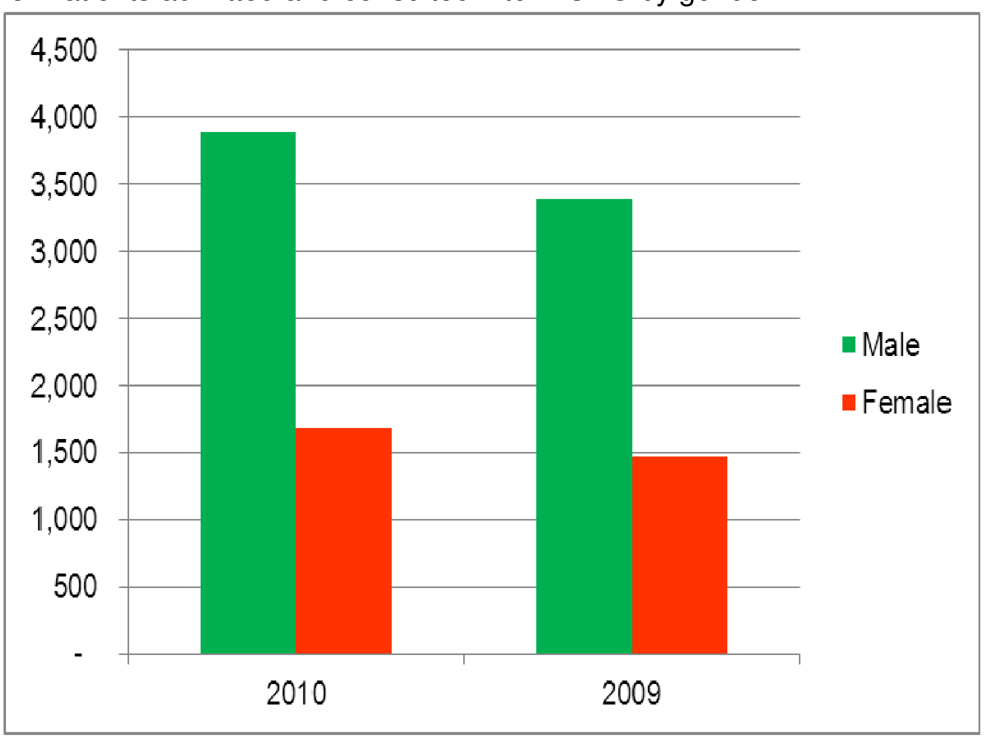
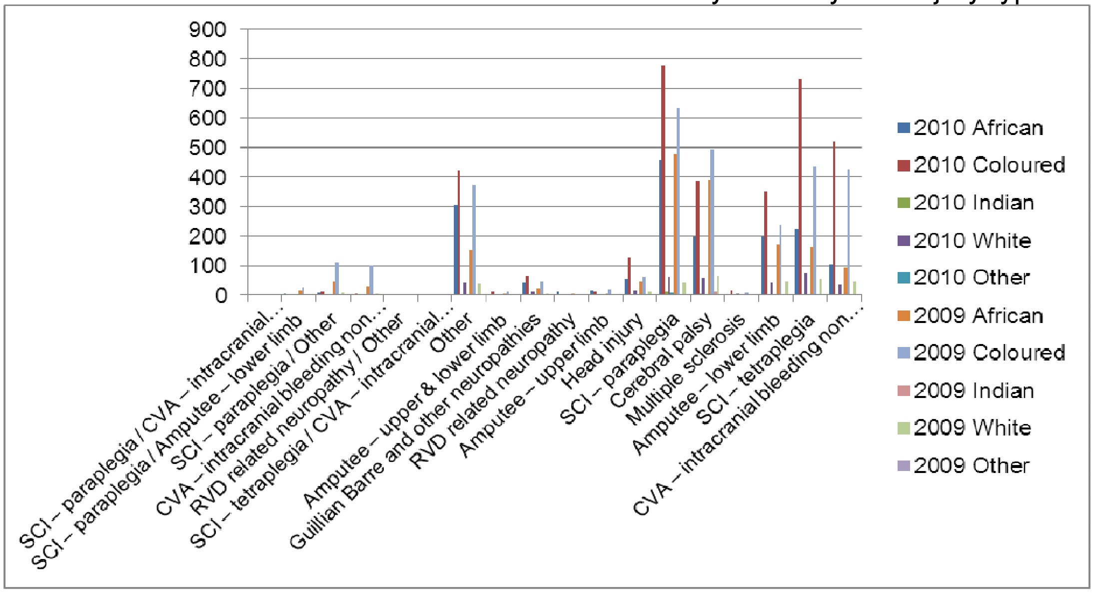


Figure 26: Patients admitted and consulted into WCRC by ethnicity and injury type



4.3.5 Purchasing and Procurement

According to the responses obtained from the interviews, WCRC does not have a purchasing policy in place. The hospital further doesn't have any procurement practices either that reflect social and environmental as well as economic costs. The hospital uses the tender system that is directed through national government with directives channelled through provincial government i.e. procurement decisions and choices are influenced by government "procurement instructions and practices". The hospital doesn't have an environmental or ethical or sustainable purchasing policy – procurement decisions and choices are also influenced by government "tenders and contracts". WCRC outsources and procures the following products and services from other sources:

Table 8: Products and services outsourced and procured by WCRC

1. Food	2. Office equipment and consumables
3. Specific labour and skills	4. Medicine and chemicals
5. Office stationery	6. Wheelchairs, assistive devices, medical and surgical requirements

WCRC procures products and services from all kinds of businesses i.e. small businesses, large to medium enterprises and small to medium enterprises amongst others. The hospital isn't any signatory nor does it adhere to any green procurement codes. Their suppliers can be based anywhere in the world and for the hospital; the best deal in terms of price amongst other government requirements is what they settle for. They don't really look at suppliers based with reference to WCRC's location as the reference point to start with. The supplier can be based anywhere in the world and its fine if the products can be delivered as required.

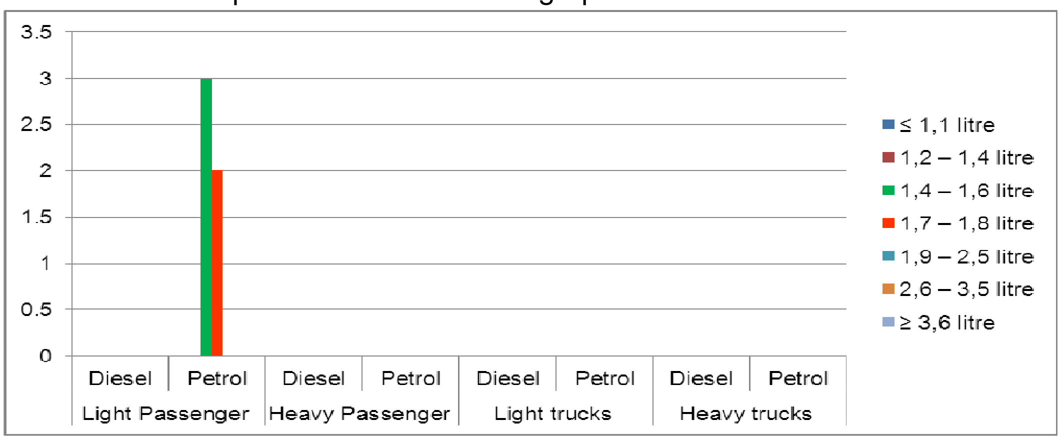
Figure 27: Sub-categories for each outsourced products and services by WCRC

Office equipment & consumables		Specific labour & skills		Medicine & Chemicals		Office stationery	
Computers	x	Experts	x	Drugs	x	Printing paper	x
Printers	x		☐		☐	Pens	x
Other……………	x		☐		☐	Note books	x
	☐		☐		☐	Files	x
	☐		☐		☐	Other………	x

4.3.6 Transport

According to the responses obtained from the interviews, WCRC does not have a travel plan or a transport policy in order to reduce the environmental impact of travel related to its activities. Neither does the hospital promote public transport usage nor walking and cycling, though the hospital requires staff to use cars for their work and its work activities.

Figure 28: WCRC hospital vehicle fleet demographic



4.3.7 Biodiversity

Responses from the interviews cited that WCRC's hospital site is designed to encourage biodiversity, i.e. the retention of unique habitats of plant and animal life for example distinct biological species like indigenous plants on site, retaining natural flora and fauna, snakes and golden moles.

4.3.8 Communication

From the interviews it was learnt that WCRC has an internal organisational communication procedure to communicate examples of good rehabilitation and medical practice to its staff. The hospitals management think that all the staff members follow this organisational internal communication protocol and practice as "it's compulsory for team members to attend these sessions". With reference to general communication / internal communication climate, not all staff is satisfied as a percentage of staff on the ground level perceives that the hospital's communication is characterised as follows:

i. Not enough transparency;
ii. Staff not included in decision making processes; and

iii. Staff does not receive enough feedback on their input / suggestions.

Hospital management itself is not satisfied with the internal organisational climate of WCRC and would like to reduce the percentage of dissatisfaction and facilitate the effective distribution of information. The hospital management feels that internal communication is integrated as their internal communication processes as follows:

i. The head of the institution gives feedback to her top managers, who distribute this information to middle managers at weekly/regular meetings. They in return give feedback to staff on ground level. (The latter process sometimes causes communication breakdown, especially with different shifts such as nursing).
ii. There are team facilitators in the functional units who are responsible for the dissemination of team related information.
iii. Communication is also done via written internal notices and email – again not always reaching all of its targets to the above mentioned processes (managers must still disseminate info to those not on email).

The hospital management said that they promote sustainable development and good environmental practice to a limited degree to improve stakeholder relationships internally and externally. They cited the following examples of what they are doing to promote SD:

1. Promoting healthier life styles (internally and externally):

1.1 Health and wellness centre (HWC) promotes optimal health for clients as well as staff. The HWC incorporates partnerships with companies.
1.2 WCRC participates in Department of Health's sports day, mental health awareness.
1.3 WCRC promotes sports like wheelchair racing, swimming, and basketball and wheelchair ballroom dancing.
1.4 Water wise and water safety programmes increase awareness about safety precautions to use when in water (combats drowning).
1.5 Drug awareness programmes in conjunction with SAP for clients.

2. Promoting public health (internally and externally)

2.1 Outreach clinics and seating clinics decrease the burden of secondary complications and burden on care.
2.2 Assistance in the training of home carers, as well as the training of peer supporters add to the extension of the 'safety net' for communities – adds to the promotion of health on primary level.
2.3 Risk management: Prevention of needle prick injury (reduces risk of HIV); promotion of correct hand washing techniques for health professionals reduces the spread of infection.
2.4 Inoculation of high risk staff against hepatitis & flu, TB checks (X-ray and sputum).
2.5 Notification of communicable diseases.
2.6 Participation in health awareness campaigns, such as TB, HIV, Hypertension, Breast cancer.

3. Investment in education

3.1 WCRC promotes continuous development through skills programmes for staff, as well as maintaining an active library, inclusive of educating staff and clients to use internet.

3.2 WCRC offers nurse training to address the skill shortage in the Western Cape in line with the Provincial Nursing Strategy.

3.3 WCRC in partnership with organisations such as Red Door offers courses in entrepreneurship to clients.

4. Women's issues

4.1 Workshops such as gender equality and diversity training/ management are offered by WCRC/ DOH. WCRC staff also attends courses such as Women in Management to assist them with their role as managers in the workplace.

4.2 Sexual harassment policies are in place.

5. Enhancing of the environment / future environment

5.1 WCRC promotes a green landscape through the planting of indigenous trees and shrubs. This is also in line with the local community's urban renewal plans.

5.2 Buildings are maintained through a private public partnership and combat the decay of buildings.

6. Upliftment of community

6.1 WCRC avails its resources such as the heated pool, gymnasium, conference venues and basketball court to the community in an attempt to share and to optimise the utilisation thereof.

7. Transportation

7.1 Although the transport system does not fully address the needs of the disabled, WCRC in partnership with Motivation and other stakeholders developed a wheelchair suitable for rural conditions as well as informal settlements. This has improved accessibility of resources for those living in those conditions.

7.2 The obstacle course, specially designed to teach clients the skills to master different terrains in their wheelchairs, enhances independent mobility.

4.3.8 Education for Sustainable Development (ESD)

According to interview responses, WCRC doesn't embed any "SD concepts or approaches into any of its organisation's courses and programmes". The hospital doesn't "use any currently available SD learning materials or developing any SD programmes and modules." The hospital hasn't formed any links or networks with "external partners in order to specifically deliver education for sustainable development within its organisation."

4.4 Towards an improved WCRC green building and green star SA rating

They are various types of intervention levels that can be used to mitigate the impact of climate change. For this hospital case study we'll focus on all the three levels (city-level, neighbourhood level and household level) as some of the interventions are cross cutting which gives ideal input into where WCRC can get/score more points in the green star rating framework in order to be a green star rateable hospital facility. According to Sim Van Ryn and Stuary Cowan, ecological design (1998), ecologically thinking about designs is a way of strengthening the weave that links culture and nature. We need to consciously cultivate an ecologically sound form of design that is consonant with the long term survival of all species just like engineering has with efficiency and safety and just like architecture as a discipline has traditionally concerned its self with problems of aesthetics, structure and form.

Table 9a: Environmental impact of the production and use of different kinds of building materials

Production												Use		
	Energy use	Resource depletion (biological)	Global warming	Ozone depletion	Toxics produced	Acid rain	Occupational health	Locally available	Carbon sink	Recycling/ reuse	Durability / maintenance	Health	Unskilled labour possible	Specialist labour required
Masonry														
Clay														
bricks, fired &	4	3	5	2	2	3	4	Yes	No	Yes	Good	0	Yes	Yes
new														
Clay														
bricks, fired and	1	0	0	0	3	0	2	Yes	No	Yes	Good	0	Yes	Yes
recyled														
Clay														
bricks,	2	3	0	0	2	0	2	Yes	No	No	Good	0	Yes	Yes
unfired														
Cement blocks	2	1	3	0	4	0	3	Yes	No	Yes	Good	1	Yes	Yes
Hemp bricks	0	-5	-5	0	-5	-5	0	No	Yes	Yes	Good	0	No	Yes
Composite boards														
Plywood	3	3	2	1	2	2	4	Yes	Yes	Yes	Poor	0	Yes	Yes
Chipboard	3	2	4	4	3	2	4	Yes	Yes	Yes	Poor	2	Yes	Yes
Fibre cement	4	1	3	0	4	2	2	Yes	No	No	Good	1	Yes	Yes
Melamine	4	0	4	2	4	3	3	Yes	No	No	Good	0	Yes	Yes
Roofing materials														
Clay tile	5	1	2	0	4	1	0	Yes	No	Yes	Good	0	Yes	Yes

Source: Swilling, 2010

We need to define ecological design as any form of designing that minimises environmentally destructive impacts by integrating itself with living processes. This integration implies that the design respects "species diversity, minimises resource depletion, preserves nutrient and water cycles, maintains habitat quality" (Garland Jay L., nd:2), and attends to all the other preconditions of human and ecosystem health. The environmental crisis is a design crisis. "It is a consequence of how things are made, buildings are constructed, and landscapes are used. Our present forms of agriculture, architecture, engineering, and industry are derived from design epistemologies incompatible with nature's own" (Garland Jay L., nd:13). It's clear that we have not given design a rich enough context. Based on this literature definition, work experience and the knowledge gained from the GBCSA accredited professional course I will paint and taint an ideal retrofitted hospital design and suggest changes that can be adopted on the current hospital design to make it a sustainable green building. This design will enable it to score a certifiable green star SA rating mark at both design and as built phases of the GSSA. As shown below the production of building materials has environmental impacts hence the construction of buildings comes with environmental impacts and building materials need to be chosen carefully (Van Ryn and Stuary Cowan, 1985).

Table 9b: Environmental impact of the production and use of different kinds of building materials

Production											Use			
	Energy use	Resource depletion (biological)	Global warming	Ozone depletion	Toxics produced	Acid rain	Occupational health	Locally available	Carbon sink	Recycling/ reuse	Durability / maintenance	Health	Unskilled labour possible	Specialist labour required
Natural slate	5	2	1	0	1	1	0	Yes	No	No	Good	0	Yes	Yes
Concrete tile	3	2	1	0	4	0	0	Yes	No	No	Good	0	Yes	Yes
Fibre cement tile	1	3	5	0	5	3	2	Yes	No	No	Good	1	Yes	Yes
Galvanised sheet metal	5	2	5	5	5	5	2	Yes	No	Yes	Good	1	Yes	Yes
Hemp tile	0	0	0	0	0	0	0	No	Yes	Yes	Good	0	No	Yes
Insulation														
Glass wool	2	1	0	0	3	2	4	Yes	No	Yes	Good	3	Yes	Yes
Hemp wool	2	0	0	0	0	0	0	No	Yes	Yes	Good	0	Yes	Yes
Polystyrene	5	2	0	0	5	4	0	Yes	No	No	Good	0	Yes	Yes

Key: 4 - Worst impact 3 - next biggest impact 2 - lesser impact 1 - smaller but significant impact 0 - No significant impact

Source: Swilling, 2010

Table 10: Green star SA rating score of WCRC's hospital office building ideally retrofitted

Green Star SA - Office As Built v1				
WCRC Hospital building ideally retrofitted **WCRC ideal picture (ideal / could be)**				
Category	**Title**	**Credit No.**	**Points Available**	**Points Achievable**
Management	**Comments on possible design improvemests**			
Green Star SA Accredited Professional	Engage an accredited professional	Man-1	2	2
Commissioning Clauses	Fully meet requirements of this	Man-2	2	2
Building Tuning	Do 12 months commissioning, quarterly reporting + final commissioning	Man-3	2	2
Independent Commissioning Agent	Appoint independent commissioning agent	Man-4	1	1
Building Users' Guide	Use this guide during construction	Man-5	1	1
Environmental Management	Adopt formal environmental management system during	Man-6	2	2

	construction			
Waste Management	Divert 70% of construction and demolition waste going to disposal	Man-7	3	3
Airtightness Testing	Test building to achieve airtightness levels	Man-8	1	1
		TOTAL	**14**	**14**

Indoor Environment Quality				
Ventilation Rates	Maintain design as is and opening windows and doors , operating window or attic fans, when the weather permits,	IEQ-1	3	2
Air Change Effectiveness	Use open able windows or trickle vents	IEQ-2	2	1
Carbon Dioxide Monitoring and Control	Use to CO_2 sensors monitor CO_2	IEQ-3	1	1
Daylight	Use Passive solar design techniques & roofing system that brings daylight into building	IEQ-4	3	2
Daylight Glare Control	Maintain blinds as is to control glare	IEQ-5	1	1
High Frequency Ballasts	Use electromagnetic fluorescent ballasts to reduce lamp flicker	IEQ-6	1	1
Electric Lighting Levels	Use LED fluorescent light tube who's Luminance: ≥400 Lux/1.5m.	IEQ-7	1	0
External Views	Use windows above 720mm and below 2400mm to view outside grounds etc.	IEQ-8	2	2
Thermal Comfort	Use user controlled mixed mode ventilation system in building for every $15m^2$	IEQ-9	2	2
Individual Comfort Control	Use mixed mode ventilation system in building as above	IEQ-10	2	2
Hazardous Materials	Maintain building as is	IEQ - 11	1	1
Internal Noise Levels	Maintain building as is	IEQ-12	2	1
Volatile Organic Compounds (VOCs)	Use zero VOC paint for all walls	IEQ-13	3	2
Formaldehyde Minimisation	Use composite wood products without formaldehyde	IEQ-14	1	1
Mould Prevention	Use full natural ventilation to prevent moulds	IEQ-15	1	1
Tenant Exhaust Riser	establish dedicated photocopying and printing area with exhaust riser	IEQ-16	1	1
Environmental Tobacco Smoke (ETS) Avoidance	Maintain non-smoking regulation in the hospital building as is	IEQ-17	1	1
		TOTAL	**28**	**22**

Energy				
Conditional Requirement	Comply with SANS 2004: 2008	Ene-	0	Achieved
Greenhouse Gas Emissions	Minimise GHG emissions associated with operational energy consumption	Ene-1	20	19
Energy Sub-metering	Provide further sub-metering for lighting & develop effective mechanism for monitoring energy consumption data from all energy	Ene-2	2	2

	sub-meters			
Lighting Power Density	Keep this as is for now	Ene-3	4	1
Lighting Zoning	Put a light switch for every 100m^2	Ene-4	2	2
Peak Energy Demand Reduction	Use energy as required for the hospital	Ene-5	2	0
		TOTAL	**30**	**24**

Transport				
Provision of Car Parking	Leave the parking bays as is	Tra-1	2	1
Fuel-Efficient Transport	Leave the transport modes as is	Tra-2	2	0
Cyclist Facilities	Provide secure bicycle storage for 6% of staff based on person per 15m^2; accessible showers based on 1 per 10 bicycle spaces; changing facilities adjacent to showers and 1 secure locker per bicycle space in the changing facilities. In addition to this visitors bicycle parking at 1 bicycle space per 750m^2 in an accessible area, signposted and close to the main public entrance into the hospital	Tra-3	3	3
Commuting Mass Transport	Maintain as mass transport as is	Tra-4	5	2
Local Connectivity	Maintain as is	Tra-5	2	1
		TOTAL	**14**	**7**

Water				
Occupant Amenity Water	Harvest rainwater and recycle	Wat-1	5	2
Water Meters	Further install an automated mechanism to monitor consumption	Wat-2	2	2
Landscape Irrigation	Maintain use of borehole water	Wat-3	3	3
Heat Rejection Water	No water heat rejection required	Wat-4	4	4
Fire System Water Consumption	Fire water system doesn't expel water for testing	Wat-5	1	1
		TOTAL	**15**	**12**

Materials				
Recycling Waste Storage	Put in place a dedicated storage area for the separation and collection of recycling materials	Mat-1	2	2
Building Reuse	Not applicable	Mat-2	0	na
Reused Materials	Keep this as is for now	Mat-3	1	0
Shell and Core or Integrated Fit-out	Use integrated fit-out	Mat-4	1	1
Concrete	Not applicable	Mat-5	0	na
Steel	Not applicable	Mat-6	0	na
PVC Minimisation	Replace at least 30% of PVC building content by alternative materials.	Mat-7	1	1
Sustainable Timber	Use at least 95% of the building timber that's FSC certified and some of being reused timber	Mat-8	2	2
Design for Disassembly	Go for 50% of the hospital building internal structural framing, partitions, roofing and façade cladding systems	Mat-9	1	1

	that are designed for disassembly			
Dematerialisation	Leave building as is –no ductwork	Mat-10	1	1
Local Sourcing	Use locally sourced materials' as is	Mat-11	2	2
		TOTAL	**11**	**10**

Land Use & Ecology				
Conditional Requirement		Eco-	0	Achieved
Topsoil		Eco-1	0	na
Reuse of Land	Site in municipally approved urban edge	Eco-2	2	1
Reclaimed Contaminated Land		Eco-3	0	na
Change of Ecological Value		Eco-4	4	0
		TOTAL	**6**	**1**

Emissions				
Refrigerant / Gaseous ODP		Emi-1	1	0
Refrigerant GWP		Emi-2	2	0
Refrigerant Leaks		Emi-3	2	0
Insulant ODP		Emi-4	1	0
Watercourse Pollution	Reduce peak storm water flows	Emi-5	3	0
Discharge to Sewer	Reduce discharge to sewer by 50%	Emi-6	5	2
Light Pollution		Emi-7	1	1
Legionella	No cooling towers servicing the building	Emi-8	1	1
Boiler and Generator Emissions		Emi-9	0	na
		TOTAL	**16**	**4**
			Sub-total weighted points achieved:	**71**

Innovation						
Innovative Strategies & Technologies	Inn-1	5	0	0		
Exceeding Green Star SA Benchmarks	Inn-2	5	0	0		
Environmental Design Initiatives	Inn-3	5	0	0		
	TOTAL	**5**	**0**	**0**	(Innovation is not weighted)	**0**
					Total weighted points achieved:	**71**

Five Star (South African Excellence) Green star SA rating score.

Hence WCRC's hospital building as designed (as could be) has achieved a 'Five Star' Green star SA rating score which implies excellence practice which means that the Minimal standards for Green Star accreditation are met.

Table 11: WCRC's systematic comparison (green star tool)

Green Star category	Weighting (as built)	What is at WCRC (as built)	Weighting (could be)	What could be at WCRC (could be)
Management	0.0	○ Test building to achieve airtightness levels,	9.0	○ Engage an accredited professional ○ Appoint independent commissioning agent, ○ Adopt formal environmental management system during construction, ○ Divert 70% of construction and demolition waste going to disposal, ○ 12 months commissioning, quarterly reporting + final commissioning ○ Commissioning Clauses
Indoor Environment Quality	7.0	○ Windows and doors ○ Open able windows or trickle vents ○ Blinds as is to control glare ○ LED fluorescent light tube who's Luminance: ≥400 Lux/1.5m ○ Windows above 720mm and below 2400mm to view outside grounds etc. ○ VOC paint for all walls ○ Use composite wood products with formaldehyde ○ Full natural ventilation to prevent moulds ○ No establish dedicated photocopying and printing area with exhaust riser non-smoking regulation in the hospital building	11.8	○ CO_2 sensors to monitor CO_2 ○ Passive solar design techniques & roofing system that brings daylight into building ○ Electromagnetic fluorescent ballasts to reduce lamp flicker ○ Use user controlled mixed mode ventilation system in building for every $15m^2$ ○ Use mixed mode ventilation system in building ○ Use zero VOC paint for all walls ○ Use composite wood products without formaldehyde ○ Establish dedicated photocopying and printing area with exhaust riser
Energy	1.7	○ Comply with SANS 2004: 2008 ○ Single metering for lighting & no developed effective mechanism for monitoring energy consumption data from all energy meters ○ Single light switch per room Peak Energy Demand Reduction	20.0	○ Minimise GHG emissions associated with operational energy consumption ○ Provide further sub-metering for lighting & develop effective mechanism for monitoring energy consumption data from all energy sub-meters ○ Light switch for every $100m^2$ Peak Energy Demand Reduction

Transport	2.6	○ Provision of Car Parking ○ No Fuel-Efficient Transport ○ No cyclist facilities ○ Commuting Mass Transport ○ Local Connectivity	4.5	○ Fuel-Efficient Transport Cyclist facilities - Provide secure bicycle storage
Water	7.5	○ Conventional city of Cape Town water ○ Borehole water ○ Single main water meter	11.2	○ Harvest rainwater and recycle grey and black water ○ Automated mechanism to monitor consumption
Materials	3.5	○ Recycling bins with no dedicated storage area for the separation and collection of recycling materials ○ No integrated fit-out ○ PVC ○ Ordinary certified timber ○ Design for without disassembly ○ Locally sourced materials' used	11.8	○ Dedicated storage area for the separation and collection of recycling materials ○ Use integrated fit-out ○ Replace at least 30% of PVC building content by alternative materials ○ Use at least 95% of the building timber that's FSC certified and some of being reused timber Design for Disassembly
Land Use & Ecology	0.0	○ Site in municipally approved urban edge	1.2	○ Maintain topsoils texture and structure through sustainable agricultural practices
Emissions	0.5	○ Peak storm water flows ○ All discharge to sewer ○ No cooling towers servicing the building	2.0	○ Reduce peak storm water flows ○ Reduce discharge to sewer by 50%
Innovation	0.0	○ None	1.0	○ Develop green policies and use it buying power with suppliers to bargain for green supplies
Total Scores	23 points	Equates to 2 star GBCSA rating	72 points	Equates to 5 star GBCSA rating

4.5 Chapter summary

When WCRC was established, key design issues like alternative infrastructure technologies, buildings, and eco-system were not considered at all. A couple of pro-sustainability initiatives have been going on at the hospital like recycling, though the key sustainability issues haven't been looked into ands addressed with great detail. Form a green building perspective the WCRC's hospital building as it is (as built) has achieved a 'two star' green star SA rating score which implies average practice and further means that the minimal standards for Green Star accreditation are not met. At the time of construction the intention was to meet immediate health needs in Mitchell's Palin where the prevalence of disability in the highest in the Western Cape. The other objective was to build a new state of the art hospital facility that was going to cut high maintenance cost of the old dilapidated spinal units that were amalgamated into WCRC. No thought was put into green building and ecological design aspects of how this hospital would look like. It was constructed in the conventional state tenderised system and what the state and DoH wanted was a hospital to serve the community's immediate health needs.

From a resource consumption (energy, water) point of view, the main findings of this research suggest that large shifts in resource quantities, forms and types (energy, water) being currently consumed by the hospital would need to take place. The research findings discussed above further revealed very high levels of dependency on conventional non-renewable resources like electricity from the Eskom grid and portable water from the CoCT supply line, without any alternative options in place to meet the hospital's needs. Healthcare service provision is a challenge to local communities and the highest prevalence of disability is found here. WCRC was seen as a solution to this challenge as it could cater for the special needs of the Western Cape provinces disability needs, but in an era where climate change and resource availability is the main talking point, this would need careful consideration given limitations such as water availability, fossil fuels like coal that are non-renewable and heavily relied upon to produce electricity in South Africa. Another consideration that hospitals like WCRC need to bear in mind is the "embodied energy" that is "consumed by all processes associated with the production of a building or hospital product, from the acquisition of natural resources to product delivery". The current trajectory of WCRC's healthcare system appears to be inherently unsustainable through a predominantly modern healthcare service delivery approach towards conventional patient treatment, not making significant progress towards transformation and alarmingly vulnerable through a large dependency on unsustainable and non-renewable resources like coal generated electricity from Eskom. Discussions will be presented in Chapter Five on a retrofit design use for WCRC hospital in the context of green buildings, sustainable and innovative resource consumption as well as long term sustainability.

Chapter 5 – Conclusion and Recommendations

This final chapter will provide an overview of key findings by research objective, including conclusions on the current state of healthcare service provision and resources consumption patterns at WCRC as well as the benefits and limitations of building a greener healthcare facility to promote sustainability in the WCRC context. Key recommendations will be presented in response to the third research objective, (iii) to recommend measures which can be taken to promote greater sustainability through WCRC's healthcare system. Opportunities for further scholarship that have been identified through the research process and findings will be presented.

5.1 Insights and summary findings

WCRC just like most conventional healthcare institutions in the world that say that their mission is to provide high-quality care and service to diagnose and treat human illness. Some mission statements also further mention disease prevention. Disease-prevention activities in practice must usually entail individual behaviour modification (exercise, smoking cessation, weight control etc.). Some institutional mission statements further mention an obligation to contribute towards the health of the surrounding community. This may be accomplished in various ways perhaps by providing free disease-screening opportunities from time to time, free care to indigent community members, or supporting various community activities. Institutions acknowledge responsibilities beyond institutional walls by doing this and, in some ways, address traditional public health concerns. But on the contrary most healthcare institutions do not intentionally focus significant resources on favourably influencing community determinants of health. In short, to the extent that the healthcare sector addresses disease prevention at all, it tends to focus on prevention of well established proximal causes, while largely ignoring what epidemiologist Geoffrey Rose called the "causes of causes" (Rose, 1992; Krieger, 1999). The summary findings of this research are presented below by research objective.

5.1.1 First research objective

The first research objective was to investigate using the GBCSA's new building rating tool, what WCRC's rating score is for the current design as built? The key finding of the literature review is that, as cited by Richard Reed, Anita Bilos, Sara Wilkinson, and Karl-Werner Schulte, "there is little dispute now that buildings are substantial CO_2 emitters and contribute substantially to climate change" (Reed and Wilkinson, 2008; Wilkinson, Reed, and Cadman, 2008:01). This argument is based on the large environmental footprint of buildings, especially when considering their high reliance on resources due to an increased reliance on air conditioning and heating. At the same time it has also been demonstrated that the value of a building can be linked to the building's perceived level of sustainability (Myers, Reed, and Robinson, 2008). Where the "stakeholders include building owners, tenants, and property appraisers or valuers" (Reed and Wilkinson, 2008:10). The problem therefore lies with how to distinguish the level of sustainability in a building, which will facilitate a direct comparison between each building. This is where sustainability rating tools can potentially play a "major role" (Reed, et al, 2009:1). Using the green star SA rating tool, WCRC currently as built achieved a two star' green star SA rating score which implies average practice and further means that the minimal standards for Green Star accreditation are not met. In the context of the end of the cheap oil era and growing awareness about the impacts of the modern healthcare systems, it is put forward that healthcare systems will increasingly tend towards green sustainable buildings. The key findings from the research presented in support of the first research objective leads to the conclusion that green healthcare hospital buildings promote greater sustainability than the current modern healthcare hospital buildings at WCRC, and that building (retrofitting) a higher rated green star scoring building for WCRC would promote greater sustainability.

5.1.2 Second research objective

Based on the findings of the first research objective, the investigation for the second research objective (from a review of the literature, how sustainable is WCRC hospital's design) was critical in establishing current practice and a baseline for making recommendations to build a sustainable healthcare system through the final research objective. Key findings of the research undertaken in support of the second research objective are presented below.

First and foremost, healthcare institutions like WCRC are really disease care institutions. They provide "care for people who are ill or injured" (wpro.who.int, nd:04). Programmes aimed at primary-disease prevention are limited. To a larger extent, healthcare institutions often give limited attention or ignore the range of environmental factors that indirectly or directly influence the health of their clients. Based on a restricted notion of their role, they can justify this believing that many of these issues are in the domain of "public health or environmental protection and not medicine" (Krieger, 1999:17). Some recent attempts to "re-examine the distribution of roles and responsibilities" related to human health calls for closer collaboration between medicine and public health and re-thinking "professional and institutional boundaries" (Lasker, 1997:35). The present realities of the early twenty first century suggest that ecological health should be explicitly added to this collaboration. What is the potential role and responsibility of healthcare systems to address a fuller range of causes of morbidity and mortality in the communities that they serve? Given the steady growth of already oversized health (disease) care expenditures, this question becomes increasingly more and more relevant as healthcare institutions like WCRC consider their plans and missions for the future (Lasker, 1997; IOM, 2003).

The findings of the research suggest that the majority of WCRCs current status of healthcare provision is done in the conventional 'business as usual approach' (thus unsustainable as WCRC's healthcare system is heavily resource dependent on renewables). The healthcare system is facing several key threats in the immediate future, including the impacts of climate change, over dependency on fossil fuels and increasing urban sprawl through development linked to population growth. WCRC's current healthcare system is too resource intensive as indicated by high percentage of balance of emissions embodied in its operations and dematerialization is required.

5.1.3 Third research objective

Based on the findings of the first and second research objectives, the investigation for the third research objective (what measures are available for sustainable resource flows at WCRC?) thus was critical in establishing current weaknesses and strengths for making recommendations to build a sustainable healthcare system through the final research objective. Key findings of the research undertaken in support of the third research objective are presented below.

The greatest weaknesses of the hospital are it heavy dependence (100%) on non-renewable energy sources as in electricity from Eskom's grid and fuel in this era of gone are the days of cheap oil. It also has a heavy reliance (90%) on portable water from the city of Cape Town's water supply and only reliant on borehole water to meet 10% of its needs which are basically irrigation and watering of the grounds. Its procurement doesn't really focus on its bio-region and local sourcing isn't promoted. The tender system is fully fledged in use and what matters in delivery as required. Sustainability isn't viewed nor seen as the corner stone to influence policy. The sustainability philosophical side of things needs strengthening with the hospital's operational and policy realms. The hospital has lots of potential to become self-sufficient and ultimately sustainable to almost becoming carbon neutral. A paradigm shift (with barriers such as complex institutional issues, cultural preferences, accessibility and affordability included), is required for this to happen and the hospital will need to build its capacity to go green, use the process as a learning curve and slowly but surely realise the dream of being a sustainable state of the art hospital.

5.1.4 Fourth research objective

The final research objective was to recommend measures to promote greater sustainability through WCRC's healthcare system (of what a design of a 'virtual' green WCRC hospital would look like), energy efficient buildings and green hospital buildings based on the research conducted through the first, second and third research objectives. The research presented in support of the fourth and final research objective aimed to provide the inputs for making recommendations for retrofitting a green hospital building and building a greener sustainable healthcare system at WCRC.

The research revealed that in the case of WCRC hospital, the flow of resources gets conducted through socio-economic systems. They are separate units/systems in the hospital like procurement, purchasing, stores, nursing, administration etc. and to make the hospital sustainable these systems need to be aligned in a sustainability driven manner. Basic socio-technical systems manage the flows but they are not aligned to any sustainability agenda apart from monitoring and verifying that the electricity and water bills received from Eskom and CoCT conquer with the consumption that the hospital incurred in the billed time frame. They are hampered by large institutional issues like the absence of an institutional sustainability statement or sustainability matrix for example. A lot relies on government policy and directives as evident by the use of the government tender system for procurement purposes, hence innovation becomes supressed and only so much can be done as compliance with government and DoH requirements is key, as they are the main funders/financing parties of the hospital. It becomes a complex large institutional issue to deal with.

Before designing the 21st century hospital, we should ask ourselves whether the healthcare system should continue on its twentieth-century path. Where is that path going? Is this relentless growth sustainable and will it continue to deliver value? To whom? Are there new opportunities for the healthcare sector to make unique contributions to the well-being of individuals and their communities? What are the determinants of health? What is health? To the extent that they address disease prevention at all, most healthcare professionals and institutions concentrate on well-established, proximate causes of disease, rather than more distal or structural causes. Are there new opportunities and responsibilities for disease prevention? What are the relationships among medicine, public health, and environmental health? How are those relationships reflected in current institutional structures and practices? (HWCH, 2008:12). Until these questions are addressed, "it is impossible to know if the services provided by healthcare institutions are appropriate for delivering real value to their communities. And, without knowing what the mix of services and activities ought to be, discussion of building and infrastructure design is premature" (Gaskill, 2006:13).

Secondly, the healthcare sector does not only treat "people whose illnesses are in part or whole attributable to environmental conditions" (World Health Organization, 2009:55), but also contributes in multiple ways to environmental degradation that "fosters ill health" (World Health Organization, 2011:3).

Thirdly, the healthcare sector has both an "opportunity and a responsibility" to address these realities by modifying "practices and modelling behaviour" in ways that demonstrate an understanding of ecological health (National Expert Panel on Community Health Promotion, nd:17). Ecological health as a concept embraces the deeply fundamental complex inter-relationships that influence environmental and human health collectively (GBC, 2011).

Finally, as the costs of medical care continue to sour, we will increasingly come face to face with the uncomfortable question: How much are we really interested in disease prevention and health promotion and restoration? Ecological health is a new and necessary responsibility for medicine and public health facilities like WCRC hospital. There is significant potential for increasing sustainability through a retrofitted hospital building (given the contribution of available alternatives as highlighted above), but this would require significant institutional support to overcome the multiple barriers currently being experienced by the hospital. An argument is presented that, in the context of the end of cheap oil, measures will have to be taken to step up and increase renewable energy production. Retrofit current hospital buildings ecologically into green hospital buildings and local sourcing in order to avoid rising health care consultation prices, consumed resource prices (food, water, electricity) all linked to rising fossil fuel prices in the context of WCRC. Green buildings are essential for the hospital as massive potential exists to play around with the current design to make it greener as highlighted in Table 10 (comments on possible points of improvement) above. I argue for retro fixation because globally buildings are "responsible for 40% of annual energy consumption and up to 30% of all energy-related greenhouse gas (GHG) emissions" (UNEP-SBCI, nd:1). The building sector has also been shown to provide the greatest potential for delivering significant cuts in emissions at low or no-cost or net savings to economies. As a collective the building sector is responsible for "one third of humanity's resource consumption, including 12% of all fresh-water use, and produces up to 40% of our solid waste" (UNEP, nd:1). The sector also employs, more "than 10% of our workforce" on average (UNEP-SBCI, 2008:3). With the rapid increase in urbanisation in the world's most populous countries, building sustainably is essential to "achieving sustainable development" (UNEP, 2010:3). The biggest argument will also be that of climate change whose main drivers are CO_2 emissions that result from embodied energy which is significantly present in all of WCRC's current supply chains in resources consumed, procurement and building design.

5.1.5 Section summary

The above findings on the current status of WCRC's hospital building and healthcare system and the potential to promote a stronger health care service delivery facility are summarised in Table 12 below through a SWOT analysis.

Table 12: SWOT analysis on potential for building a stronger WCRC's healthcare facility

Strengths	Weaknesses
Adequate roofs and climate Knowledge institutions Strong secondary economy Demand from growing patient base	High land value Low margins of return/limited funding No supportive knowledge institutions Limited availability of water
Opportunities	**Threats**
The end of cheap oil Demand across hospital departments Niche services and chemicals Value-adding	Climate change Dependency on fossil fuels Fluctuations on health budget allocation

Based on the research findings presented above, core conclusions will be drawn in Section 5.2 and key recommendations put forward in Section 5.3.

As profitability and margins have decreased over the last decade, hospitals around the world have been faced by increasing financial challenges. Bothe public and private healthcare system administrators are challenged with very similar budgetary constraints. The recent global recession has led to losses for many for profit hospitals and has squeezed margins in others. Added to that the staggering statistic that by the year 2050, the world population aged over 60 years will nearly triple from 700 million to 2 billion leading to "an increase in the number of potential patients" hospitals will need to serve (Schneider Electric, 2010:3). Yet it is highly unlikely that governments will raise taxes significantly or take on additional debt to pay for this change. How will healthcare systems handle this increasing financial pressure is the question? Must hospitals innovatively find ways to do more with less? Energy efficiency projects, water efficient projects and greener building projects can unlock trapped capital that can improve a hospital's profit margins or be used to fund technological advancements, purchase medical equipment, or improve the patient experience and above all save the environment.

5.2 Trends and conclusions

As stated previously, energy use in the WCRC hospital facility has increased by a margin since it started operating. Despite this increase, energy efficiency initiatives for example have been overlooked historically as an option to reduce hospital operational costs. Chief financial officers (CFOs) and hospital administrators have typically focused on implementing new technologies, improving processes to reduce costs and reducing staff numbers. In fact, in a recent survey of hospital CFOs, decreasing utility costs was not even mentioned as a way to cut expenses, and therein lies the disconnect.

Increased energy, food, and water costs are consuming profits that could be reinvested to aid the hospital's growth and support patient-centric projects. By investing in energy efficiency projects now, WCRC can reduce on-going operating costs and reinvest their savings to purchase new equipment and technologies. Hospital campuses could be expanded with a new wing or outpatient centre. New community care initiatives, such as speciality clinics for disability care or intellectual medicine, could be launched to address the aging population's medical needs. For example why is energy being overlooked? Because generally energy costs typically represent only 2% – 5% of a hospital's total operating budget, hospital management focus on traditional cost-cutting measures, like:

- Reducing staff numbers and/or staff benefits: this option could potentially make a nursing shortage even more critical and lead to an increase in the risk of medical errors. Lower staffing levels have been linked to higher numbers of adverse outcomes, such as urinary tract infections, pneumonia, shock, and failure to rescue.
- Renegotiating with suppliers: although renegotiating pricing with suppliers may improve the bottom line for one to two years, it is difficult to sustain such savings over the long term, especially as the economy begins to improve.
- Remove services: sometimes hospitals choose to no longer offer specific services, such as end of life care or nonmedical procedures. Due to the poor economic climate that prevailed throughout 2009 and 2010, hospitals have most likely exhausted this option. Making additional cuts could jeopardise patient care and customer service.

Hospital administrators in South Africa should be armed with the knowledge that if energy costs increase by 25% over the next five years as predicted the average hospital profitability could decrease by up to 0.5%. This reduction is significant when you consider that the average hospital has a profitability of only 3.3%. This translates to approximately $^{1}/_{6}$ of a hospital's profits lost due to increased energy prices alone. The figure below shows the financial impact for a fictitious, average 235 – bed hospital. This analysis assumes that the hospital spends R2.39049 million on energy/utilities – a number based on the average energy spending by hospitals the size of WCRC (Figure 30). This amount varies slightly in regions and from hospital to hospital, and depends partly on the climate zone and current energy efficiency, as well as the hospital's energy intensity (i.e. the number of operating theatres and types of technology used).

Figure 30: Financial impact of 25% rise in utility costs

	Current financial performance (,000)	If utility costs rise 25% (,000)
Total operating revenue	159,259	159,259
Total operating expenses	154,066	155,029
Income (loss) from operations	5,193	4,230
Margin	3.3%	2.7%

There are core conclusions that have been drawn from the research, including the value of local healthcare systems in promoting sustainability, the importance of green healthcare buildings for sustainability and the challenge of retrofitting a green WCRC hospital building, the impact of the end of cheap oil on facilitating a transition towards sustainability through local procurement, sourcing and bio-regionalism.

5.2.1 The value of local healthcare systems in promoting sustainability

The current global polycrisis (including impacts as a result of the functioning of the modern healthcare system) is impacting negatively on the sustainability of communities, and counter movements are emerging in response to these impacts. The findings of the literature review clearly established the benefits and limitations of local healthcare systems in promoting sustainability over the current modern healthcare system. Supported by the findings of the case studies that were documented (in Box 1, Box 2, Box 3 and Box 4), it is put forward that green hospital facilities have a greater tendency to promote sustainability. A core conclusion is that the success of both green hospital building initiatives and sustainable healthcare system initiatives in the cited local case study contexts has been as a result of strong support from individuals and organisations committed to community development. Within WCRC and Mitchell's Plain there currently isn't a green building or sustainable healthcare movement, with any support from the local community and a large potential for growth doesn't exist as yet.

5.2.2 Importance of green healthcare buildings for sustainability

A core conclusion is the importance of both green hospital buildings and healthcare facilities for the sustainable development of local communities. The literature review established that the critical importance of green building rating and certification systems are intended to foster more "sustainable building designs, construction and operations" by promoting and making possible a better integration of environmental concerns with cost and other traditional decision criteria (Trusty, WB., nd:1). Different building assessment systems approach this task from somewhat different perspectives, but they have certain elements in common. Most, if not all, deal in one way or another with site selection criteria, the efficient use of energy and water resources during building operations, waste management during construction and operations, indoor environmental quality, demands for transportation services, and the selection of environmentally preferable materials. And they do an admirable job of fostering and facilitating integrated design practices and a holistic approach (UNEP, 2011). But there tends to be a disconnect between broad understanding of this relationship and the specifics intended to foster appropriate decisions. In a sense, there is an absence of a clear objective function, or at least a failure to always have the objective function in the forefront. The ultimate objective from an environmental perspective is to minimise the flows from and to nature: the use of natural resources of all kinds and emissions to air, land and water throughout a building's complete life cycle. Until we know much more at a hard scientific level, it is difficult to conceive any more sensible route to environmental sustainability (UNDP, 2010).

The problem is most easily understood in the context of the credits or scores assigned in rating systems for building material choices. It arises because material credits have typically evolved from a consensus-based understanding of environmental issues, understandings that, in some cases, have taken on an aura of conventional environmental wisdom that does not always stand up to objective analysis. As well, there is a risk of confusing means and ends, with the means becoming objectives in their own right to the possible detriment of environmental performance (BREEM, 2011). Similar kinds of problems arise even with the most sacred of rating system credits, those for operating energy use. Not all energy is equal: combustion emissions differ by energy form, and the upstream, pre-combustion implications of producing and moving different energy forms can be even more significant. As a result, a credit system that promotes minimal energy use without regard for the form of that energy may be misleading, especially if it results in the use of materials or construction techniques that have significant resource use or emission implications in their own right (UN-HABITAT, 2011).

An argument often advanced to support giving precedence to the minimisation of operating energy irrespective of material use implications is that "operating energy use dominates the total of operating plus embodied energy" (Dutil, Y., 2011:452). Whilst this is generally true, the argument ignores other potentially serious environmental implications of "too narrow a focus on operating energy" (Trusty, WB., nd:3). For example, toxic releases to water are more likely to result from the "production of building materials than from building operations", and we must therefore cast our net wide enough to catch a full range of potential effects (UNEP, 2010:05).

These are complex issues, and there is a danger in over-simplifying this in a short research report. One of the complications worth noting here, for instance, is the potential for conflict between stewardship reasons for a specific credit and the realities of specific industries. For example, the recycling credit is relatively easy to achieve by the use of steel construction systems and might therefore promote more use of that material. But it is unlikely to promote more recycling because recycling is already a fundamental part of that industry's structure and operations, and is driven primarily by industry economics. This is an area where the GBCSA new office rating tool used in this research falls short and a dedicated hospital building specific rating tool needs to be developed, to address the issues articulated above and have waste as a stand-alone weighting category.

WCRC is experiencing challenges of both unsustainable resource flows and a non-green hospital building. Priority should be given to addressing these challenges through sustainability on the path towards development. Renewable energy sources like wind and solar are identified as critical to supply energy to the hospital. Recycled water is also identified as critical for the hospital as this has potential for promoting water and energy security at a hospital community level. These and other components of strengthening the WCRC healthcare system have been shown to promote community resilience and economic development and above all pursue sustainability.

5.2.3 Determining best retrofitting for a green WCRC hospital building

As shown by the WCRC leadership and management findings discussed above in Section 4.2.1 and 4.2.2, it is not a straight forward issue of retrofitting the hospital. They are a lot of complexity issues that come into play for example the management structure is like a four tier which starts from national government, then moves to provincial government, then to WCRC board and finally PPP. The process of retro fixation has to involve all these players in some way and it isn't easy just to sail recommendations through this bureaucracy and get decisions passed. All these parties have to understand the reason behind the hospital retrofit and with financial implications coming into the picture, it won't be a walk in the park given the fact that according to the hospital management's interview responses, they was no allocated funding for establishing additional rehab centres – this was not part of the Departments priorities and strategic plans. So retrofitting the hospital might still not be a part of the department of health's priorities and strategic plans in the near future, which makes a complex tall order. The amalgamation of the special units at Conradie and Karl Bremer hospitals to form WCRC wasn't a priority nor strategically planned by the department of health in the first place, so it won't be a straight forward quick retrofit to get WCRC hospital to become a green building – some heavy convincing and funding availability partly needs to be done to get this done apart from getting the decisions, and approving the whole exercise from the top to bottom. This is supported by Burgess and Maiese, who argue that intractable conflicts are extremely complex processes with large numbers of actors using many different strategies to pursue many different objectives over a long period of time. The ability of people to deal constructively with these conflicts is largely determined by how well they understand the situation. If the parties do not understand who is involved, what they are doing, and why, it is very easy for them to adopt strategies that are unlikely to succeed. They has to be some form of political buy in and obviously adaptive leadership is required for this four tiered structure to understand the importance of a greener WCRC hospital facility, its benefits and opportunities that it potentially has to other hospitals around. Fioretti and Visser, further argue that "organisational theory has construed complexity as an objective characteristic of either the structure or the behaviour of an organization" (Burgess and Maiese, 2004:5).

5.2.4 Future challenges and bio-regionalism

The impact of the end of cheap oil on facilitating a transition towards sustainability through local procurement and bio-regionalism is important for WCRC. A critical aspect for consideration is the end of cheap oil and the associated impacts it will have on local hospitals, from resources through to transportation. Whilst this can be considered as an opportunity to localise procurement and build a stronger local health economy, the transition will certainly have impacts on local healthcare and livelihood security. The majority of resources in most hospitals in the region / country are derived from fossil fuels (such as electricity) and the rising cost of fuel has already further narrowed the profit margins of both small private clinics and commercial private hospital dependent on these resources (Kruetten *et al.*, 2005). Without adequate preparation, the transition to a low energy input future could have severe impacts on the community of WCRC currently unprepared for such a shift, and especially on the poor and most vulnerable disabled residents in the Western Cape already living with health and livelihood insecurity.

5.2.5 Challenges on the path to green materials

Gaining the benefits of the transition to green materials is not without its own challenges, which include:

- Collecting the data needed to evaluate materials and the products they are part of;
- Identifying products made with green materials; and
- Adjusting work habits to the properties of new materials.

One particular challenge to evaluating the toxicity profile of materials is gaining "access to data on the chemical constituents of a material" (The Center for Health Design, 2011:10). In fact, many product vendors do not know the materials included in their products nor do they know the chemicals that are in those materials. Gaining data on the chemical and material constituents of products will require "deeper partnerships with vendors" to be forged by hospitals (UN-HABITAT, 2011:17).

5.3 Recommendations

For a sustainable building based approach to promoting sustainability through the healthcare systems, within the context of a predominantly modern global healthcare system, the key recommendation for WCRC is to promote a greener healthcare system. This could be achieved in part through the set of recommendations for the WCRC hospital building and healthcare system presented below. Further recommendations will also emerge from future scholarship.

According to Reed and Wilkinson, consideration should be given to all "buildings, not just new high-profile trophy buildings" (2008:05). The largest known "offenders to sustainability are older buildings" (Reed and Wilkinson, 2006, cited in Richard Reed, et al., 2009:17). The LEED Materials and Resources Technical Advisory Group (TAG) has already identified problems of the kind discussed above on the "credits or scores assigned in rating systems for building material" choices, and has wrestled with how they might be resolved in future versions of the system (Trusty, WB., nd:2). One recommendation has been to develop a matrix that would integrate such objectives with the amount of product or material in a building, with a variable outcome based on project inputs. The TAG has also discussed the potential role for life cycle assessment (LCA), which would be roughly approximated by the matrix approach. LCA is also the direction that has already been at least "partially adopted in the GBTool" (Reed and Wilkinson, 2006:4). Dove tailing from WCRC's green star rating tool systematic comparison above between, 'what WCRC's building design at the moment' and 'what WCRC's building design could be' as a green healthcare hospital facility. We can establish a progression of measured set of recommended steps to steadily improve the hospital's design impact of WCRC's design under the following GBCSA GB rating tool categories (explained in much detail under Section 5.3.1 – 5.3.3).

1. Management

As part of its hospital building retrofixation process I recommend WCRC to:

- Engage an accredited professional who can re-design the hospitals building and make it greener.
- Appoint an independent commissioning agent as part of its hospital building retrofitting process.
- Adopt formal environmental management system during retrofit construction.
- Divert 70% of construction and demolition waste going to disposal during retrofit construction.
- Undertake 12 months commissioning, quarterly reporting and final commissioning after the retrofit construction process.
- Adopt the commissioning clauses as part of the retrofit construction.

2. Indoor Environment Quality

Under this category I recommend WCRC to:

- Put CO_2 sensors in its hospital building so that it can monitor CO_2 levels within the building.
- Its needs to use the passive solar design techniques and roofing system that brings daylight into building which doesn't necessitate the use of lights during broad daylight.
- Use electromagnetic fluorescent ballasts to reduce lamp flicker.
- Use user controlled mixed mode ventilation system in building for every $15m^2$.
- Use mixed mode ventilation system in building.
- Use zero VOC paint for all its painted walls.
- Use composite wood products without formaldehyde.
- Establish dedicated photocopying and printing areas with exhaust risers.

3. Energy

Under this category I recommend WCRC to:

- Minimise GHG emissions associated with the hospital's operational energy consumption.
- Provide further sub-metering for lighting and develop an effective mechanism for monitoring energy consumption data from all energy sub-meters in the different wards.
- Incorporate light switches for every $100m^2$ of the hospital building.
- Use solar and wind energy stored in batteries as an alternative to Eskom's as a peak energy demand reduction mechanism.

4. Transport

Under this category I recommend WCRC to:

- Use fuel-efficient transport methods like bicycles on the premises as opposed to cars.
- Construct cyclist facilities on the hospital premises and provide secure bicycle storage.

5. Water

Under this category I recommend WCRC to:

- Harvest rainwater for watering the grounds and recycle its black and grey water for re-use.
- Install an automated mechanism to monitor the consumption of water in the respective wards.

6. Materials

Under this category I recommend WCRC to:

- Establish an onsite dedicated storage area for the separation and collection of recycling materials which wasteman can manage.
- Use integrated fit-out when dealing with materials.
- Replace at least 30% of PVC building content by alternative materials that are greener as and when its current PVC pipes break or wear and tear.
- Use at least 95% of the building timber that's FSC certified and some of it being reused timber when it retrofits.
- Design its retrofitted hospital building for disassembly.

7. Land Use & Ecology

Under this category I recommend WCRC to:

- Keep upgrading the topsoil's texture and structure through sustainable agricultural practices

8. Emissions

Under this category I recommend WCRC to:

- Significantly reduce its peak storm water flows through rainwater harvesting as recommended in point 5 above.
- Reduce its discharge to sewer by 50% or more through grey water and black water recycling as alluded to above in point 5.

9. Innovation

Under this category I recommend WCRC to:

- Develop green policies and use it buying power with its suppliers/value chain to bargain for green products and supplies for its hospitals (See appendix F).

Transitioning to greener materials is part of a journey to “creating safer and healthier products” (Rossi, M., 2006:20). It is a journey that will take time, experimentation, and “adjustments to error in short, continuous improvement” (Rossi, M., 2006:22). As the experiences of Kaiser Permanente, HUMC, and other cases discussed in Chapter Two above show, however, the “potential rewards for the healthcare system are huge” (The Center for Health Design, 2011:30). Patient outcomes, staff satisfaction, retention, and operating costs all stand to gain. Healthcare with its large purchasing volume is uniquely positioned to shape the future of material development and reap substantial benefits to the bottom line while improving global health and the environment (HWCH, 2006). Hence at a local scale I further suggest and recommend the following interventions for WCRC’s hospital building and healthcare system:

5.3.1 Greening the current hospital building (retrofitting)

Greening the current hospital building with key ecological design and green building features is required, specifically improved environmental performance, and other features that make it healthier for its occupants such as “increased daylight, fresh air and non-toxic materials” (Mark Rossi & Tom Lent, nd:16). It also needs to reduce the amount of energy and water amongst other resources that the hospital is currently using (EPA, 2008).

Firstly the hospital needs to put together a design team with an accredited green star professional to work on a green building retrofit design that will suit the hospitals needs and serve its functions. The hospital needs to achieve these outcomes by focusing on them from its retrofitting conception and first stages of retrofit design, implementing them throughout retro fixation construction, and by continually “monitoring and measuring its performance in operation” (Rossi, M., 2006:42). The hospital as a green building needs to minimise resource use, pollution and waste, from the start (HWCH, 2006).

The selection and use of building materials is important as the hospital goes green. It needs to consider using greener materials when replacing broken items like use rubber sink drainage pipes as opposed to PVC drainage pipes that the hospital currently has. It can replace burnt light bulbs with energy efficient low mercury ones (preferably solar domes) and as the current stock of inefficient light bulbs gets weaned, the hospital will eventually have a full stock of energy efficient low mercury containing compact fluorescent light bulbs. According to National Geographic News, fluorescent lights' mercury poses dim threat and the use of CFLs requires some common sense precautions (2007). The hospital needs to phase the unsustainable bits and pieces as it goes to avoid putting itself under lots of financial strain try to retrofit everything at one go. This includes the prioritisation of energy efficiency of the hospital building and an ecologically designed green spatially planned hospital building (taking into account urban growth), including:

a) Provide healthy buildings: unsustainable building design aims to create buildings that are not harmful to their occupants nor to the larger environment. An important emphasis is on "indoor environmental quality, especially indoor air quality" (Levin, Hal, 1995:3). Apart from re-painting the internal walls using low volatile organic compound (VOC) based paints when repainting is due, the hospital must also dedicate a central printing room in each ward area with copiers and printers that is fitted with an exhaust riser to avoid employees from inhaling fumes and vapour produced by these office gadgets. It is clear that human society needs to reduce the absolute burden on the environment of all construction activities, while at the same time maintaining or even increasing "material welfare and services provided to customers" (Bringezu, 2001:5).

b) Productive use of urban hospital agricultural space: including raised beds (or organoponics), rooftop gardening, common greens, a section of the hospital park, green LSEN school, communal centre and backyard or allotment garden as well as self-provisioning at the factory workshop, offices and business and suburban nurse residents around the hospital perimeter. If WCRC were to allocate only 0.10% of its hospital space and roofs towards urban agriculture, a couple of tonnes of vegetables per annum could be produced from within the hospital boundary. Urban agriculture activities can range from hospital community gardens to productive enterprises and market gardens that contribute to both local production and the local economy.

c) Greening quality of life issues: this can be used as a design for the purpose of adding mass and thermal resistance value to reduce heating in buildings. A university of Toronto study by Brad Brass reveals that green roofs can also "reduce energy consumption and heat loss in winter conditions" (Robertson, C., 2006:42). Most of this energy is normally generated from fossil fuel based fuels, which are currently driving climate change. This further reduces cooling through evaporative cooling especially when the roof is "glassed to act as a passive solar heat reservoir and terrarium" – a concentration of green roofs in an urban area can significantly "reduce the city's summer average temperatures" (Sydney City Council, nd:84). This further reduces storm water run-off which potentially causes soil erosion or goes down storm water drains into the sea or rivers in many cities. This also further creates a natural habit and results in an urban wilderness and these plants will filter carbon dioxide and pollutants "out of the atmosphere, which helps lower disease rates such as asthma" (Sydney City Council, nd:85). This process also further filters heavy metals and pollutants out of rainwater (Brass, 2005). The buildings sound insulation is also improved as plants block higher frequencies and the soil blocks lower frequencies. This also has financial benefits of increasing the real estate value of the building and dramatically increasing the roofs life span (Gill, S.E., J.F. Handley, A.R. Ennos and S. Pauleit, nd). The same also applies to planting native trees and shrubs within a community and around the hospital grounds which don't seem to have that many trees either. WCRC currently only has 0.05 native trees per square kilometre and they can increase this to equate to about 17 trees per acre, thus 17 trees in the open spaces.

d) Food security via food planting and composting: as opposed to chucking away the agricultural waste from the hospital premises to the Vissershoek landfill site in Durbanville, which is full. Hospital gardening staff members who are on the lower income side brackets can benefit from food planting and composting (by using the agricultural waste in their own food gardens around the perimeter on the hospital). This includes economic, social and ecological aspects of sustainability. If implemented well this will provide food to the local staffing community. These staff members can grow food to meet their immediate needs, and further sell some of their excess produce to generate some income whilst also assisting in sequestrating carbon dioxide and pollutants out of the atmosphere. This staff gardening will aid in managing surface run off water, provide for recreation and provide for wildlife. According to McLennan the intention of sustainable design is to "eliminate negative environmental impact completely through skilful, sensitive design" (McLennan, J. F., 2004:64). Manifestations of sustainable design require no non-renewable resources, impact the environment minimally, and relate people with the natural environment.

They is no comprehensive set of directions to achieving truly green materials but rather they is a definition of the initial set of steps that can start WCRC along the path to green materials. These guidelines are deeply influenced by my concerns with the use and exposure of humans and the environment to toxic chemicals. For this reason, they start with screening to eliminate materials that contain or contribute to the release of highly hazardous substances (HWCH, 2006). See appendix G for more details on the directions.

5.3.2 Energy switching towards sustainable renewable resources

WCRC needs to shift away from the conventional energy sources that it currently heavily relies on as in 100% electricity from the Eskom grid and 90% of portable water from the city of Cape Town's water supply. According to Frank Spencer, an eco-energy home has a positive environmental impact as it "produces more energy than it needs; sequesters carbon; supplies its own water, produces its own electricity and produces its own food" (Spencer, 2010:18). WCRC needs to use this transition towards renewable energy sources as a learning process. As cited in Darby, Fuchs and Arentsen, (Fuchs and Arentsen, 2002:12) have pointed out the need to "emphasise learning and communication as an integral part of policy" to enable a community to learn and learn from its experiences on which eco-design best suits their context (Darby, 2006:6). As much as the hospital has implemented energy saving initiatives through the 'switch off' campaign, purchase of energy efficient equipment, computers and monitors set to power down. It has also used the purchase of energy saving globes; switch off computers after hours, increased awareness of staff, and switched off lights in non-essential areas / empty offices. In this case an increased awareness of staff is basically based on the assumption that the staff members are perfect and will adhere to these requirements and implement these saving measures. Where as in reality the hospitals consumption is going up both due to rising electricity cost and secondly because the hospital is consuming more electricity. Hence like Darby further cites Pohl and Gisler, (Pohl and Gisler, 2003) who have described how sustainable energy concepts must pass through "different 'social worlds' on the journey from their origins to implementation", each with its own "language", conventions and dynamics (Darby, 2006:8).

Social learning by technologists through shared experience has been emphasised by Macdonald and Schrattenholzer (Macdonald and Schrattenholzer, 2001), and Kamp et al., (Kamp et al, 2004). Where non-specialist energy users (like nurses, doctor and therapists in this case) are concerned, there has been a plea for energy education that respects and uses the processes and language of everyday life, applying the insights of the educationalist Vygotsky (Dias et al., 2004). I concur with this argument, as they are different forks for different strokes. This principle applies to different contexts. It's important that everyone concerned at WCRC understands the objective and processes that form the journey towards ecological design and what the different roles are in this journey. The learning process also needs to factor in what Darby argues as the main challenge to constructivist thinking comes from behaviourism (Darby, 2006). People are not always perfect and using a systems perspective is required as argued by Crane and Swilling. Beyond a certain point in the development process, material economic growth can become developmentally dysfunctional (Crane and Swilling, 2008). They further argue that systems change incrementally at the micro-level, as new modes of production and consumption get designed, constructed and implemented via the complex interplay of market forces, policy interventions and regulatory provisions (Crane and Swilling, 2008). As Swanepoel articulates, the South African context would need to overcome certain "key obstacles and barriers to renewable energy" (Fakir and Nicol, 2008:7). Not every context in the world will have the same "obstacles and barriers to renewable energy" as South Africa; some could be similar, whilst some are completely different (Darby, 2006).

Human behaviour has been recognised by researchers as a "crucial and problematic element in household energy consumption for around three decades now," with the most well-known statement of this being the Twin Rivers study (Sonderegger, 1978:09). As behaviour is open to change through learning, the importance of understanding learning processes is clear. Constructivism contributes to energy research by highlighting the affective dimension to learning and the importance of the context within which learning happens. Hence the need not to assume that human behaviour is perfect and will conform to eco-design as shown in Figure 8. WCRC needs to strive to meet the following principles:

(a) Energy: WCRC must have energy using facilities that are primarily, designed to rely more on renewable energy as opposed to fossil fuel driven energy sources like biogas, biomass, and renewable energy source like wind, solar, micro-power and bio-fuel energy. Renewable energy sources produce "no greenhouse gases in operation and reduce or eliminate the need for additional coal fired power stations and large hydro-electric dams" (Government of Australia, 2005:123). The hospital must look into using sun-domes for its lighting and save between "75% – 90% on daytime lighting" with this tubular skylight (Sun-dome, 2009:1).

(b) Water: WCRC must be able to supply, and produce its own water, to meet its water needs and demands. Water is limited (especially in South Africa) and "resources of water must be protected against depletion and against pollution" (ITDG, 2005). Hence neighbourhoods need to be able to harvest rain water, recycle their grey and black water, "ensure sufficient water of good quality; recover and recycle finite nutrients found in wastewater; clarify the relation between energy and water, investigate and implement source control technologies" (Wilsenach, undated:2). According to ITDG and Practical Action, clean sufficient drinking water supply is essential for life in a "world that cannot afford the capital intensive and technically complex traditional water supply systems" which are widely promoted by governments and agencies throughout the world (Practical Action, nd:1). The supply of safe clean water is still dire in the world despite decades of work by organisations and states to bring portable water to the poor. Rain water harvesting is an option that can potentially solve part of the water problem though it's not the definitive answer to household water problems as a set of complex inter-related circumstances that need consideration exist, for choices to be made. Rain water harvesting (RWH) in eco-designed communities can be practised to control and utilise rain water close to the point where the rain reaches the earth. This can be done through "domestic RWH" or alternatively through "RWH for agriculture, erosion control, and flood control and aquifer replenishment" (ITDG, 2005:15).

(c) Low-impact materials: "choose non-toxic, sustainable produced or recycled materials," which require little energy to process (ITDG, 2005:10).

(d) Energy efficiency: use "manufacturing processes and consume products", which require less energy (embodied energy), (Practical Action, nd:11).

(e) Quality and durability: longer-lasting and better-functioning products will have to be replaced less frequently, "reducing the impacts of producing replacements" (ITDG, 2005:20).

(f) Design for reuse and recycling: products, processes, and systems should be designed for performance in a commercial 'afterlife' (Anastas, P. L. and Zimmerman, J. B, 2003).

(g) Service substitution: shifting the mode of consumption from personal ownership of products to provision of services which provide similar functions, e.g., from a private automobile to a car sharing service. Such a system "promotes minimal resource use per unit of consumption" (e.g., per trip driven), (Ryan, Chris, 2006:12).

(h) Renewability: materials should come from nearby (local or bioregional), sustainable managed renewable sources that can be composted when their usefulness has been exhausted (Anastas, P. L. and Zimmerman, J. B, 2003).

(i) Sanitation and solid waste: e-waste is one source of mercury pollution and WCRC needs to start recycling its e-waste in addition to all the other materials that the hospital is already recycling.

5.3.3 Local health movement engaging suppliers, focussing on sustainability

Local economic development can be fostered by increasing the quantity of resources procured locally by the hospital as well as bio-regional processes that form part of a wider local community for WCRC. As identified by Marsden and Smith, sustainable wealth creation and local economic development require new entrepreneurial initiatives that focus on “investing in the local environment, creating / strengthening local institutions and employing people and their resources” (Marsden & Smith, 2005: 440 – 441).

Different local supply economy initiatives such as the Khayelitsha horticulture initiative, local markets and suppliers are critical in supporting locally grown produce in reaching consumers more directly and effectively. A local sustainability hub for local suppliers and food produces should be established to assist both local suppliers and WCRC hospital in connecting more directly and maximising the benefits of central coordination. By connecting local suppliers more directly to the hospital economies that support them and the individuals behind that hospital economy, closer bonds can be forged within a community around healthcare systems and local healthcare delivery. There are also opportunities for local value adding enterprises (such as fresh vegetable produce and meaty foods) that not only stimulate the local economy further, but also assist in maintaining a supply of local fresh produce to the hospital throughout the year.

A key recommendation in preparing the community of WCRC for a more sustainable future with a gentle transition into a low energy future is through building knowledge systems that promote learning for change (Pretty, 2002). Feenstra identifies leadership, collaboration and civic renewal as crucial in building stronger local health economies linked to equitable and sustainable communities. Learning through experience has been highlighted as one of the most meaningful methods of shifting behaviour and again points to the importance of connections with local WCRC healthcare systems that allow opportunities for such engagement. In this way, local health economies are as much about the flow of knowledge and social capital as resources, as about the flow of healthcare itself (Feenstra, 1997:34).

5.4 Next steps and opportunities for further scholarship

Several opportunities for further scholarship have been identified in the absence of primary data, reliable secondary data or recent research for several sectors of the WCRC building design, resource consumption patterns and healthcare system. Opportunities for further scholarship were also identified in Chapter 3 and further presented below.

Future policy and research should be aimed at the bigger question of how buildings can provide a positive environmental contribution. This includes moving towards true sustainability by utilising holistic measures that place buildings in social context and attempt to harmonise with the natural landscape in terms of form and function. The GBCSA rating tool needs to factor in waste as an individual wieghtung category as a green building progress indicator. Using waste as a measure of progress towards sustainability logically arises from a fundamental understanding of the thermodynamic nature of the economic process and its irrefutable connection with the environment as a source for materials and a sink for wastes (Costanza et al. 1997; Georgescu-Roegen 1976a; 1976b).

1. Hospital building rating tools research

Research needs to be done into developing a green star hospital building rating tool. Further detailed surveys and mapping of both actual and potential hospital building rating scores need to be undertaken and green star rating. Explore how waste can be used as a category weighting for hospitals and try and incorporate the social category weighting into this rating tool. A recommendation for further research is detailed mapping the current set of building rating tools (LEED, CASBEE, BREEAM, GBTool, Green Star South Africa, *etc.*) tend to focus on technical aspects such as energy consumption, water use or materials. This is a concern to some commentators (the author of this thesis included) because actual performance in operation can be severely “compromised because the specification and technical performance fail adequately to account for the inhabitants’ needs, expectations and behaviour” (Mumovic, D., Santamouris, M., 2009:25). Unexpected behaviour by occupants can degrade whole system performance and potentially overturn the savings expected by designers or policy-makers.

Despite this, only the most tentative steps have been taken to refocus attention on building users and their ability to be productive within the physical environment of a building. According to Meir *et al.* (2009), the issue of sustainability, holistic by definition, may be too complex to determine by measurements alone. Obviously user sensibility and satisfaction must play a pre-eminent role in evaluating all types of facilities and therefore they must play an “active part in building performance evaluations of all types” (2009:5). In this thesis, I argue for the inclusion of “user performance criteria” in building sustainability rating tools (BSRTs), and their application to buildings in operation (as opposed to new buildings for which the existing tools are mainly designed) [Meir, I.A.; Garb, Y.; Jiao, D.; Cicelsky, A., 2009].

Given the thesis author’s overall aim of effecting an improvement in the performance of existing commercial and institutional buildings from the point of view of the building users, two key issues arise in with respect to such an approach. The first relates to the establishment of an “independent and unbiased set of performance benchmarks for users’ perceptions of the buildings” in which they work (Baird, G., 2009:1070). The second relates to the development of a methodology for incorporating these benchmarks into relevant “building sustainability rating tools” (Baird, G., 2010:9). Finally the thesis advocates for the development of a set of user benchmarks for existing hospital buildings, as a key ingredient in making progress towards a truly sustainable building stock and the need to note developments in this direction currently under way in South Africa. According to Baird, buildings that perform poorly from the users’ point of view are unlikely ever to be sustainable (2009).

2. Case study research

Mapping and documenting case studies in the South African context focusing primarily on activities such as green hospital buildings, waste minimisation, promoting the use of non-burn waste treatment technologies, improved waste segregation practices and the use of appropriate alternatives to mercury-containing devices etc. It must delve into evidence on the financial performance of green office buildings like in the USA (GBCSA hopes to compile their very own local version this year!). Insights must include the following: despite “increases in the number of green buildings, and the recent downturn in property markets, green premiums” have been maintained (Eichholtz, P., 2011:5); and energy star-certified buildings command “rents that are 2.1% higher” compared to similar, non-certified properties (Eichholtz, KOK, Quigley and RICS, 2010:5).

3. Healthcare system initiatives

A recommendation for further research is an in depth market feasibility analysis research on further opportunities for local healthcare system initiatives within different sectors, e.g., creating model healthcare facilities or programs through collaborations with hospitals, smaller clinics, rural health and/or central waste treatment facilities etc. Use this to determine locally suitable optimal resource flows in hospital departments and carry out detailed surveys of alternative healthcare waste treatment technologies appropriate to conditions in much of sub-Saharan Africa including systems for the hospital to account where resources are sourced from. This should include detailed surveys of how the hospital offers its services. More research into developing and sustaining best healthcare waste management practices in a way that is both locally appropriate and globally replicable.

4. Suppliers, bio-regionalism and local sourcing sector research

A recommendation for further research is detailed mapping of WCRC’s healthcare system and opportunities in greater detail (such as producers, bioregionalism, partnerships etc.).
There is a significant opportunity for further research to establish a representative profile of suppliers and bioregion patterns for the WCRC greater Mitchells’ plain region. This would require primary data capture through surveys and demographic profiling. Furthermore, research to compile recommended optimal resources for the WCRC hospital, based on its requirements and preferences, and would be critical in identifying more accurately areas for intervention that would promote greater local sourcing security for the WCRC hospital. Further research should also be carried out on targeted programmes for improving local sourcing security in the WCRC context.

5. Local health economy specific research

There are opportunities for further investigation into the current local health economy initiatives (including local hospitals or medical networks) operating in the Mitchell’s plain region as well as surrounding communities. In-depth research of the case studies highlighted to document health models and key findings would also contribute to a better understanding of the local health movement in the Mitchells Plain region whose status lens in terms of sustainability is unknown and could not be established in this research.

In-depth market analysis research on further opportunities for local health economy initiatives within different sectors should be investigated. This could include opportunities for promoting a stronger local health economy through local sourcing and supply in the medical sector, catering for the large population in Mitchell’s Plain as well as local healthcare centres and opportunities for engaging local clinics into the local health economy of local sourcing, bulk buying and promoting the sustainability agenda through consumer power.

6. Hospital agricultural practice specific research

A recommendation for further research is detailed mapping of current agricultural practices on the WCRC hospital grounds for each parcel of land. This would require detailed surveys that could then be viewed according to sustainable agricultural lens. This research would be strongly complimented by mapping agricultural potential of a small gardening section of the total land area based on soil condition, water availability and climatic conditions. Further research based on these findings could then be conducted on suitable land use and crop combinations as well as potential for vegetable gardening. The mapping exercise should include the potential for vegetable production within the hospital boundaries.

5.5 Chapter summary

In planning for the twenty first century, the healthcare sector – as institutions for healthcare delivery and as businesses - has opportunities to design their roles, services, buildings, and infrastructure intentionally within this integrated approach. The healthcare sector can be drivers of change, not only by modifying their own practices and activities, but also by helping other sectors to identify and ameliorate their contributions to impaired public environmental health and discover opportunities for positive change.

The design of the menu of services provided by healthcare institutions must “logically precede the design of buildings to house them” (Schettler, T., 2006:11). Revisiting the nature of those services and how they are financed are certain to be at times controversial and subject to debate. Nevertheless, those services should be reviewed with full consideration of their appropriateness, the ecological context in which they are provided, their environmental impacts, and the demonstrable reality that health status in South Africa is inferior to that in countries that spend far less on healthcare. Those services should also be reviewed through an expanded lens of bioethics that embraces the fundamental “interconnections among individual, public, and environmental health” (Gaskill, 2006:4).

Each institution, professional association, and healthcare-related business will need to address what it believes its roles and responsibilities are in disease prevention, preserving and restoring ecological services on which all life depends, and engaging with other sectors in a more integrated approach to improve public health. This will be an opportunity to decide whether to embrace the status quo or to begin to develop a new path into the twenty-first century based on current science and circumstances.

The following are examples of questions to consider:

- What is health? What are the boundaries of the framework in which that question is considered? Why?
- How can we incorporate an expanded view of bioethics into all institutional activities?"
- Some notable economists have argued that large increases in medical expenditures will serve as the engine to drive the economy and are not alarming since Americans for example are "wealthy and need to spend their money on something" (Kolata, 2006:56). What are the implications of this point of view for disease prevention and the environmental impacts of the healthcare sector?
- To what extent do we truly care about disease prevention? Do our activities aid or hinder disease prevention? For example, in hospitals offering weight-reduction surgery, are any steps also undertaken to address the underlying causes of obesity in the community?
- How do we encourage (or discourage) health promotion and disease prevention in individuals and in communities that we serve? In homes, schools, businesses? Are there new opportunities that we should explore? What can we do to promote community health restoration and resilience?
- Given their importance, how are we addressing the social determinants of health? How can we help to alleviate poverty and stress in our communities? What institutional services could we design into our programs to help do that?
- How are we supporting our local economy and doing what we can to keep money flowing through the local economy as long as possible?
- What is the size of our environmental footprint? How can it be reduced?
- How can we reduce our use of toxic chemicals and encourage improved chemical and materials production policies in the manufacturing sector?
- How can we support and promote an agricultural system that provides nutritious food with reduced ecological impacts?
- How can adverse public environmental health impacts of diagnostics and therapeutics be minimised (including pharmaceutical prescribing practices)?
- As a way of integrating many of the environmental factors known to influence reproductive health and childhood development, how can we help to ensure that all babies born in this community are full term, of normal weight, and receive appropriate new-born, infant, and child services?

Building design, construction, and operations can be much more meaningfully addressed after questions like these and others are discussed in an open, transparent, and inclusive process. Twentieth-century answers will result in twentieth-century buildings. They may be more energy efficient, use less water, recycle more waste, and foster greater patient satisfaction than earlier versions but still not address fundamental ethical, economic, and ecological concerns.

These basic, underlying concerns will not go away by being ignored. Jane Lubchenco, president of the American Association of the Advancement of Sciences, argues that as the magnitude of human impacts on the ecological systems of the planet becomes apparent, there is increased realisation of the intimate connections between these systems and human health, the economy, social justice, and national security. She called for a new social contract for science that would more adequately address the problems of the coming century than does our current scientific enterprise. The contract, she said, should be predicated upon the assumptions that scientists will (i) address the most urgent needs of society, in proportion to their importance; (ii) communicate their knowledge and understanding widely in order to inform decisions of individuals and institutions; and (iii) exercise good judgment, wisdom, and humility (Lubchenco, 1998).

WCRC's work and other businesses inside and outside of healthcare needs to reveal an emerging path for defining and selecting environmentally preferable or green materials. Green material is defined as having the following key properties:

- No toxic chemistry: Uses only green chemicals in production, use, and disposal. Green chemicals are those that are healthy to humans and the environment and are produced in accordance with the twelve principles of green chemistry (see Appendix D).

Research shows that traditional cleaning products were loaded with known or suspected human carcinogens, hormone and endocrine disruptors, and neurotoxins. Hence WCRC needs to develop a Greening the Cleaning program for the hospital, which includes a list of hazardous ingredients to avoid in cleaning agents (see Appendix E). From a small-scale this program can develop into a full-scale cleaning protocol across the facility based upon environmentally friendly, nontoxic cleaning products that utilize natural or naturally derived ingredients.

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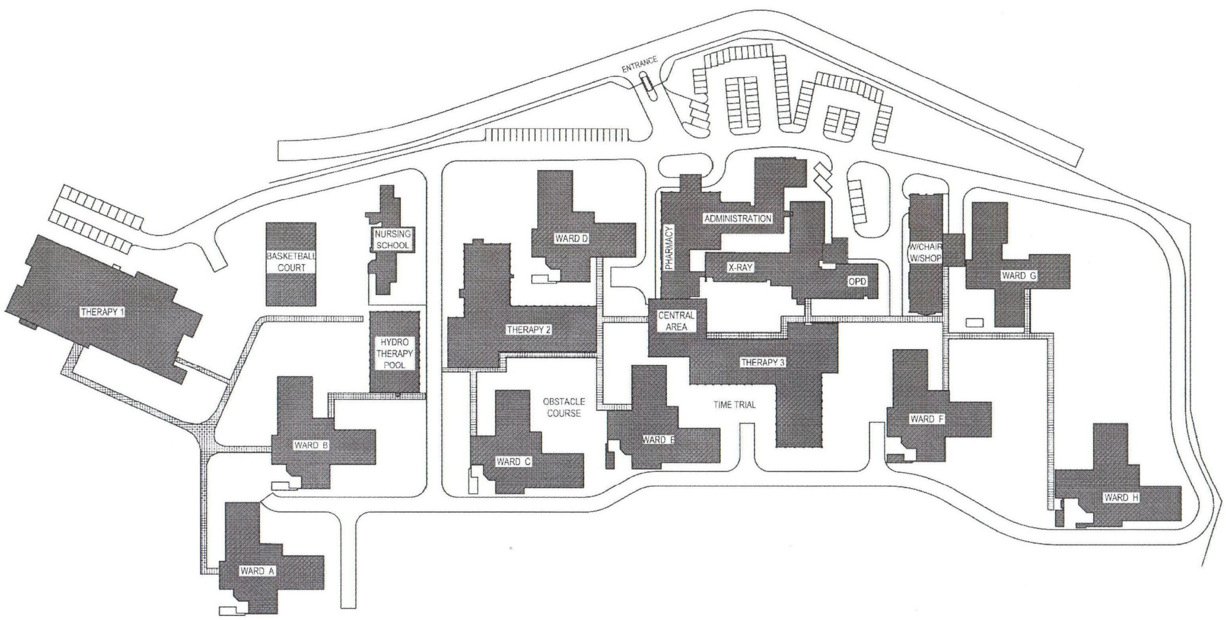
Appendix A

WCRC Site Map and Area of Study

westerncaperehabilitationcentre

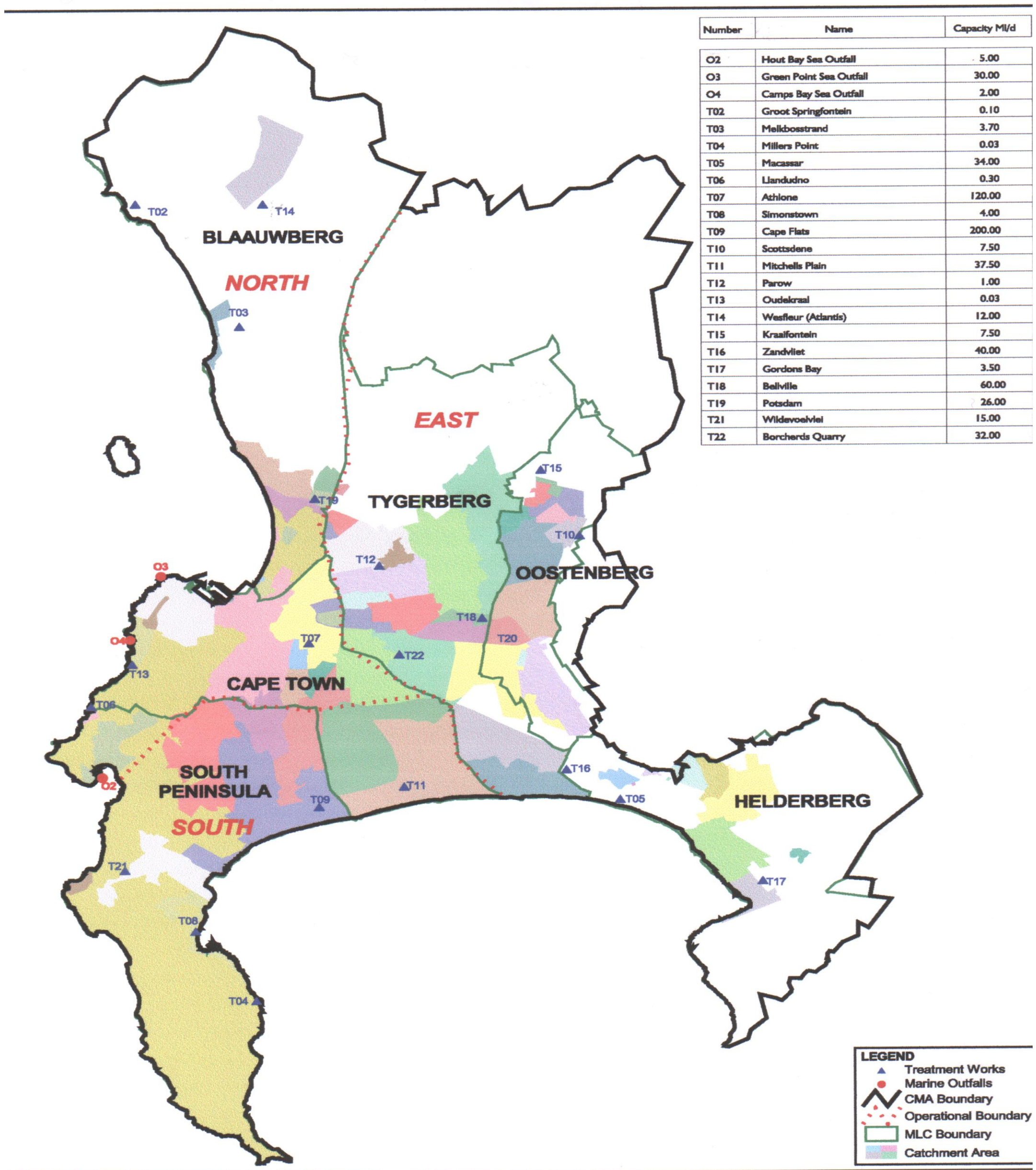
SITE PLAN OF WESTERN CAPE REHABILITATION CENTRE



MAP2

Appendix B

Mitchells Plain Wastewater Treatment Works



Number	Name	Capacity Ml/d
O2	Hout Bay Sea Outfall	5.00
O3	Green Point Sea Outfall	30.00
O4	Camps Bay Sea Outfall	2.00
T02	Groot Springfontein	0.10
T03	Melkbosstrand	3.70
T04	Millers Point	0.03
T05	Macassar	34.00
T06	Llandudno	0.30
T07	Athlone	120.00
T08	Simonstown	4.00
T09	Cape Flats	200.00
T10	Scottsdene	7.50
T11	Mitchells Plain	37.50
T12	Parow	1.00
T13	Oudekraal	0.03
T14	Wesfleur (Atlantis)	12.00
T15	Kraaifontein	7.50
T16	Zandvliet	40.00
T17	Gordons Bay	3.50
T18	Bellville	60.00
T19	Potsdam	26.00
T21	Wildevoelvlei	15.00
T22	Borcherds Quarry	32.00

FIGURE 16	WASTE WATER FACILITIES: WASTEWATER TREATMENT PLANTS

Source: City of Cape Town (2001: 2)[1]

[1] Available online at http://www.capetown.gov.za/en/Water/WaterservicesDevPlan/Documents/5.4a_GOTO 5.4_Bulk wastewater infrastructure1.doc

Appendix C

Stockholm Convention Persistent Organic Pollutants (POPs); Persistent, Bioaccumulative, and Toxic (PBT); and Very Persistent and Very Bioaccumulative (vPvB) Lists

		POPs[1]	PBTs			vPvBs
CAS	Chemical		EU[2]	US EPA Priority PBTs[3]	WA[4]	EU[2]
87-61-6	1,2,3-trichlorobenzene		1			
120-82-1	1,2,4-trichlorobenzene		1			
84852-15-3	4-nonylphenol (branched)				1	
309-00-2	Aldrin	1		1	1	
120-12-7	Anthracene		1			
7440-43-9	Cadmium				1	
57-74-9	Chlordane	1		1	1	
3734-48-3	Chlordecone (Kepone)				1	
50-29-3	Dichlorodiphenyltrichloroethane (DDT)	1	1	1	1	
60-57-1	Dieldrin	1		1	1	
68515-49-1 & 26761-40-0	Di-isodecyl phthalate (DIDP)				1	
84-75-3	Di-n-hexyl phthalate (DnHP)				1	
several	Dioxins	1		1	1	
90640-86-1	Distillates (coal tar), heavy oils		1			
115-29-7	Endosulfan		1			
72-20-8	Endrin	1			1	
several	Furans	1		1	1	
76-44-8	Heptachlor	1			1	
1024-57-3	Heptachlor epoxide				1	
36355-01-8	Hexabromobiphenyl				1	
25637-99-4	Hexabromocyclododecane				1	
118-74-1	Hexachlorobenzene	1	1	1	1	1
87-68-3	Hexachlorobutadiene				1	
7439-92-1	Lead			1	1	
58-89-9	Lindane		1			
7439-97-6	Mercury			1	1	
2385-85-5	Mirex	1		1	1	
1836-75-5	Nitrofen		1			
25154-52-3	Nonylphenol				1	
	Octachlorostyrene					
several	PAHs				1	

56-49-5	PAHs - 3-Methyl chlolanthrene				1	
218-01-9	PAHs - Benzo(a)phenanthrene (Chrysene)				1	
50-32-8	PAHs - Benzo(a)pyrene			1	1	
205-99-2	PAHs - Benzo(b)fluoranthene				1	
191-24-2	PAHs - Benzo(g,h,i)perylene				1	
205-82-3	PAHs - Benzo(j)fluoranthene				1	
207-08-9	PAHs - Benzo(k)fluoranthene				1	
189-55-9	PAHs - Benzo(r,s,t)pentaphene				1	
192-65-4	PAHs - Dibenzo (a,e)pyrene				1	
189-64-4	PAHs - Dibenzo (a,h)pyrene				1	
226-36-8	PAHs - Dibenzo(a,h)acridine				1	
53-70-3	PAHs - Dibenzo(a,h)anthracene				1	
224-42-0	PAHs - Dibenzo(a,j)acridine				1	
206-44-0	PAHs - Fluoranthene				1	
193-39-5	PAHs - Indeno(1,2,3-cd) pyrene				1	
198-55-0	PAHs - Perylene				1	
194-59-2	PAHs -7H-Dibenzo(c,g)carazole				1	
13654-09-6	PBDE - Decabromodiphenyl ether				1	
32536-52-0	PBDE - Octabromodiphenyl ether		1		1	
32534-81-9	PBDE - Pentabromodiphenyl ether				1	
1336-36-3	PCBs	1		1	1	
608-93-5	Pentachlorobenzene				1	
133-49-3	pentachlorobenzenethiol	1			1	
1763-32-1	Perfluorooctane sulfonates (PFOS) Acid				1	
29081-56-9	Perfluorooctane sulfonates (PFOS) Ammonium salt			1		
70225-14-8	Perfluorooctane sulfonates (PFOS) Diethanolamine salt				1	
29457-72-5	Perfluorooctane sulfonates (PFOS) lithium salt				1	
2795-39-3	Perfluorooctane sulfonates (PFOS) Potassium salt				1	
32241-08-0	Polychlorinated naphthalenes - Heptachloronaphthalene				1	
1335-87-1	Polychlorinated naphthalenes - Hexachloronaphthalene				1	
1321-64-8	Polychlorinated naphthalenes - Pentachloronaphthalene				1	
1335-88-2	Polychlorinated naphthalenes - Tetrachloronaphthalene				1	
1321-65-9	Polychlorinated naphthalenes - Trichloronaphthalene				1	
92061-94-4	Residues (coal tar), pitch distn.		1			
85535-84-8	Short-chain chlorinated paraffins				1	
79-94-7	Tetrabromobisphenol A				1	

95-94-3	Tetrachlorobenzene, 1,2,4,5-				1	
75-74-1	Tetramethyllead		1			1
8001-35-2	Toxaphene	1		1	1	
56-35-9	Tributyltin oxide (TBTO)		1			

[1]Source: Stockholm Convention on Persistent Organic Pollutants, http://www.pops.int/documents/convtext/convtext_en.pdf.

[2]Source: European Chemicals Bureau, European Union, Status report on PBTs and vPvBs for New and Existing substances, http://www.defra.gov.uk/environment/chemicals/achs/060606/achs0614d.pdf

[3]Source: US EPA, Priority PBTs, http://www.epa.gov/pbt/pubs/cheminfo.htm

[4]Source: Washington State PBT list, http://www.ecy.wa.gov/programs/eap/pbt/pbtfaq.html

Appendix D

Green Chemistry

Twelve Principles of Green Chemistry

1. Prevent waste: Design chemical syntheses to prevent waste, leaving no waste to treat or clean up.
2. Design safer chemicals and products: Design chemical products to be fully effective, yet have little or no toxicity.
3. Design less hazardous chemical syntheses: Design syntheses to use and generate substances with little or no toxicity to humans and the environment.
4. Use renewable feedstocks: Use raw materials and feedstock's that are renewable rather than depleting. Renewable feedstock's are often made from agricultural products or are the wastes of other processes; depleting feedstocks are made from fossil fuels (petroleum, natural gas, or coal) or are mined.
5. Use catalysts, not stoichiometric reagents: Minimise waste by using catalytic reactions. Catalysts are used in small amounts and can carry out a single reaction many times. They are preferable to stoichiometric reagents, which are used in excess and work only once.
6. Avoid chemical derivatives: Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.
7. Maximize atom economy: Design syntheses so that the final product contains the maximum proportion of the starting materials. There should be few, if any, wasted atoms.
8. Use safer solvents and reaction conditions: Avoid using solvents, separation agents, or other auxiliary chemicals. If these chemicals are necessary, use innocuous chemicals.
9. Increase energy efficiency: Run chemical reactions at ambient temperature and pressure whenever possible.
10. Design chemicals and products to degrade after use: Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.
11. Analyse in real time to prevent pollution: Include in-process real-time monitoring and control during syntheses to minimize or eliminate the formation of by-products.
12. Minimise the potential for accidents: Design chemicals and their forms (solid, liquid, or gas) to minimise the potential for chemical accidents including explosions, fires, and releases to the environment.

Source: Anastas, P. T., and J.C. Warner., 1998. Green Chemistry Theory and Practice New York: Oxford University Press. Also see Green Chemistry Institute Web site at www.greenchemistryinstitute.org.

Appendix E

Greening the Cleaning Must Not List

Greening the Cleaning is a cleaning protocol developed at the Deirdre Imus Environmental Center for Pediatric Oncology at Hackensack University Medical Center. The protocol guides users to eliminate to the greatest extent possible all cleaning agents containing hazardous ingredients and replace them with environmentally friendly products that utilize natural or naturally derived ingredients.

The Greening the Cleaning protocol uses the following guidelines – which were adapted from the US Department of Interior's Guidance and Training on Greening Your Janitorial Business: Environmentally Preferable Attributes of Chemical Cleaners and other standards – for formulating cleaning and related products.

They

Must not contain carcinogens, mutagens, or teratogens.

Must not contain any ozone-depleting compounds, greenhouse gases, or substances that contribute to smog.

Must not be corrosive or irritating to the skin or eyes.

Must not be delivered in aerosol cans.

Must not contain petrochemical-derived fragrances.

Must not contain toxic dyes.

Must not contain arsenic, lead, cadmium, cobalt, chromium, mercury, nickel, or selenium.

Must not contain hazardous wastes.

Must not contain petroleum distillates over 0.1 percent.

Must not be combustible.

Must not contain chlorinated solvents.

Must not contain persistent or bio-accumulative substances.

Volatile organic compound (VOC) levels must meet or be less volatile than the California Code of Regulations maximum allowable VOC level for the various categories.

Must be readily biodegradable.

Must be bio based.

Must be dispensed through automatic systems to reduce employee contact.

Must have a pH level between 4 and 9.

More information on Greening the Cleaning and the Deirdre Imus Environmental Center for Pediatric Oncology at Hackensack University Medical Center can be found at http://www.dienviro.com. Reprinted with permission.

Appendix F
Recommended GBCSA Steps of Innovation for WCRC

First steps

- Adopt purchasing policies that clearly state a preference for green materials that are protective of health and maintain the highest standards of patient car.
- Incorporate green building material preferences into design goals early in capital projects.
- Use the Plastics Environmental Preference Spectrum as a guide when specifying plastic-based products.
- Prefer polypropylene and polyethylene plastics that do not contain hazardous additives and sustainably sourced bio based materials.
- Give preference to low VOC products (HWCH, 2006).

Next steps

- Require suppliers to disclose chemical and material content of products.
- Avoid materials that contain highly hazardous chemicals. Start with chemicals listed Appendix C.
- Prefer materials and products with high recycled content and end-of-life recycling programs (Gaskill, 2006).

Fully engage

- Partner with suppliers who manufacture and develop products using green materials.
- Require suppliers to provide comprehensive hazard data on the chemicals contained in materials and products (HWCH, 2006).

Appendix G
Green Materials Hierarchy for Healthcare

Table G1: Green Materials Hierarchy for Healthcare

Criterion 1: Do not use materials that contribute to the formation of persistent organic pollutants (POPs) as defined by the Stockholm Convention.

Criterion 2: Do not use materials that contain or emit highly hazardous chemicals, including:

a. Do not use materials that contain

1. Persistent, bio accumulative, toxics (PBTs) or
2. Very persistent, very bio accumulative (vPvB) chemicals

b. Avoid materials that contain

1. Carcinogens
2. Mutagens
3. Reproductive or developmental toxicants
4. Neurotoxicants
5. Endocrine disruptors

c. Avoid materials that emit criteria levels of VOCs.

Criterion 3: Use sustainably sourced bio based or recycled and recyclable materials.

a. Prefer sustainably produced bio based materials that are:

1. Grown without the use of genetically modified organisms (GMOs).
2. Grown without the use of pesticides containing carcinogens, mutagens, reproductive toxicants, or endocrine disruptors.
3. Certified as sustainable for the soil and ecosystems.
4. Compostable into healthy and safe nutrients for food crops.

b. Prefer materials with the highest postconsumer recycled content.

c. Prefer materials that can be readily reused or recycled into a similar or higher value product and where an infrastructure exists to take the materials back.

Criterion 4: Do not use materials manufactured with highly hazardous chemicals, including those described in criterion 2.

Table G2: **Rationales for Green Material Hierarchy for Healthcare**

Criterion	Reasons for Action
1. Do not use materials that contribute to the formation of Stockholm Convention Persistent Organic Pollutants (POPs).	POPs are highly hazardous. POPs circulate and accumulate globally. Governments have identified POPs as a top priority for action and agreed to a global treaty for elimination (Stockholm Convention on POPs).
2. Do not use materials that contain or emit highly hazardous chemicals.	Government agencies have identified these as priority health hazards. These highly hazardous chemicals escape from materials in the healthcare environment. Patients and healthcare workers may be exposed to these chemicals.
3. Use sustainably sourced bio based or recycled and recyclable materials.	Create sustainable material supply systems. Reduce environmental impacts from virgin material production and from agriculture.
4. Do not use materials manufactured with highly hazardous chemicals.	Reduce exposure of communities outside the hospital walls to high hazard chemicals. Improve wider community and ecological health.

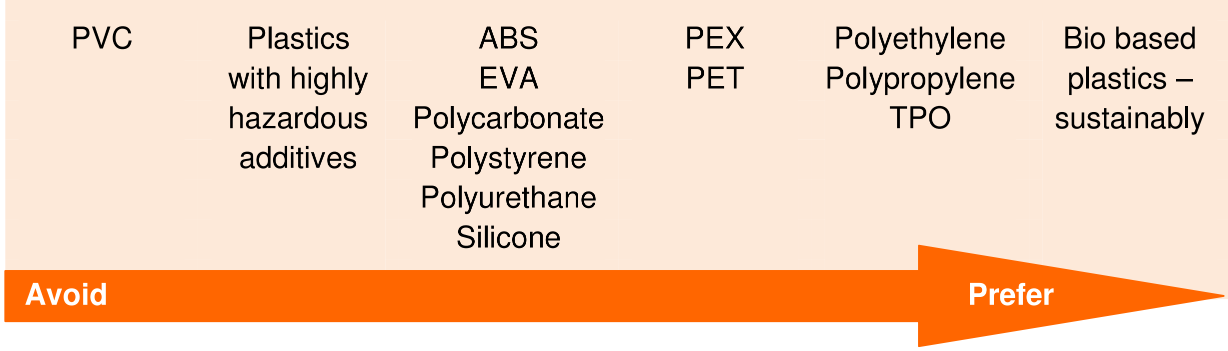
Putting the criteria into practice

Specifying preferable plastics

Since many products used for interior finishes, furniture and medical products are made from plastics, plastics are the largest consumer of organic chemicals, and many threats to health and the environment are related to plastics production and use, plastics provide a good place to start in implementing the Green Materials Hierarchy in a healthcare facility. The criteria in the hierarchy can be applied to plastics to provide guidance on selecting the healthiest options. Figure G1 provides a guide for purchasers and specifiers on plastics, ranging from the worst plastic (PVC) through increasing preferability of the fossil fuel-based plastics to the most preferred plastic (sustainable bio based plastics). Shifting specifications to plastics further to the right on the spectrum will reduce health impacts and increase sustainability (Gaskill, 2006; HWCH, 2006).

1. Plastics whose production or disposal contributes to the formation of Stockholm Convention POPs (criterion 1);
2. Plastics that contain highly hazardous additives (criterion 2);

Figure G1: Plastics: Environmental Preference Spectrum



ABS = Acrylonitrile Butadiene Styrene
EVA = Ethylene Vinyl Acetate
PET = Polyethylene Terephthalate
PEX = Polyethylene (PE) Cross-linked (X)
PVC = Polyvinyl Chloride
TPO - Thermoplastic Polyolefin

3. Use sustainably sourced renewable or recycled and recyclable materials (criterion 3);
4. Do not use materials manufactured with highly hazardous chemicals (criterion 4).