

ACKNOWLEDGEMENTS

I would like to convey my sincere thanks to my supervisor Prof. Dieter Helm.

The project was a great learning experience. I feel privileged to have had the opportunity to work under one of the most respected professionals in the field.

Towards sustainable building design principles for medium density, middle income housing in Gauteng.

by

Neil Oliver and Jeremy Givord of the CSIR Builtek for being willing to share the prototype SBAT document with me. Thank you for all the professional assistance and advice.

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Submitted in partial fulfilment of part of the requirements for the degree

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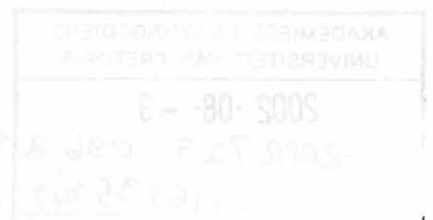
Pretoria

To my husband, Jürgen and daughter, Lisa. Thank you for your whole hearted support and understanding. You make a great team.

July 2001

I dedicate this to death and all young children. They deserve a right to a beautiful and healthy planet.

The study uses the Harvard method



ACKNOWLEDGEMENTS

I would like to convey my sincere thanks to my supervisor Prof. Dieter Holm. The patient manner in which he shared his broad knowledge of this subject is an inspiration. I feel privileged to have conducted this research under one of the most respected professionals in the field.

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I dedicate this to Beatrix and all young children; they deserve a bright future on a beautiful and healthy planet.

This study uses the Harvard method.

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ABSTRACT

Towards sustainable building design principles for medium density, middle-income housing in Gauteng.

by

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Supervisor: Prof. D. Holm

School of the Built Environment

Degree: Master of Science (Applied Sciences)

This dissertation addresses the current need for information specific to the sustainability of middle-income, medium density houses in Gauteng (FOURways house). The research explores principles and assesses tools that will assist in achieving more sustainable development of the FOURways house. The research identifies that if development in this sector is to be sustainable, information must be accessible to users as well as professionals. This requires clarity of information, which avoids exclusion due to scientific jargon. This research is qualitative and therefore no calculations are made comparing initial capital investment versus long term cost savings.

The concept of sustainability in domestic buildings is explored as principles that contribute towards achieving a sustainable living environment. Since the principles provide a broad background of information, the CSIR prototype “sustainable building assessment tool” (SBAT) has been adapted as a tool to introduce the topic of sustainability for discourse. A graphic representation of the adapted SBAT developed as a flower metaphor illustrates the extent to which a house is sustainable, or not.

It is proposed that the adapted SBAT document be used as an introduction at the project onset to the topic of sustainable building design. The principles can be followed to achieve the aim and finally the result can be tested using the adapted SBAT table and diagram.

This proposal was tested on a case study of the representative FOURways house. The principles checked and the adapted SBAT table and diagram illustrate that the building does not satisfy the requirements for a sustainable domestic building. Furthermore the case study revealed that current developments do not make use of sustainable principles.

Accepting that the FOURways house is a role model to the lower income groups (six earlier Living Standard Measure groups), sustainability in this housing sector urgently requires attention if sustainability is to be achieved across the range of domestic housing in South Africa.

EKSERP

Op pad na volhoubare ontwerpbeginsels vir middel-digtheid, middel-inkomste behuising in Gauteng.

deur

Marianne Müller-Warrens

Leier: Prof. D. Holm

School vir die Bou-omgewing

Graad: M.Sc (Toegepaste Wetenskappe)

Hierdie verhandeling spreek die huidige gebrek aan inligting spesifiek tot die volhoubaarheid van middeldigtheid, middelinkomste huise in Gauteng (FOURways huise) aan. Die studie ondersoek beginsels en identifiseer middele wat sal help met die ontwikkeling van 'n meer volhoubare FOURways huis. Die studie beklemtoon die belangrikheid van inligting wat deur gewone mense sowel as beroepslui verstaan kan word. Dit benodig eenvoudige presentasie van die konsep sonder die gebruik van wetenskaplike terme wat die inligting buite die bereik van gewone mense sal plaas. Aangesien die ondersoek kwalitatief is, is daar geen berekeninge wat kapitaalbelegging vergelyk teen opsigte van eindelik langdurige besparings.

Die konsep van volhoubaarheid in huishoudelike geboue is ondersoek in die vorm van beginsels wat bydra tot 'n volhoubare lewensomgewing. Aangesien die beginsels 'n breë agtergrond van inligting lewer, word die WNNR prototipe "sustainable building assessment tool" (SBAT) (gereedskap vir waardebeoordeling van volhoubare geboue) aangewend om volhoubaarheid as 'n besprekingspunt in die bouproses in te lei. Die oorspronklike SBAT is aangepas vir gebruik aan die FOURways huis. 'n Grafiese voorstelling van die aangepaste SBAT is ontwikkel in die vorm van 'n blom-metafoor om die volhoubaarheid van 'n huis te illustreer.

Die voorstel is om die aangepaste SBAT as inleiding tot die onderwerp van volhoubaarheid in die bouomgewing te gebruik. Die beginsels kan gevolg word om die

doel te bereik en die aangepaste SBAT-dokumente toets die resultaat met die aangepaste SBAT-tabel en SBAT-diagram.

Die voorstel is getoets op 'n praktykgeval wat die gemiddelde FOURways huis verteenwoordig. Die aangepaste SBAT-tabel en -diagram illustreer dat die voorwaardes vir 'n volhoubare huishoudlike gebou nie bereik word nie.

Die studie aanvaar die FOURways huis as 'n verteenwoordigend vir die vorige ses LSM groepe, en vind dat volhoubare ontwikkeling in hierdie huis-sektor dringende aandag nodig het as volhoubaarheid oor die hele reeks woongeboue in Suid Afrika bereik wil word.

and being built for the house-owners and

The name has been recognized as an important factor in the design and construction of a building. The name of the building is a reflection of the building's identity and a sustainable building should reflect the values and principles of the building's owner group. The middle income group is one of the largest and most diverse percentage of the population group in South Africa. It is therefore important that this group sets a good precedent to follow and is therefore important that they and achieve sustainable building design in South Africa. The research objectives of this study is to investigate the applicability of the SBAT tool to the middle income group and to develop a set of design principles for a sustainable building design.

Furthermore, the study aims to investigate the applicability of the SBAT tool to the middle income group and to develop a set of design principles for a sustainable building design. The study also aims to investigate the applicability of the SBAT tool to the middle income group and to develop a set of design principles for a sustainable building design.

1.1 Statement of the problem

This research proposes to develop a set of design principles for a sustainable building design for use in medium density residential developments in South Africa (FOURways houses). The study will use the Sustainable Buildings Assessment Tool (SBAT) to assess the applicability of the SBAT tool to the middle income group and to develop a set of design principles for a sustainable building design.

CHAPTER I *Introduction*

1 INTRODUCTION - THE PROBLEM AND ITS SETTING

This dissertation aims to address the current scarcity of accessible information on sustainability specifically aimed at house type and location. The study ultimately aims to inform architects and designers, developers, builders and users how to realise a sustainable building environment in the medium density, middle-income housing group in the province Gauteng, South Africa.

Sustainability is generally the term used to describe an environmentally responsible way of designing while simultaneously meeting the needs of current users and respecting the needs of future generations. Design that is balanced in its giving and taking from the natural environment.

The home has been recognised as an influential factor that contributes to sustainability and the health of the living environment. Current information available on sustainable building design does not address the specific needs of the middle-income group. The middle-income group is an important role model that a large percentage of the population group aspires to follow. Promoting sustainability in this group sets a good precedent to follow and is therefore important to promote and achieve sustainable building design in South Africa. The provision of information dedicated to this economic group will assist efforts to achieve greater sustainability and a continued habitation of our corner of the planet.

1.1 *The definitions*

Furthermore, South Africa covers a number of different climatic, geological and ecological areas which all have different requirements in terms of sustainability. Sustainable principles that are area specific will be generally appropriate and more accessible to implement, resulting in wider application in the built landscape.

The analysis will be limited to sustainable building design through the study of

1.1 **Statement of the problem**

This research proposes to develop accessible information on sustainable building design principles for use in medium density, middle-income houses in Gauteng, South Africa (FOURways house). Local and international precedent together with the Sustainable Buildings Assessment Tool (SBAT) developed by the CSIR will be analysed to specifically address the criteria for a sustainable FOURways house.

The expected life span of the information presented is approximately two decades (roughly based on the current rate of technological development)

1.2 The sub-problems

1.2.1 Sub-problem 1 The first sub-problem is to define and discuss sustainable building design principles.

1.2.2 Sub-problem 2 The second sub-problem is to test the SBAT towards achieving sustainable building design principles for medium density, middle-income housing in Gauteng (the FOURways house).

1.2.3 Sub-problem 3 The third sub-problem makes use of the first and second sub-problem findings to analyse the use (or lack) of sustainable building design principles in current examples of the FOURways house. This sub-problem highlights the difference between buildings that do and do not make use of sustainable building principles.

1.3 The hypotheses

1.3.1 Hypotheses 1

The first hypothesis postulates that available information on sustainable building design does not address the specific needs of the FOURways house.

1.3.2 Hypotheses 2 The second hypothesis is that the adapted SBAT will produce criteria towards achieving sustainable building design principles for the FOURways house.

1.3.3 Hypotheses 3 The third hypothesis is that typical FOURways houses in Gauteng currently do not make use of sustainable building design and construction.

1.4 The delimitations

1.4.1 Geographical delimitation

The study is limited to middle income housing developments within the Gauteng provincial borders.

The analysis is limited to medium density housing developments within the urban area.

The analysis will be limited to sustainable building design principles; the aesthetic merit of the selected architectural designs will not form part of this study.

The study does not discuss the effect of sustainable building design and the healthy environment on the psychological well being of the occupants.

In this study the three-column definition of sustainability is acknowledged, however, the detailed study will exclude economic aspects of sustainability.

The study is limited to literature available in English and Dutch.

The expected life span of the information presented is approximately two decades (roughly based on the current rate of technological development).

1.7 The assumptions

1.5 Abbreviations

CSIR -	Council for Scientific and Industrial Research
LSM -	Living Standards Measure
SAARF -	South African Advertising Research Foundation
SBAT -	Sustainable Building Assessment Tool
SBDP -	Sustainable Building Design Principles
GBC -	Green Buildings Challenge
GBTool -	Green Buildings Tool
GSBDP -	Sustainable Building Design Principles for Gauteng

1.6 The definition of the terms

Middle income group is defined in Section 2.5.2

Middle income house is defined in Section 2.5.2

Medium density house is either a cluster home or townhouse. A cluster home is a house situated on a secured single entry property with a number of free-standing houses that are of a similar style. A townhouse is a series of same style homes that are built with adjoining boundary walls. Both are generally situated in an urban area.

Gauteng, one of the nine provincial areas defined within the borders of South Africa. The geographical area, Gauteng houses the greatest percentage of working population in the country. It is located on the escarpment and is characterised by a Highveld climate.

FOURways house is a medium density, middle-income house in Gauteng.

Living environment is the physical space we inhabit. The space is defined by the enclosure created by the building structure composed of floor, walls and roof surfaces as well as the general natural area in which our built space exists.

Sustainability is defined and discussed in chapter three.

Health of the living environment constitutes the physical and psychological comfort and protection that the built environment and its surroundings provide human beings. A healthy living environment does not harm the body or the natural environment and is conducive to well being.

1.7 The assumptions

1.7.1 Assumption 1 The first assumption is that the middle income group will continue to be an identifiable sector of the urban population that influences the built environment.

1.7.2 Assumption 2 The second assumption is that medium density homes will continue to be developed for at least another two decades.

1.7.3 Assumption 3 The third assumption is that sustainability can be assessed using local and international precedent as well as the SBAT so that improvements can be made to current and new FOURways houses.

1.7.4 Assumption 4 The fourth assumption is that people who fall in the middle income group in Gauteng are interested in their well-being and therefore will actively take steps to improve the health of their living environment. A need for information on sustainable building principles for medium density, middle income houses does therefore exist.

1.8 The importance of the study

A symbiotic relationship can exist between man and the natural environment. World-wide the issues regarding the exploitation of our natural resources are being addressed. In order to sustain human life on earth it is important to understand the impact of human habitation and stress the importance of sustaining a habitable environment. Housing forms a cornerstone of our survival on earth; therefore all housing projects should address the issue of sustainability.

In South Africa most research focuses on the sustainability of low-income housing developments. The opposite end of the economic scale the high-income earners are supporting sustainability as a fashionable issue. Current housing developments illustrate that little emphasis is placed on the role that the middle-income group can play in contributing to a sustainable environment.

This group forms a role model which lower income groups aspire to. If sustainability is to be successfully implemented the importance must be addressed at all economic levels. The middle income group is a considerable market force and will greatly help in a market transfer equalling motion towards sustainable building and building materials.

The provision of information dedicated to this economic group will assist efforts to achieve greater sustainability and a continued habitation of our corner of the planet.

The contribution that middle-income earner can make to sustainable development is invaluable and must be addressed as part of a holistic approach to a sustainable future.

The information that this study aims to present is directed at all interested parties, casual users and professional designers alike. This study aims to address the issues of sustainable building development in South Africa and to make otherwise inaccessible information available to all interested parties.



Figure 1.1 – “No- this time we are doing without humans” (Vanderstadt 1996:96)

CHAPTER II

2 THE REVIEW OF RELATED LITERATURE AND INFORMATION AVAILABLE

2.1 General overview of literature available on sustainable building design

There are several books available that discuss the topic of sustainability and the healthy home environment that will form a basis of reference for the analysis. Information will be primarily sourced from literature in English and Dutch available from the Academic Information Service at the University of Pretoria and the researcher's private collection. Other library catalogues and the World Wide Web will supplement the primary sources of data. Key words and phrases for the search are 'sustainable-, green-, eco- and environmentally friendly -architecture and -construction', 'nature conservation' and 'environment'.

A criterion for relevant literature is the accessibility as well as the scientific backing of the content, implying that there needs to be a step from the scientific to the more popular writing style. The results of this study are to be accessible to a broad public and not deemed for professionals alone. A catalogue search using the keywords revealed that available literature is either presented scientifically and excludes non-specialists or has no relevant information for application in South Africa.

The first book referenced on the topic that satisfied the criteria was *The natural house book – Creating a healthy, harmonious and ecologically sound home* by David Pearson (first print 1989). This original Gaia book is written in a popular style which eleven years onwards remains a best seller. In 1998 Pearson published an updated book *The new natural house book – Creating a healthy, harmonious and ecologically sound home* which again has reached best-seller status. It is one of the first works where the *Gaia* principle is presented to the broader public through a 'coffee table' book style. "...the earth and all its life systems as an entity, Gaia (the ancient Greek Earth goddess), which is self sustaining and has the characteristics of a living organism...the house is seen as an micro-ecosystem, interacting with the wider ecosystem of Gaia." (Pearson 1989:21) The book is characterised by an easy reading style, clear illustrations and descriptive photography. It is a manifesto to enduring quality and a definitive work presenting the subject of sustainability that is accessible to a broad public.

The recent increase in available publications displays the growing demand for books that discuss various aspects of sustainability. When selecting books further criteria are recent publication date and the inclusion of recent technical advances and examples. *The Healthy House – Creating a safe, healthy and environmentally friendly home* by Sydney and Loan Baggs (1996) contains holistic practical advice on the prevention of building pollution. The authors combine science and technology with philosophy to present the idea of the earth as an organism that we should choose to live on suitable, considering the needs of both people and the natural environment. *Architecture and the Environment – Bioclimatic Building Design* by David Lloyd Jones (1998) presents recently completed mainstream architectural works that are also environmentally responsible. The discussion chapters preceding the examples concisely discuss a broad range of data relevant to assessing the environmentally responsive designs presented. *Geopathic Stress – How earth energies affect our lives* by Jane Thurnell-Read (1995), is a scientific based research presented not as a report but a readable book. The content is informative and accessible to lay people.

Other literature may be released or become evident as the research progresses and these may form part of the analysis. South Africa has unique problems and available information must be adapted for local use. While lessons can be learnt from international examples of sustainable buildings, the application of available information must always be in terms of the South African context. Appropriateness and accessibility are the keywords to developing user-friendly guidelines.

2.2 Historical overview of international sustainable building design

Interest in sustainability is not merely a passing fashion. History illustrates that societies have from early times realised that in order to sustain life on earth we must respect the natural order of the environment. A respect for nature dates back to ancient times when the sun was revered and knowledge of the earth was passed on from one generation to the next. The earliest pictographic recording of the earth sciences can be found in murals in Mesopotamia and Egypt. Knowledge about survival was associated with the need for shelter, protection, food and clothing. An understanding of nature in the form of environmental design has its origins in the earliest times when man began to build shelters. The shelter was the primary medium of environmental control. The fabric of the shelter was the interface between the external and internal environment, man's second skin. The origin of Environmental Design Theory can be traced back to the "*Ten Books of Architecture*"

by Vitruvius. In Book IV Vitruvius wrote (Hawkes 1996:12): "In the north, houses should be entirely roofed over and sheltered as much as possible, not in the open, though having a warm exposure. But, on the other hand, where the force of the sun is great in the southern countries that suffer from heat, houses must be built more in the open and with northern or north-eastern exposure. Thus we may amend by art what nature, if left to herself, would mar." In other books he discusses issues such as the site of a city, direction of streets, even the correct exposure of different rooms for maximum comfort is discussed

Since the time of Vitruvius there have been many architectural movements, yet as society develops and techniques improve we become more and more engrossed in a consumer society which has lost its respect, understanding and appreciation of nature. Modern society scarcely appreciates the passing of day and night characterised by the movement of the sun and moon. Industrialisation resulted in rapid urbanisation and population shift, which has led to the loss of skills and understanding with regard to human survival on earth.

Luis Barragán clearly described the modern attitude when he wrote:

"Before the machine age, even in the middle of cities, Nature was everybody's trusted companion....Nowadays, the situation is reversed. Man does not meet with Nature, even when he leaves the city to commune with her. Enclosed in his shiny automobile, his spirit stamped with the mark of the world whence the automobile emerged, he is, within nature, a foreign body. A billboard is sufficient to stifle the voice of Nature. Nature becomes a scrap of Nature and man a scrap of Man." (Frampton 1992:319) (See Figure 2.1)

The energy crisis of the seventies is seen by many as the instigator of debates addressing the issues of modern development versus the natural environment. Whether it was a political issue, or the threat of a global shortage of energy, is irrelevant, the renewed awareness that human survival on earth depended on man's attitude has forced many designers to address the issues surrounding the building and its use of energy.

In architecture the movement known as 'Critical Regionalism' can be seen as the move away from Modernism to a more nature specific approach to building design. Critical regionalism respects the local climate, light and topography. It is characterised by the use of local materials, crafts and techniques, effect of local light

and natural topography. It does not exclude modern techniques nor does it become sentimentally vernacular; however, the vernacular is respected as having grown out of the requirements of that locality. The building materials growing in a specific location are usually the most suitable building solutions for that specific climate providing the right type of comfort and protection. Critical regionalism can be identified globally in the work of the Mexican Luis Barragán, Finnish Alvar Aalto, Japanese Tadao Ando and many other international architects.

In recent years the German Institut für Baubiologie & Oekologie (Institute for Building Biology and Ecology) has led Europe in heightening the consciousness of people as to the problems of development and environmental sustainability. Building bio-ecology takes a step further than critical regionalism. The aim is not only to integrate the building with the environment but that it should integrate the whole process of human settlement with nature in a sustainable way. "In future we have to recognise that we are a part of nature and that everything we do to the natural world, we are actually doing to ourselves...Integration is our goal. The question is how to integrate nature with habitat" (Berström *et al* 1992: 2). A holistic approach to human habitation is required. The built environment and the natural environment must be recognised as being part of one ecosystem.

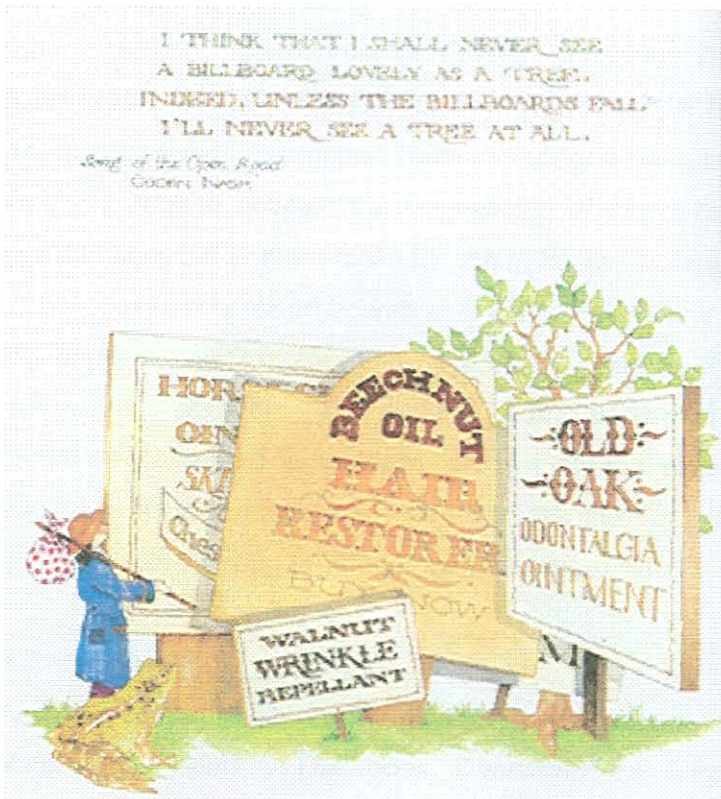


Figure 2.1 - Of trees and billboards. (Denman 1990)

Internationally the idea of permaculture is growing. Permaculture goes beyond the ideas of building biology. Permaculture is not only permanent agriculture but a type of habitation, "a planning and design method with the aim of creating stable self supporting systems, a sustainable economy and culture based on ecological principles, and adequate supply of wholesome food, energy, warmth, beauty and meaningful pursuits. They provide at the same time a vision and a firm ethical base" (Kennedy 1992:46). Ralph Erksine's work at 'Ekerö Mälartown' in Stockholm is an example of an ecological approach.

While lessons can be learnt from international examples of sustainable buildings, the application of available information is not always appropriate to the South African context. South Africa has its own unique problems and available information must be adapted for local use.

2.3 Precedent towards achieving sustainable building design principles for the FOURways house

2.3.1 South African precedent

The Department of Mineral and Energy affairs have released a series of policy and design guidelines promoting the efficient utilisation of energy in buildings in Southern Africa. The '*Primer on Energy Conscious Design*' by D. Holm and R. Viljoen (1996) and the '*Manual for Energy Conscious Design*' by D. Holm (1996), provide accessible information that encourages the use of passive solar design. This study aims to emulate the accessibility of this document with a broader focus on sustainable building practices for use in middle income housing developments.

The non-governmental organisation – Earthlife, in early 2000, launched the *green living and development files* that deal with a diversity of aspects concerning green building and habitation. The content of this document is diverse and where the information presented is relevant to the Gauteng area it will be included in the guidelines. These files are open for perusal on the World Wide Web at <http://www.earthlife.org.za-ghouse-gfiles-aware.JPG>

2.3.2 International precedent

The Dutch concept of 'bio-ecological building' is brought to public attention by Hugo Vanderstadt (1996). The book *Duurzaam en Gezond Bouwen en Wonen* (Sustainable and Healthy Building and Habitation) will be reviewed for information

relevant to the South African situation and the presentation and accessibility of information.

Professor Peter Schmidt of Eindhoven University of Technology is a leading figure in Europe on the subject sustainability. He has written and presented various papers which display his deep understanding of the inter-linking of all aspects, human and scientific, to achieve sustainability. His approach to the problem of sustainability may be described as holistic and at times esoteric. Professor Schmidt's biological sustainability is beyond the limits of this research, but credit must be given for both the success of his initiatives and popularity among colleagues.

The World Wide Web (Internet) sourcebook, '*Sustainable Building Sourcebook*', was developed as part of the Green Building Program by the City of Austin, U.S.A. It is divided into the different aspects of the construction process. Each subject is discussed according to its sustainability with guidelines for relevant use. A critique revealed that many topics are relevant for discussion, but the specific information is not relevant to the South African situation. The sourcebook is available on the World Wide Web at <http://www.greenbuilder.com/sourcebook>

Many countries have been involved in the development of an assessment tool to rate buildings for their sustainability. One of these is the British Centre for Sustainable Construction that has developed the Building Research Establishment Environmental Assessment Method (BREEAM). This method assesses the environmental impact of a building with regard to the global, local and internal environment. The method is highly technical and specific to European conditions and is therefore not appropriate for use in this study. The Green Buildings Tool (GBTool) developed by the Green Buildings Challenge (GBC) is an international initiative supported by 17 countries as an attempt to equalise parameters for assessing the sustainability of a building through a rating system. Various tools including BREEAM have been used to develop the GBTool. The GB Tool has a module for multi-residential units which is interesting in terms of the medium density, residential aspect. This document, however, remains the domain of 'green specialists' requiring many scientific readings and team of assessors and is therefore inappropriate for daily quick reference by all players in the built environment. This assessment tool is not suited to the study aim. The GBTool is available for downloading on the World Wide Web at <http://www.greenbuilding.ca>

2.4 Overview of the growing concern in South Africa with sustainability

The literature available on sustainable building design in South Africa is growing. The South African Green Building Initiative was launched at the University of Pretoria on 5 June 1997. The Initiative currently focuses on commercial buildings, yet many of the concerns are parallel to housing. The Initiative recognises that; “healthy and environmentally sound buildings can reduce illness and absenteeism, boost morale, and increase productivity. Additionally, the use of energy efficient technologies and practices can substantially reduce company operating costs” (Conserva 1997:21). The above motto can easily be applied to the housing sector as well. South Africa must strive to improve the quality of life of all people both at home as well as the workplace.

The Green Buildings for Africa (GBFA) launched in 1998 by the CSIR Boutek takes the 1997 initiative into action by assessing projects for their environmentally responsible usage. The GBFA represents South Africa in the Green Buildings Challenge (GBC).

Various non-governmental organisations such as World Wildlife Fund, Earthlife and Green Peace are using their influence to promote conservation and sustainability on the large scale at governmental policy level to ensure every effort is made to preserve the natural environment. While South Africa is using many of the ‘buzz’ words for sustainability these organisations are ensuring that international agreements signed, such as the Kyoto protocol of 1997 (Lace 2000:64), will be upheld.

The government has published a white paper on the “Conservation and Sustainable use of South Africa's Biological Diversity”, however this document only touches on the issues relevant to the building industry. The department of housing has committed to sustainability by including the issue in both the “Housing Act” and the “Housing Bill” and the initiative “African Solutions Towards Sustainable Urban Development”. Which aims to uphold the slogan; “Creating a network of learning for the sustainable development of African cities”. The department of housing has also printed a guideline for “Environmentally Sound Low Cost Housing” which is a specific move to address sustainable buildings within the broader aim of sustainable development. These specific moves by the government indicate their commitment to sustainability as a whole.

The South African Sustainable Building Environment Conference in 1998 and 2000 held in Gauteng brought together diverse local and international professionals who represent the growing concern for sustainability in South Africa. These gatherings are an initiative to stimulate discussion specific to sustainability in South Africa.

The CSIR offers two tools for assessing the sustainability of a building, the GBTool and SBAT. SBAT is essentially a quick check that can be used throughout a project compared to the specialised GBTool, which requires expertise as well as many measurements. The CSIR is currently developing SBAT as a local, widely accessible derivative of the GBTool. It is being developed as a tool that can be used from the outset of a project by the whole project team including the client, architect, developer etc. It does not require specific tools of measurement but rather sets out parameters when adhered to achieve a more sustainable building. Use is made of the three-column definition of sustainability, which include economic and social aspects as well as the obvious environmental issues.



Figure 2.2 - Map of South Africa (Tyson et al. 1995: 49)

Gauteng, 'place of gold' in the Sesotho language occupies the area previously known as the Pretoria-Witwatersrand-Vereeniging triangle (PWV), covering an area of 19 810 square kilometres (see Figure 2.3). The industry and commerce in the

2.5 Literature on middle income housing development in Gauteng

2.5.1 Defining the Gauteng area and identification of developing areas

Literature on Gauteng, South Africa relevant to this study is available in the *Environmental Potential Atlas for South Africa* by Van Riet *et al* (1997). This is one of the only comprehensive works that focuses beyond urban location and land form to include a diversity of interrelated information including demographics, geology, vegetation and so on.

The statistical information is to be gleaned from The South African Bureau of Statistics and the South African Advertising Research Foundation as these sources provide the most recent and accurate information required.

Gauteng is one of South Africa's nine provinces. Located inland on the Great Escarpment it is bounded by the Northern Province in the north, Mpumalanga in the east, Free State in the south and North-West Province in the west (see Figure 2.2). Johannesburg is the provincial capital. Gauteng is located between the 25th and 27th latitude south and the 26th and 28th longitude east.

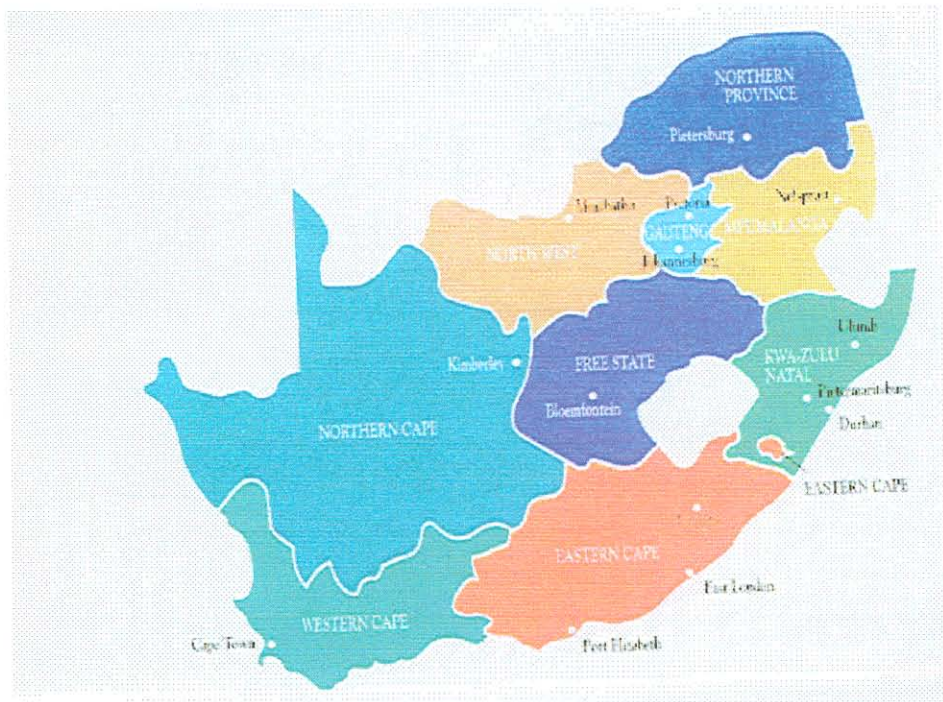


Figure 2.2 - Map of South Africa (Tyson *et al* 1996:49)

Gauteng, 'place of gold' in the Sesotho language occupies the area previously known as the Pretoria-Witwatersrand-Vereeniging triangle (PWV), covering an area of 18 810 square kilometres (see Figure 2.3). The industry and commerce in this

area produce nearly 40% of the GDP with 70% of the country's labour force. Major mining houses, insurance, banking and financial corporation headquarters are located in this province.

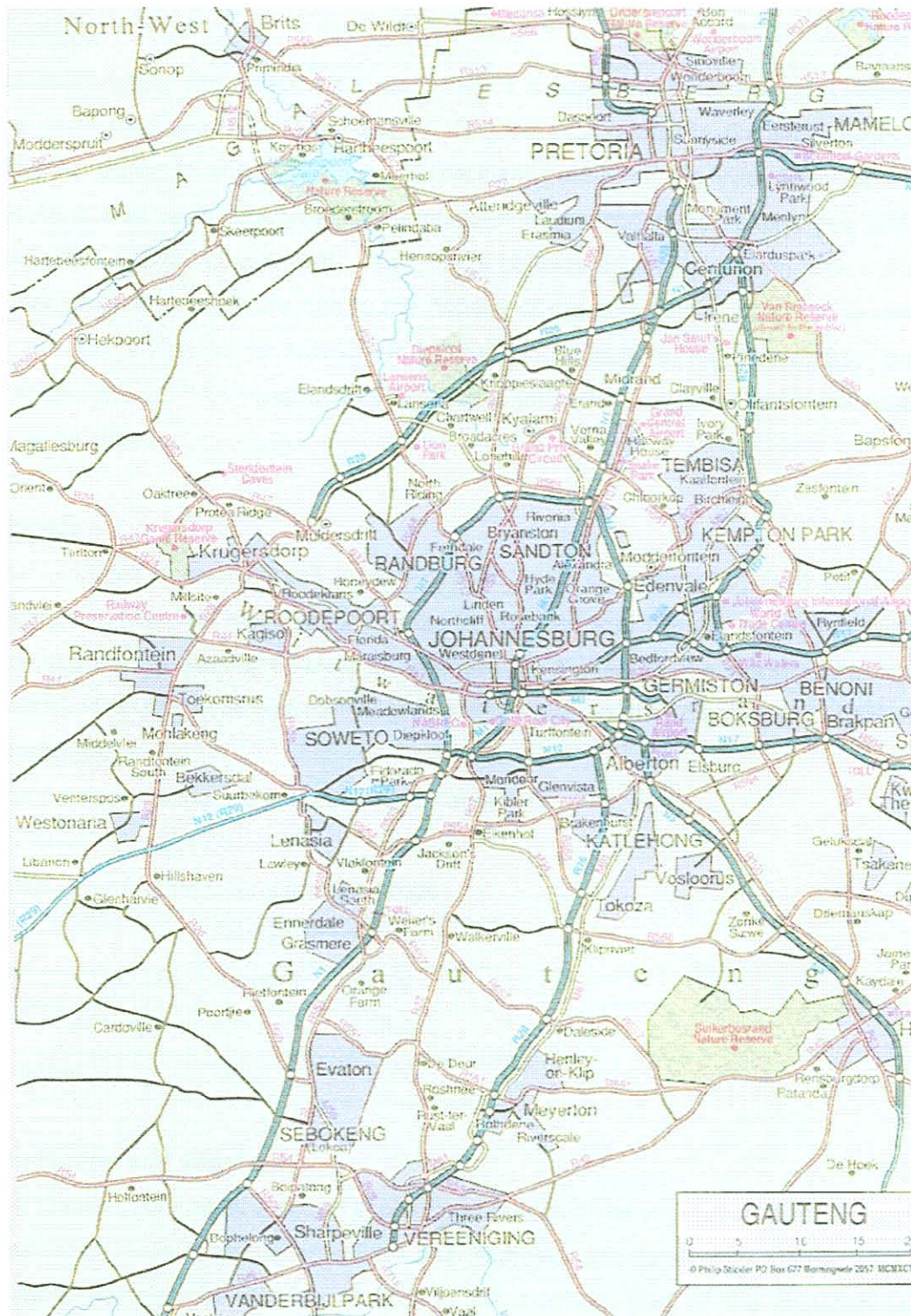


Figure 2.3 - Map of Gauteng (Smith 1998:8)

Gauteng is the most densely populated province with 7,4 million people in 1996 (Tyson *et al* 1996:46). The large number of urbanised people has resulted in a housing crisis with many being housed in squatter developments.

Location

Gauteng drains into three catchment areas, Limpopo in the north west, Olifants in the north east and Vaal to the south. The summer rainfall in Gauteng made it a suitable region for maize farming. Dependant greatly on the Vaal Dam for water Gauteng due to the high-density population has a runoff per capita per annum being below 500 cubic metres. Gauteng is considered an area with high surface water production pressure due to the density of the population. Water is essential to life and is needed for survival and growth in agriculture, industry and for basic human survival. The importance of economic and effective use of water in Gauteng must be stressed.

Climate

The average annual rainfall is 650-800mm, with characteristic short but heavy thunderstorms. The wet season occurs in summer and the dry season in winter. The average of sunshine hours is amongst the highest in the world. The winter months are characterised by a great difference in the diurnal and nocturnal temperatures.

The average temperature is 20°C (see Table 2.1)

Table 2.1 – Gauteng temperature range

	Temperature range	
	January	July
Johannesburg	26°C.	16.5°C.
Pretoria	28°C.	20°C.

Landscape and vegetation

The Gauteng biome as a broad ecological association of vegetation types is mostly grassland (rocky Highveld grassland and Highveld grassland) with a small section of savannah (sweet/mixed bushveld) in the northern part of the province (see Figure 2.4). The vegetation types named are the originals before farming and urbanisation changed the grasslands to maize and wheat farming and urban development with its concrete, asphalt and exotic plants.

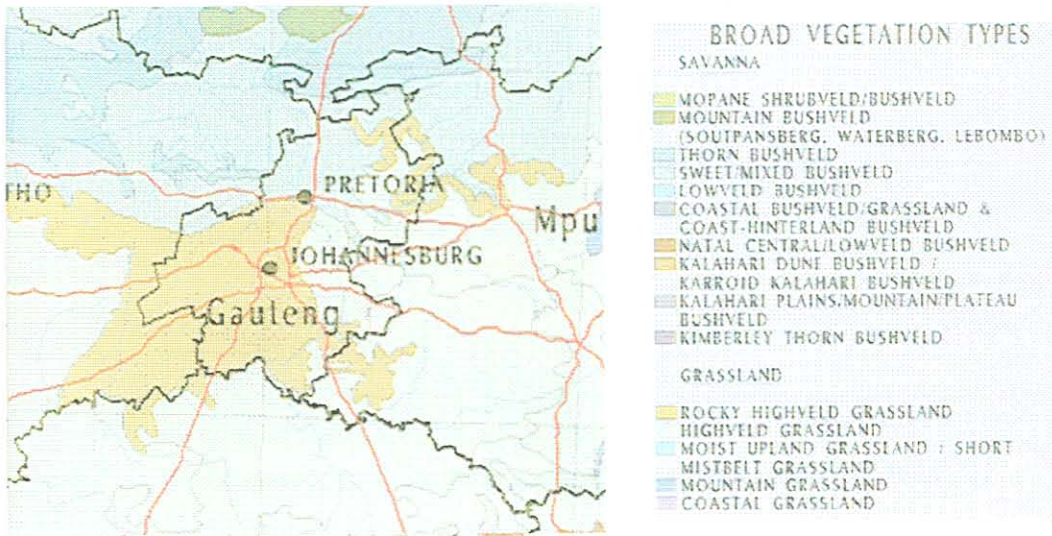


Figure 2.4 - Broad Vegetation types of Gauteng (adapted from van Riet *et al* 1997: 12)

Landscape scenery is an important aspect of the human appreciation of the environment. The greater part of Gauteng is low lying with relief from higher lying ridges such as those around Pretoria, Bedfordview and the beginning of the Magaliesberg etc. Gauteng is considered to have an average natural resource for human appreciation, the metropolitan areas however cannot produce sufficient biomass for the high population. The land is not able to generate biomass to sustain life both in the natural and agricultural environment.

Geology

The geology of an area influences the soil, vegetation and landforms. The Witwatersrand quartzite led to the gold rush and consequent urbanisation of Johannesburg and its surrounds. The mining activity has had an impact on the environment. The issues are to minimise the impact of mining on the environment. Generally Gauteng has a low susceptibility to erosion. If one is the greatest susceptibility on a scale of one to twenty, the areas in Gauteng have a rating between twelve and eighteen. Even though Gauteng has a high population density the geology of the area ensures that there is only a low susceptibility to erosion (see Figure 2.5).

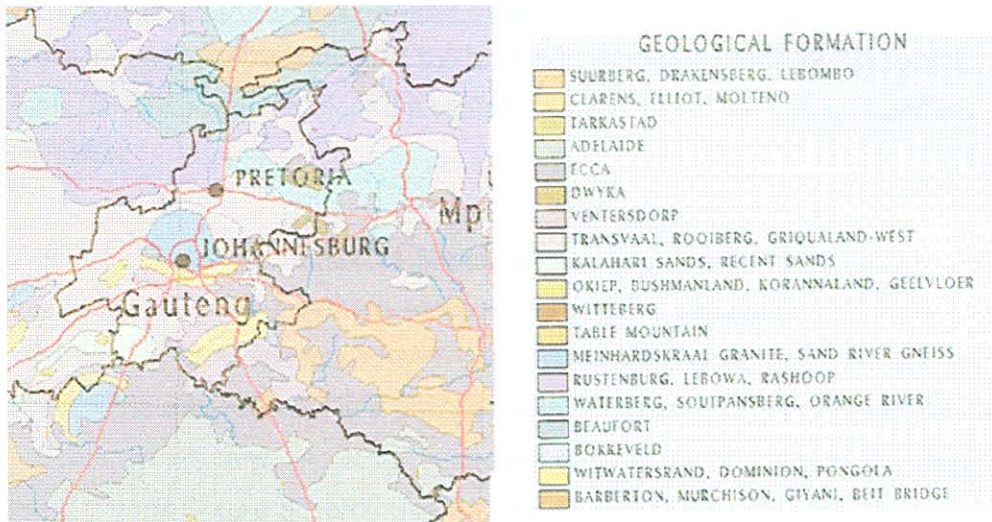


Figure 2.5 - Broad geology of Gauteng (adapted from van Riet *et al* 1997: 6)

Gauteng is in need of an environmental reconstruction programme in order to achieve an environmentally sustainable future. This programme must incorporate the need for economic development. Permanent environmental damage has already occurred due to uncontrolled urban sprawl and extensive mining. In order to sustain the environment for future generations an effort must be made to bring the situation under control and repair where possible. There are municipalities such as Midrand and Centurion that have applied control measures but the province as a unit should work as a team if these measures are to be effective.

2.5.2 The definition of middle income house

The **middle income group** is defined by the South African Advertising Research Foundation (SAARF) who developed a system in 1989 called the Living Standard Measure (LSM).

“The SAARF LSM (Living Standards Measure) has become the most widely used marketing research tool in Southern Africa. It divides the population into eight LSM groups, 8 (highest) to 1 (lowest). LSM-7 and LSM-8 are divided into Low and High respectively. The SAARF LSM is a unique means of segmenting the South African market. It cuts across race and other outmoded techniques of categorising people, and instead groups people according to their living standards using criteria such as degree of urbanisation and ownership of cars and major appliances.”
(<http://www.saarf.co.za>, January 2001)

The system therefore measures living standards better than single variables only, that is population, sex or age. The All Media and Products Survey reports for 2000A establishes that the population is categorised into eight LSM groups. Category 7 defines the group on which this research focuses; it is the most heterogeneous LSM of all and is composed of 11,4% of the adult population. This group is highly urbanised with nearly three out of five living in metropolises (59%) with strong representation in Gauteng (33%) and the Western Cape (22%). There is almost an equal distribution in gender: 49,6% male and 50,4% female. 6% have been to school...over half have gone at least as far as matric. Average income climbs sharply to R6 539 per month. Marriage is more common than in the lower LSMs with ‘young couples’ and ‘new parents’ just significantly above the country average. 28% of this group, unlike lower LSMs, can afford domestic help. This group includes the highest proportion of Coloured and Indian population than in any other LSM. (SAARF LSM, November 2000:48)

Middle income house

A middle income house is a house that is affordable for the middle income group. A general rule that financial institutions apply when granting home-loans is that the monthly instalment of a bond may not exceed 30% of the gross monthly income. The joint income of married couples is taken into consideration where applicable.

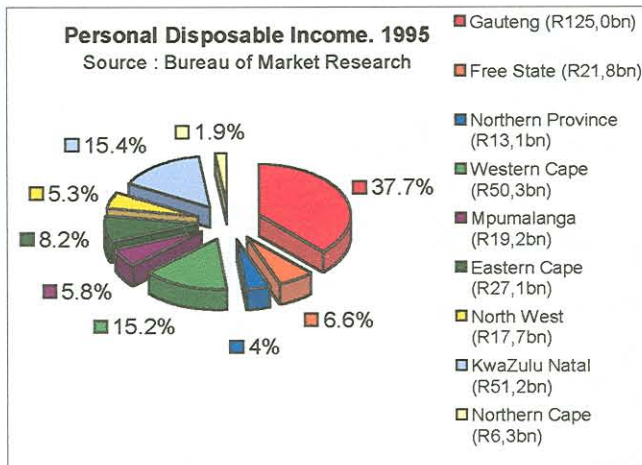


Figure 2.6 – Personal disposable income per province (Tyson *et al* 1996:52)

“Absa Bank calculates the maximum home loan that you can afford based on your monthly home loan repayment, not exceeding a maximum of 30% of your single or joint gross monthly income. This is done so as to reserve cash for the remaining household commitments. The restriction of up to 30% is necessary to ensure your other monthly expenses are met adequately from your remaining household income, and to avoid financial difficulties in the future.” (<http://www.absa.co.za>, 25 January 2000). Taking a bond repayment over 30 years at prime rate (14-15 %) with a household income of R6 500 we can establish that a bond of approximately R 170 000 will be granted to a family with a middle income. A middle income house is therefore a home valued at approximately R170 000.

LSM 7 is associated with specific consumer behaviour, which has an impact on the requirements that will be set when selecting a home. Table 2.2 illustrates the demographics and residential character of this group.

“The only dwelling types of significance in this group are houses (79%) and flats (15%). Cluster/townhouse accommodation stands at 3%, making the total for conventional urban type homes 97%. However, only 68% own the property they live in. Over a quarter (29%) have mortgage bonds. All have electricity, nearly all have in-home water (99%) – usually both hot and cold (93%) – and everyone has a flush toilet. All but 2% have a kitchen sink in their home, while one in ten has a pool.” (SAARF LSM November 2000:48-50).

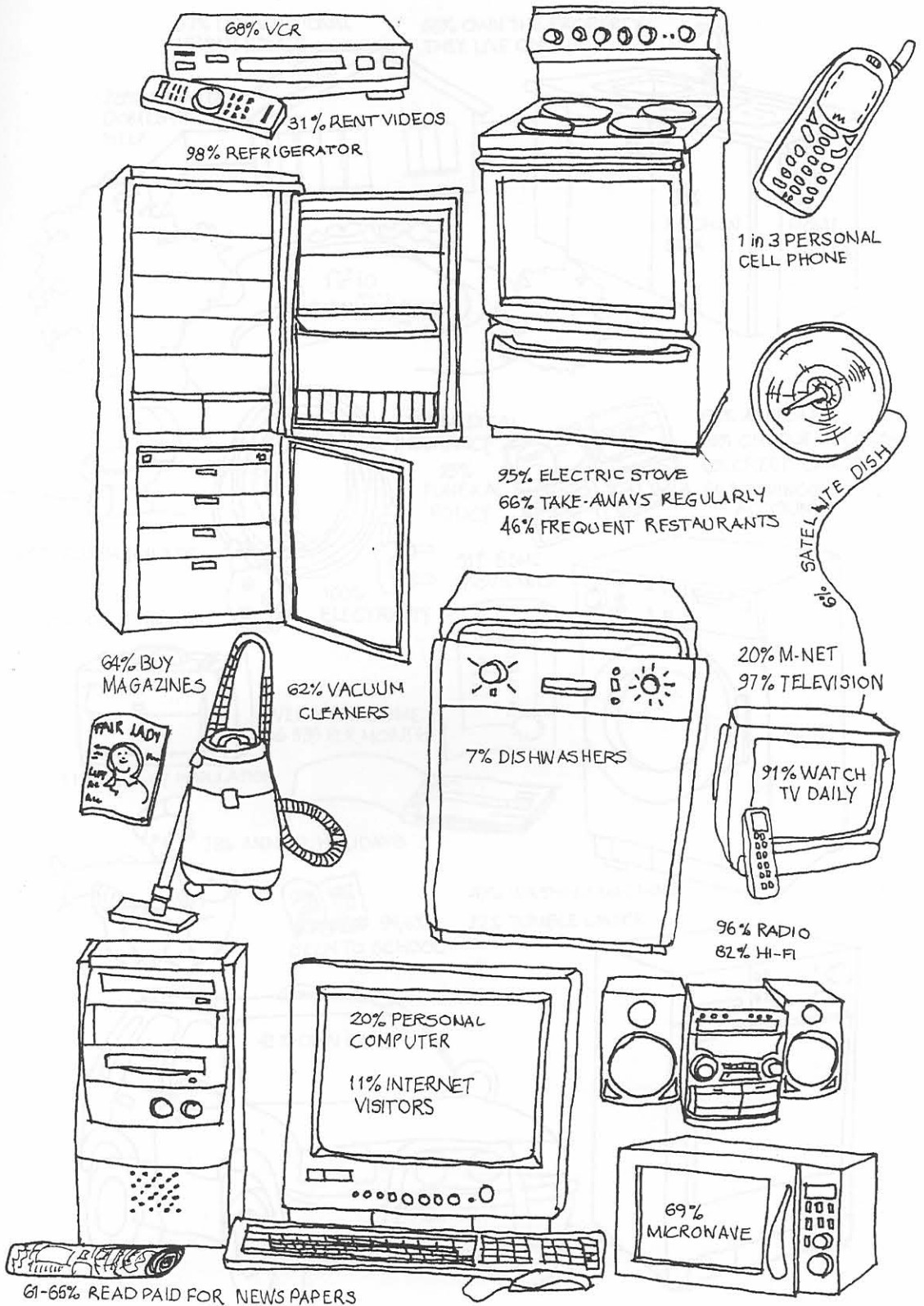


Figure 2.7a – Illustrating LSM 7 demographics and residential characteristics (adapted from SAARF LSM 2000: 50)

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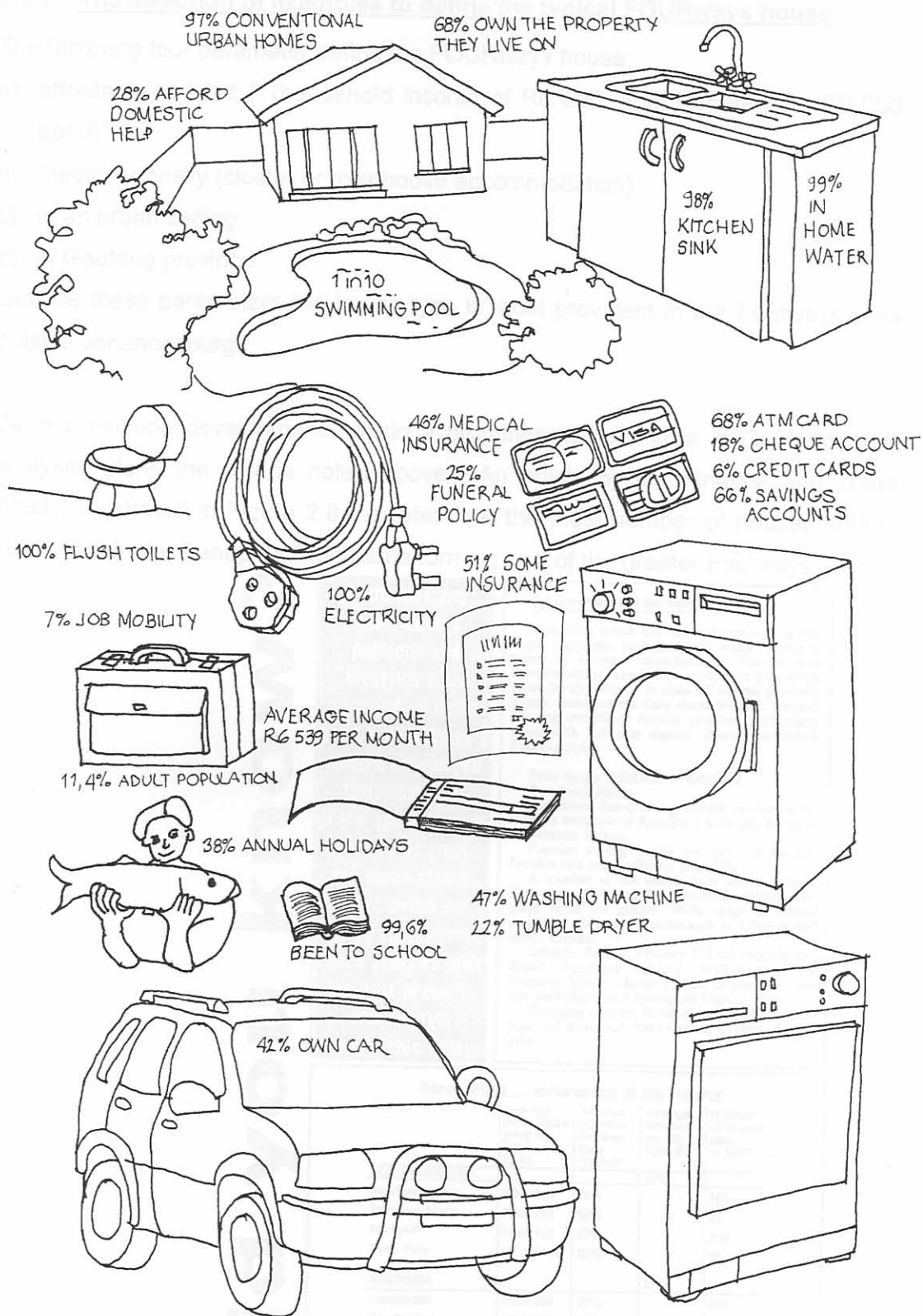


Figure 2.7b – Illustrating LSM 7 demographics and residential characteristics (adapted from SAARF LSM 2000: 50)

2.5.3 The selection of examples to define the typical FOURways house

The following four parameter define the FOURways house:

- affordable to LSM 7 (household income of R6 500, approximately R 170 000 bond)
- medium density (cluster or townhouse accommodation)
- in an urban setting
- in Gauteng province

Outside these parameters the house type is most prevalent in the Fourways area outside Johannesburg

Various housing developments within a prominent growth area in Gauteng were analysed along the criteria noted above. An article by the Finance and Trade Weekly illustrated in Figure 2.8 indicates that the most number of houses sold in 1997 were in the Randpark Ridge area forming part of the greater Fourways area.

Did you know?

South Africans' home buying patterns and lifestyles have changed so much over recent times a suburb considered fashionable 10 years ago, no longer necessarily enjoys the same status. F&TW carried out a survey to determine which suburbs offer the best property and lifestyle investments today.

Johannesburg and surrounds

Escalating crime has made safety one of the most important considerations when buying a home in Greater Johannesburg. That is why suburbs with manned access control, or permission from the city council to close off streets, generally attract more interest than those without. Secured housing complexes remain popular, particularly those with full title stands allowing individual building styles.

Price range: R200 000 to R400 000

Randpark Ridge

Attractive, fast-growing suburb on the north-westerly outskirts of Randburg with easy access to the western bypass.

Popular among young married couples and families (see age profile on page 12).

A number of the streets have access control. Houses are fairly new (low maintenance) and offer good value for money. Wide range of cluster complexes. Several nurseries such as Lifestyle and Keith Kirsten.

Schools: Boskop Primary School (double medium), Randpark Primary, Weltevreden Park Primary, Trinity House Private School (primary and secondary) and Randpark High.

Shopping centres: Randridge Mall, Rock Cottage and Randpark Spar Centre. Close to North-gate.

House prices... performance of top suburbs

Suburb	Average purchase price in 1997 (000)	Average increase per area from 1994-97	Average increase per city 1994-97	Number of houses sold in 1997
JOHANNESBURG				
Randpark Ridge	R276 836	25%	15%	358
Parktown North	R492 701	33%		77
Northcliff	R457 100	27%		210
Hyde Park	R1 258 410	37%		36
PRETORIA				
Garsfontein	R266 286	27%	17%	241
Faerie Glen	R329 096	12%		207
Lynnwood	R430 587	31%		217
Waterkloof	R629 122	31%		340

F&T Weekly, 27 March 1998

Figure 2.8 – Marketing information adapted by developers from “SA’s best suburbs to live in” in *F & T Weekly*, March 27 1998, vol.50, no.12, p12-16.

A site visit to the area indicated that the strip flanking the highway ten kilometres to the north bounded by William Nicol Drive on the east and DF Malan Drive on the west (see Figure 5.1) indicates intense medium density development that is sold out before construction has commenced.

The case study has been selected from the Randpark Ridge, Weltevreden Park, Radiokop, North Riding area which is one the growth points in Gauteng. The area called North Riding is part of the extending urban sprawl originating from the central Johannesburg and Randburg area (see Figure 2.9). It is situated north-west of Johannesburg centre and forms part of the greater Randburg area. (see Figure 5.3)

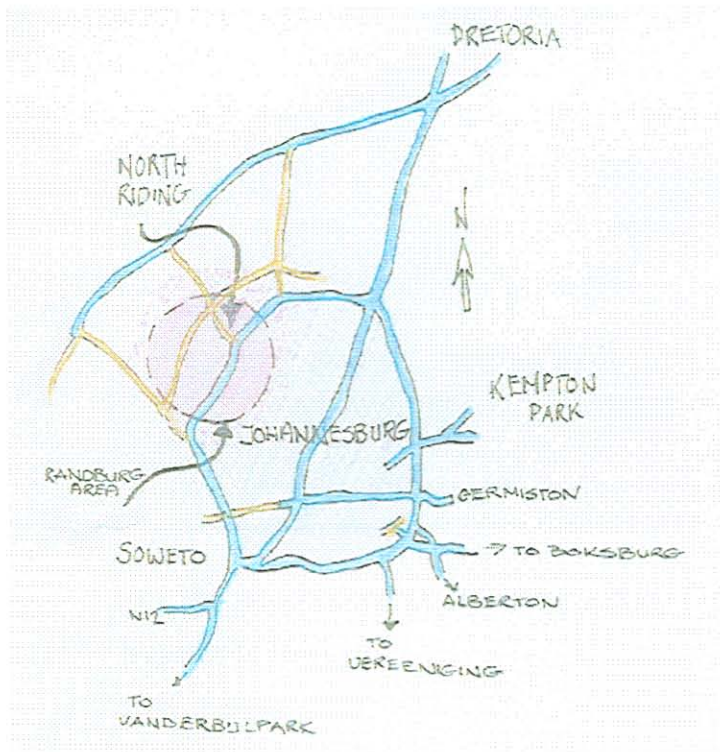


Figure 2.9 - The Randburg area relative to the area Greater Johannesburg

One housing development, with two variations, was selected for analysis. The development Ravenna in North Riding, which is partially complete and inhabited was selected for the case study. (see Figure 2.10) The developers were approached and permission was gained to access drawings and the site.

There are still several undeveloped stands on the site, which will be developed as home-buyers select and purchase off plan. Two new houses will be built as from January 1999 to stimulate further sales at Ravenna enabling an in-depth an of the construction process.

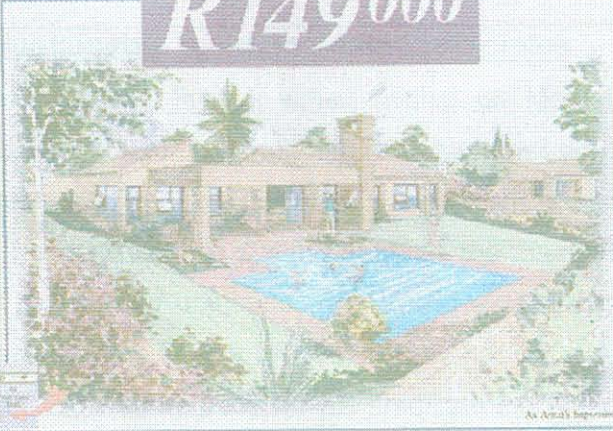
46 Saturday Star PROPERTY GUIDE November 14 1998

Shows Time

A UNIQUE, CLUSTER HOME IN NORTHRIDING (Blandford Road)

FROM **R149 000**

2+3 BEDROOM FREEHOLD CLUSTERS ON LARGE INDIVIDUAL STANDS



Clear in Northridge and Sunnyside
Established development, paved roads, all services etc.
Safe effective security in place!

BUY WITH COMPLETE CONFIDENCE!

HOMES
ESTABLISHED INTO
Building fine homes
for over 25 years.

NO ONE IN THE NORTH GIVES YOU MORE VALUE FOR YOUR MONEY THAN WE DO!

Call: **011-252-5555**
On Show Sunday 11am - 5pm

011-7541 (Office) 011-250-5151

Follow the water mainline from the main
Strip to the Blandford Drive to site in
Northridge Road.

Figure 2.10 - The advertisements of the case study (The Saturday Star – Property Guide 14 November 1998: 86)

CHAPTER III –

3 SUSTAINABLE BUILDING DESIGN PRINCIPLES (SBDP) AND THE FOURways HOUSE

Sub-problem 1 The first sub-problem is to define and discuss sustainable building design principles.

Hypotheses 1 The first hypothesis postulates that available information on sustainable building design does not address the specific needs of the FOURways house.

3.1 Defining sustainable building design principles

Four hundred years ago the French writer, Michel de Montaigne (1533-1592), warned us when he wrote, "Let us permit nature to have her way: she understands her business better than we do" (Hawkes 1996). In a world dominated by technology people no longer connect with nature as the source of their existence, instead they try to control and dominate her. World-wide environmental chaos is not surprising considering the lack of respect society has for nature, if we continue to destroy the planet at the same pace we will eradicate the source origin and basic survival. The implications of such a tragedy are too numerous to mention; hunger, lack of oxygen, polluted water, illness and ultimately death are only part of the scenario.

The Brundtland Report of 1988 contains the internationally accepted definition of sustainability, which reads as follows: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition falls short in terms of protecting the natural environment itself. A broader definition is more appropriate. D.L. Jones (1998:44) adapts the definition to read: "Development that meets the needs of the present and is at least as valuable to future generations as the value of the environmental exploitation that results".

The research into the definition of sustainability reveals that an even broader definition, which includes social and economic criteria as well as the environmental criteria, must be acknowledged as integral to achieve sustainable building design. This research will not discuss the economic aspects of sustainability. The social criteria are seen as inter-linked with the living environment and well-being and therefore are not dealt with separately.

Consider the meaning of the words “sustain” and “sustainable” as described in the Collins English Dictionary (1977:1034): “**sustain** (sus-tān’) v.t. to keep from falling or sinking; to support or uphold; to nourish or keep alive; to endure or undergo; to withstand; to encourage... - **sustain’able** a. —...the act of sustaining; support”.

Also consider the Gaia principle defined by Doctor James Lovelock which: “proposes that all life on Earth has a symbiotic relationship with the planet....We are our environment (and vice versa) at a very fundamental level” (Baggs *et al* 1996:14). Combine these statements to conclude that if we do not sustain, nourish or uphold our planet we are killing our environment, and in so doing we are committing suicide.

Sustainable building design aims to assist the renewed relationship between people and the environment. A balanced design integrates the building ecosystem with the natural ecology; design through which nature and man are reunited (see Figure 3.1). A sustainable design has increased efficiency, fewer toxins, less pollution and healthier natural systems; it benefits rather than destroys the inhabitants' sense of well being.

"It will enhance the life of all species and, therefore, reduces fear or insecurity, and produces hope for the future. In a sustainable system, every element fulfils many different functions, and every function will be fulfilled by many elements. Thereby

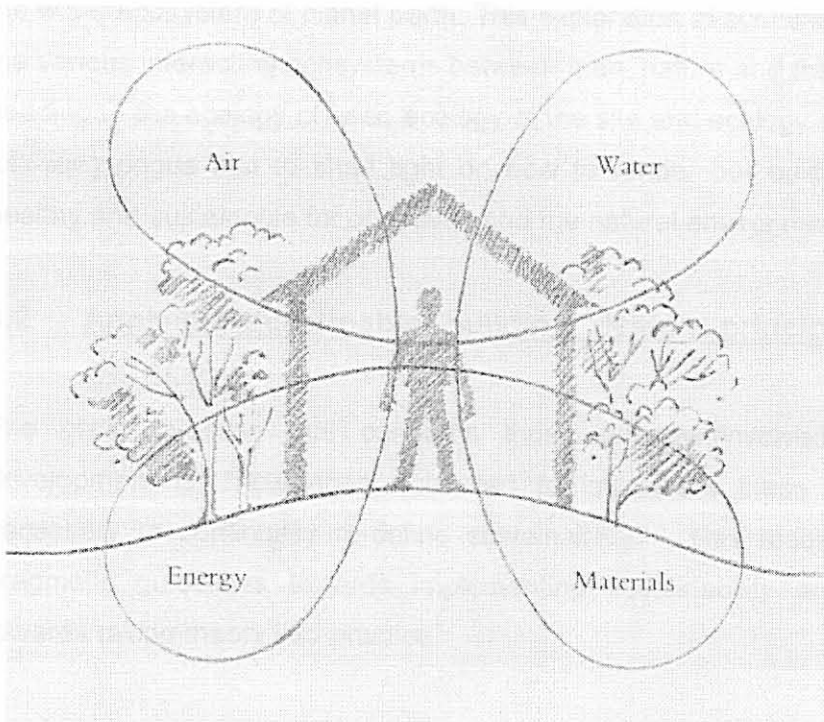


Figure 3.1 - The ecosystem of house and nature (Pearson 1989:25)

we will create the highest degree of flexibility and stability. As one element fails, others will be there to take over its function. Instead of maximising the function of single elements without the interrelationship to one another, we optimise the overall result by creating the largest number of useful links...in this system, people do not see themselves as masters of short term, exploitation of the earth, but as the custodians and stewards of a system which has come into being long before them and will operate long after them" (Kennedy 1992:47).

Natural forces like air circulation and natural heating together with building elements that are environmentally friendly are only some of the aspects of architecture that contribute to a sustainable building.

Well-being directly relates to health issues. To be healthy and have a sense of well-being one must live firstly in a healthy surrounding, that is a healthy home and surrounding environment. Secondly one's work place must also be a healthy environment. The workplace is outside the scope of this research, but the principles applied to a home also relevant here. Sound logic goes a long way to improve the quality of our living environment and eliminating illnesses relating to our modern lifestyle.

The movement Gaia promotes the house as a micro-ecosystem that interacts with the wider ecosystem of planet earth. This exploration of sustainability is divided into the various interacting ecosystems between man, nature and the building hence the headings - the ecology of user, ecology of the site and ecology of the building. The following pages aim to shed light on how to render our built environment more healthy and sustainable for ourselves and the natural environment.

3.2 Applying sustainable building design principles in Gauteng (GSBDP)

The great question that concerns those already involved with sustainable development is: "how does one start to implement these principles?" Is it necessary to continually re-define sustainability? This research proposes that pragmatic guidelines towards implementing sustainability are a relevant step towards taking theory into practice.

If we continue to destroy earth's non-renewable resources and accelerate the rate renewable resources are used; a lack of alternatives will force people to use ecological means like solar energy and wind power. It might be too late then to save us from self-destruction. People must be educated about the dangers immediately. Many people know the term "sick building syndrome"; few know what it truly means nor realise that it can be applied to their homes and not only their offices.

Five basic steps to move towards sustainable design were defined by Sim van der Ryn at the 1996 VIBA conference in the Netherlands. Table 3.1 discusses these five steps which are integrated with the Gaia principle where the house is a micro-ecosystem that interacts with the wider ecosystem of planet earth. The steps are commented on for their relevance to this study.

Table 3.1 - Five basic steps to move towards sustainable design

Sim van der Ryn:	Comment:
a) Solutions start with place (physical and cultural)	Gauteng, South Africa
b) Physiological accounting (ecological) = economic accounting	The benefits of environmental focus are automatically felt economically
c) Nature is the model for all design (bio-diversity) design with nature	The ecology of the building
d) We are designers and all users must be involved; by participating we become healed	Ecology of the user
e) Make nature visible	Ecology of the site

The environment consists of two aspects, human and biophysical. The built environment is composed of the human additions and alterations to the land surface. An urban area such as Gauteng is characterised by a built environment that dominates the natural environment. If development is continued with its characteristic modern disrespect for nature our planet will become exhausted.

A paradigm shift is required - a return to respect nature and her systems. Our habitation of earth should become a response to the natural environment.

There are two routes that reflect opposing philosophical attitudes to achieve sustainable housing developments, the “high tech approach” (see Figure 3.2) and the “permaculture approach” (see Figure 3.3). The “high-tech approach” believes that technological development can not be stopped in its course and therefore aims to optimise appropriate technology.

Jones (1998: 54) proposes that: "The channelling of scientific research and technological invention towards reducing material resource (and thus leading to energy conservation)". "For some salvation can only be met through a radical change in social and cultural values, with economic growth ceasing to be the panacea for prosperity and well-being, and with the family and community precedence over the individual. These people look to simple community-based lifestyles for their model, where materials and labour are obtained locally, and where everything that is taken from the world's limited supply of resources is returned, one way or another, in useful form" (Jones 1998: 11).

Possibly, the preferred route to building design and procurement is to find a balance between the two options. The application of sustainable building design principles can be applied from the outset of a project as a design philosophy or as retrofit. Retrofit is more costly, but the reality is that buildings already exist and many could provide healthier environments by applying sustainable building design principles.

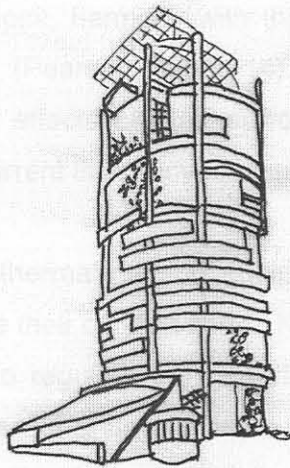


Figure 3.2 - The high tech approach to sustainable building design (illustration adapted from a K. Yeang design)

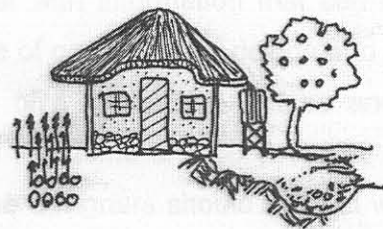


Figure 3.3 - The permaculture approach to sustainable building design (author's illustration)

3.3 Ecology of the user

Humans are a complex and diverse species and to define well-being for individuals is not the purpose of this study. The general range of phenomena that contribute to a sense of well-being will be used to establish what can be considered a healthy environment that enhances a sense of well-being.

Air, light, water, food, warmth, food, clothing and shelter are basic human needs that are derived directly and indirectly from the environment. The first humans depended on essentials for survival, but through the centuries humans have developed the desire for 'more'. Food varieties, different forms of shelter determined by style, a greater choice of clothing and as the world modernises rapidly our demands get more elaborate - we have moved a far way from basic survival to a culture of 'greed' rather than 'need'.

The user educated in the benefits of applying sustainable building design principles will make the choice and ultimate purchase of a house in a different way to a purely economic standpoint. The number and type of rooms, lifestyle and aesthetic style still play a role, but the list of requirements will have changed. A new understanding of the relationship between the inhabitants and their lifestyle in relation to the environment on a local and broader scale should be the root of a new set of requirements. Users will increasingly become aware of the influence their surroundings has on their physical and mental well being. "Health for the body, peace for the spirit, harmony with the environment - these are the criteria of the natural house" (Pearson 1989: 14). The inhabitants should be educated to understand the effects of their surroundings in order that they can protect and improve their current living environment to a pollution free, healthy environment.

Understanding thermal comfort equips the user with information that can help to actively regulate their comfort zone. Knowledge of passive solar design and natural air circulation to regulate the generic climate of a space can reduce and even eliminate the use of artificial climate control in the home and so doing be energy efficient. When the design is initially set out the designers should interact with the buyer to ensure the layout complements the lifestyle and natural surrounding environment. The designer should facilitate the initial interaction between the home owner, the home and the environment.

A comfort zone is the average definition of comfort for a group of people; rather, the absence of discomfort incorporates a larger group of individuals that define comfort differently. The absence of discomfort means to remove all materials and systems that adversely affect the health and to allow for individual adjustment to internal climatic conditions.

The physiological requirements of users

The building must be designed to meet the use requirements set by human needs. Beyond spaces required for specific activities the building should provide for human well-being as well. Well-being is when a person has optimal health and a happy disposition. A healthy body and good physiological state leads to productivity and consequently prosperity. The built environment should promote well-being by providing shelter that is a healthy surround with thermal comfort. Air that is not polluted and will not affect ones health adversely, sound levels that do not damage hearing or could be considered disturbing, internal climate that is comfortable and thereby supports both activity and rest.

Mechanical equipment can artificially provide the “ideal” environment for living in, with air conditioning, humidifiers, ionisers etc. This approach is costly in terms of purchasing and running the equipment and has negative effects on the existing natural surroundings. There are many alternatives to provide a shelter that fosters well-being without the use mechanical equipment. Environmentally conscious building design meets human needs and avoids a destructive impact on the environment.



Figure 2.4 - The city (over city and suburbs) dominated by buildings (author's illustration)



Figure 2.5 - The country (rural area and nature reserves) dominated by vegetation (author's illustration)

3.4 Ecology of the site

Ideally a healthy home is built of sustainable materials in an area that is conducive to well being. Unfortunately such an ideal is largely unattainable and compromise is necessary. The goal is to deliver the best possible living environment within a given location for a fixed budget. To achieve the goal of sustainable living environments there are several principles that if adhered to will produce a house and environment that act as an integrated ecosystem.

The movement Gaia promotes the house as a micro-ecosystem that interacts with the wider ecosystem of planet earth. The site is the first interface between the building, its occupants and the environment. Site investigation is the first step to understanding the environment of the building.

The earth and her ecosystems have been functioning for thousands of years, even before the event of human beings. The earth has witnessed the modification of many ecosystems since the first humans inhabited her, essentially the continual changing renders the planet earth no longer "original", such is the essence of evolution. Jones (1998:63) suggests that we can assume that whether a site is located in an urban area or rural setting it remains equally artificial or unnatural, the only difference is that the city is dominated by buildings (see Figure 3.4) and the countryside by vegetation (see Figure 3.5). An environmentally aware design will generate a building that is anchored to its surroundings by its physical and cultural context.

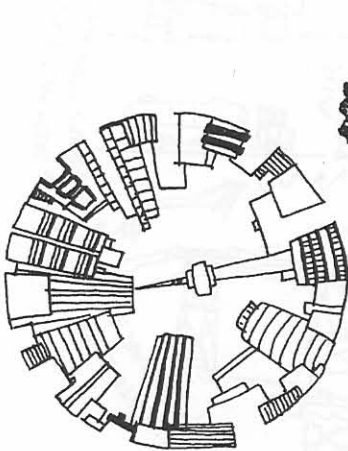


Figure 3.4 - The city (inner city and suburbs) dominated by buildings (author's illustration)



Figure 3.5 - The countryside (farming area and natural reserves) dominated by vegetation (author's illustration)

3.4.1 Location

When selecting a site consider the surroundings as part of the whole building design. To understand the nature of the environment of the building it is necessary to assess the site and the surrounding area. Figure 3.6 illustrates the factors important to a site location. A sustainable building must respond to the immediate and broader surrounding. Proximity to air, noise, ground and electro-pollution negatively affect both our senses and physical well being and should therefore be avoided when possible. Alleviated negative effects by considering the orientating away from the problem and choosing materials and construction methods that do not add to the problem with toxic emissions and the like. Rather mitigate the negative effects through harnessing benefits such as acoustic absorption, air and water filtration and so on.

The area must display a balanced of mixed use areas with public and private, open spaces and built forms, young and old, schools, shopping centres, recreation areas, playgrounds and homes all within walking distance. Diversity ensures a better social structure and avoids the formation of ghettos.

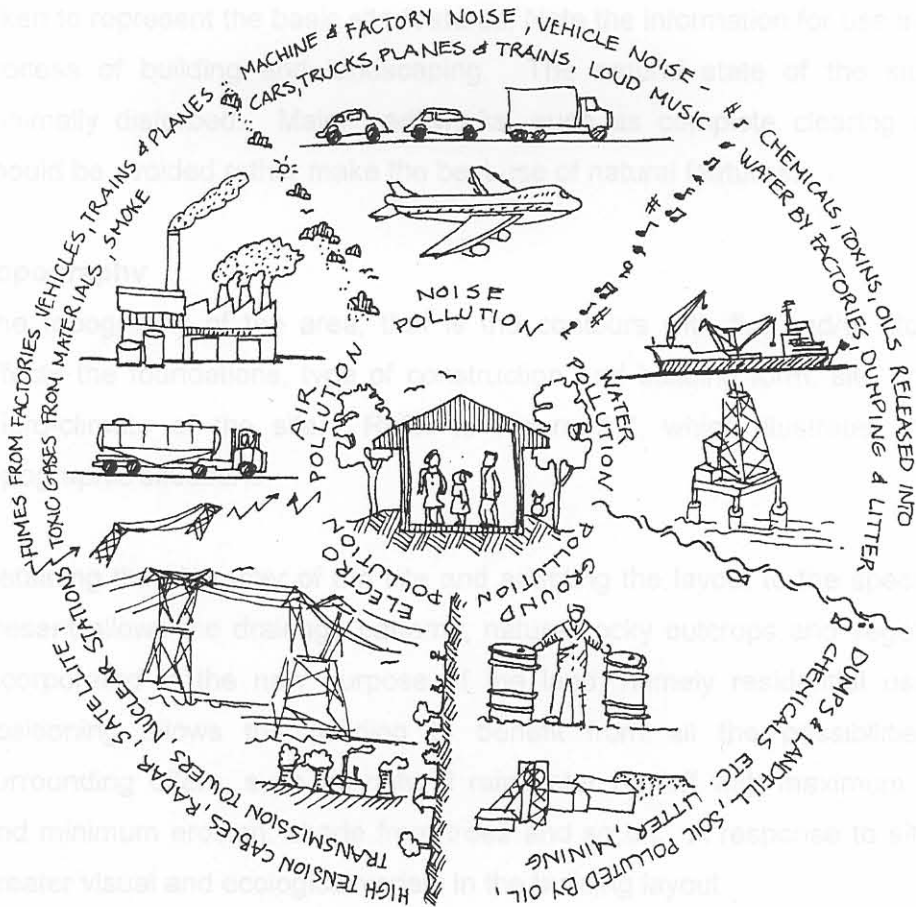


Figure 3.6 - Factors important to a site location (author's illustration)

The interest in local climate, light and topography are not restricted to the movement 'critical regionalism'. Local climate, light and topography are part of our response to understand the character of the natural environment that forms the specific site. The existing flora and fauna, cultural heritage, topography and climate of the site all influence the planning of a building that responds appropriately to its location.

3.4.2 Site features and natural environment

Assess the condition of the natural state of the site and the immediate environment, flora, fauna and topography including the soil condition and ground water to determine if the site can be developed in a sustainable way, where the ecology of the site and the building ecosystem form an integrated whole. Identify the broad geology and vegetation type of the location. Identify the soil type, rocks, fall of the site, drainage patterns and natural surface water on the site. In the case of a mechanically cleared site where no specific evidence remains of the broader information about geology and vegetation together with the soil analysis will be taken to represent the basic site features. Note the information for use in the design process of building and landscaping. The natural state of the site must be minimally disturbed. Major earthworks, such as complete clearing of the site, should be avoided rather make the best use of natural features.

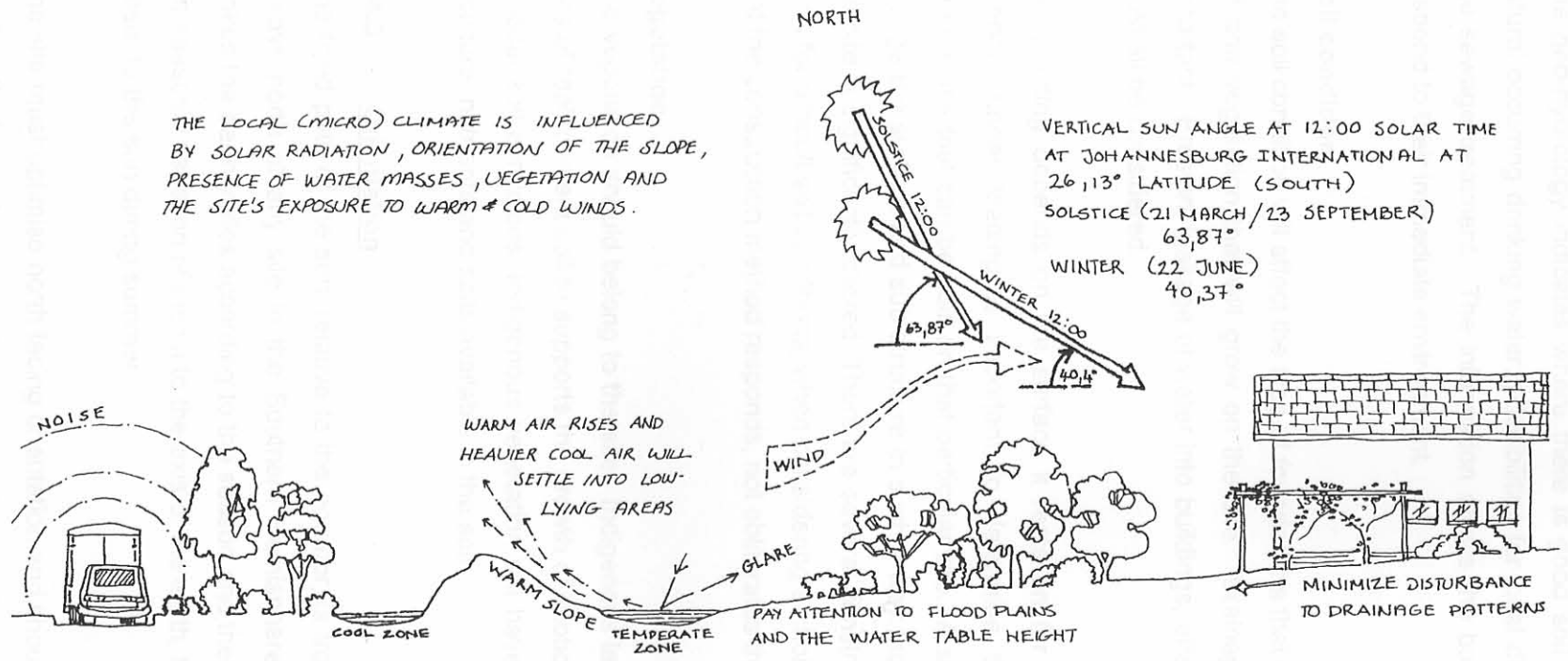
Topography

The topography of the area, that is the contours with flat and/or sloped areas, affects the foundations, type of construction and building form, site drainage and micro-climate of the site. Refer to Figure 3.7, which illustrates the different topographic situations.

Retaining the character of the site and adapting the layout to the specific features present allows the drainage patterns, natural rocky outcrops and vegetation to be incorporated in the new purpose of the land, namely residential use. Correct positioning allows the building to benefit from all the possibilities that the surrounding offers, such as natural rain-water run-off with maximum penetration and minimum erosion, shade from trees and so on. A response to site results in greater visual and ecological variety in the building layout.

Figure 3.7 - The effect of the topography of a flat site and a sloped site. (Illustration)

Figure 3.7 - The effect of the topography of a flat site and a sloped site (author's illustration)



THE LOCAL (MICRO) CLIMATE IS INFLUENCED BY SOLAR RADIATION, ORIENTATION OF THE SLOPE, PRESENCE OF WATER MASSES, VEGETATION AND THE SITE'S EXPOSURE TO WARM & COLD WINDS.

VERTICAL SUN ANGLE AT 12:00 SOLAR TIME AT JOHANNESBURG INTERNATIONAL AT 26,13° LATITUDE (SOUTH)
SOLSTICE (21 MARCH / 23 SEPTEMBER) 63,87°
WINTER (22 JUNE) 40,37°

• VEGETATION
ACTS AS A NOISE BARRIER AND ALSO ACTS AS A FILTER FOR THE POLLUTED AIR ARISING FROM THE TRAFFIC. TREES PROVIDE A SCREEN FOR PRIVACY.

• WATER
BODIES OF WATER EFFECT VARIATIONS IN LOCAL CLIMATE

• TOPOGRAPHY
ACTS AS A WIND BARRIER. THE SLOPE FACING THE SUN, THE NORTHERN SLOPE, HEATS UP FASTER AND CAUSES AIR MOVEMENT. COOL AIR SETTLES ON THE SHADED SLOPE

THE ORIENTATION OF THE SLOPE AFFECTS THE LOCAL TEMP.

• VEGETATION
PROVIDES SHADE AND ACTS AS A WIND BARRIER. EVERGREEN TREES PROVIDE SHADE ALL YEAR ROUND. TREES WILL PROVIDE A WIND PROTECTED AREA OF 15 TO 25 GREATER THAN ITS HEIGHT.

VEGETATION HOLDS THE SOIL AND PREVENTS EROSION AND REDUCES LOSS OF WATER TO EVAPORATION.

CREEPERS AND VINES REDUCE THE AMOUNT OF SUN REACHING THE WALLS, PROVIDES SHADE & COOLING THROUGH EVAPORATION. ON A STRUCTURE WON'T DAMAGE THE WALL.

The geo-hydrology indicates where there is good soil for planting, the source of natural occurring drinking water, possibilities for local disposal of rainwater and in-situ sewage treatment. The information allows the building and its occupants to respond to their immediate environment.

Soil condition

The soil condition will affect the type of foundations that can be used, the water runoff and vegetation that will grow on the site. Drainage of the site and soil are important. Erosion, leakage of water into buildings, effect of moisture on materials must all be considered.

The building depends on the surface it rests on for basic support. The soil's strength under loading is important to determine the type of structure and foundations that can be built on that particular site. A sustainable building may not change the surface and sub-structure in such a way that the character or nature of the site is significantly altered. There are several construction methods that can be used for difficult soil conditions, when considering a choice the important principle is that the construction method responds, not obliterates the site.

Vegetation

The vegetation should belong to the site. Indigenous landscaping does not require tons of replacement soil to supports the growth of exotic gardens, as it has adapted to local soil conditions. Indigenous vegetation will have adapted to the amount of moisture, nutrients and salts available in the soil.

3.4.3 Orientation

The fixed path of the sun, relative to the equator, is from east to west. The sun is always north of any site in the Southern Hemisphere. The angle that the sun strikes the earth varies according to the season and the position of the site. Due to the seasonal variation of the tilt to the axis of the earth, the Southern Hemisphere is closer to the sun during summer.

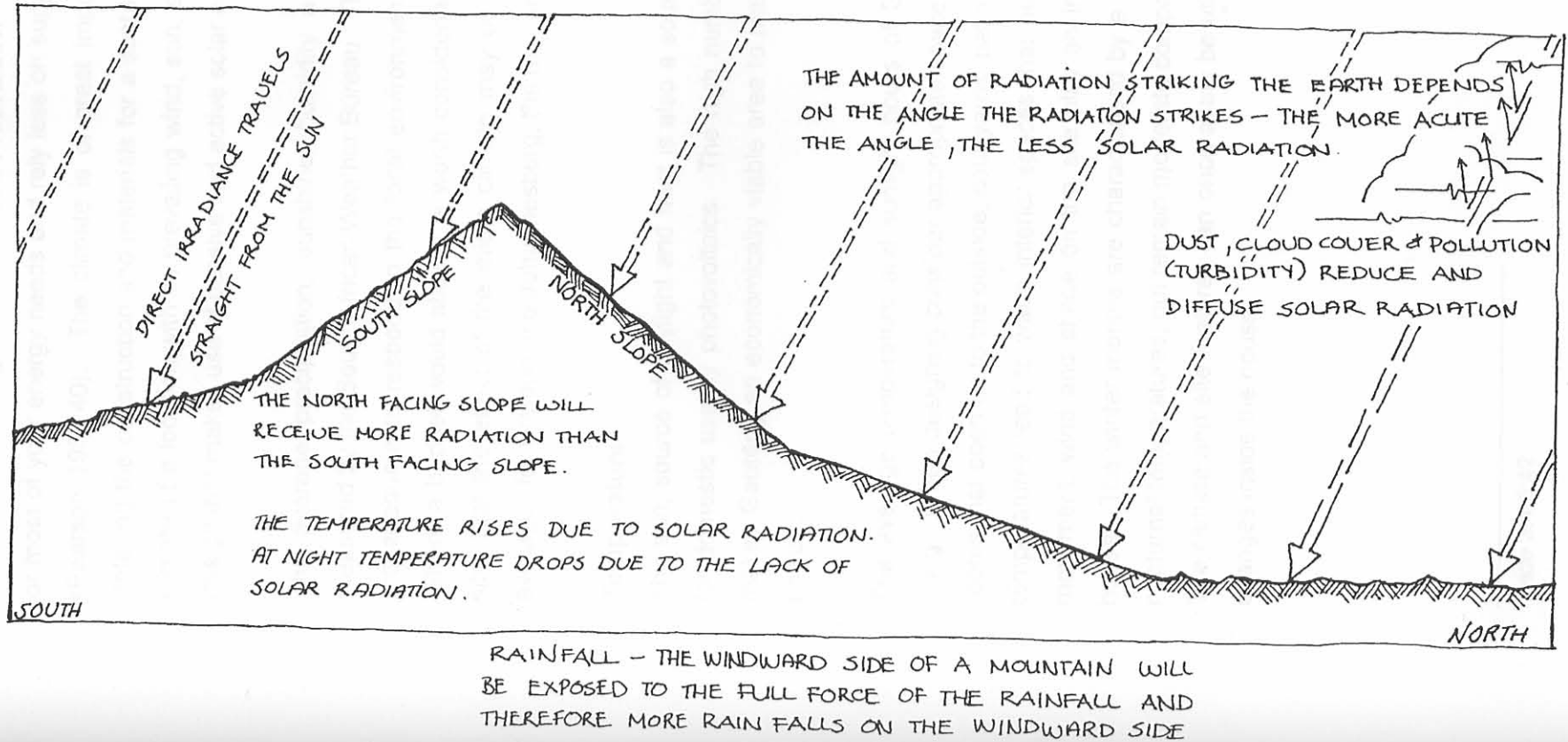
The site must optimise north facing orientation and should have a side, preferably in the length, longest axis running east-west, to facilitate the maximum opportunities to design a north facing building. The optimal siting of a building will influence the opportunities for sustainability such as daylight, ventilation and heating etc.

The type of view will also influence the orientation of the building on the site. Preferably, a home would not directly view industry, high-tension pylons, highways and other man-made constructions, yet these are real objects in the landscape of the location. There are various means of dealing with problems of view such as vegetation, landscaping, and treatment of openings. The view is closely linked to the spiritual content of the building therefore further discussion is outside the scope of this research.



Figure 3.8 - The effect of orientation on a flat site and a sloped site (adapted from Holm & Viljoen 1996)

IRRADIANCE IS THE AMOUNT AND RATE OF SOLAR RADIATION MEASURED ON A UNIT AREA AS WATTS PER METRE SQUARED. SOLAR RADIATION IS RECEIVED ON THE GROUND ACROSS A RANGE OF FREQUENCIES, FROM INFRA-RED THROUGH THE VISIBLE SPECTRUM TO ULTRA-VIOLET. (HOLM & VILJOEN 1996: 4)



3.4.4 Climate

One of the principles promoted by Gaia is: "site, orient and shelter the home to make best and conserving use of renewable resources. Use the sun, wind, and water for all or most of your energy needs and rely less on supplementary, non-renewable energy" (Pearson 1989:40). The climate is of great importance when locating, orientating, detailing the construction and materials for a sustainable building. Understanding the climate of a location with its prevailing wind, sun, shading and precipitation allows for design that makes use of passive and active solar energy and natural ventilation.

The average precipitation, sunshine, humidity and temperatures in Gauteng are measured by the South African Weather Bureau. The averages calculated for the area are adequate to respond to the local environment of a site in an appropriate way. Where a budget would allow it is worth considering specific measurements taken on site, that the effect of the micro climate may be determined. Table 3.2 gives the averages for Pretoria and Johannesburg, the two largest cities in the province.

Temperature

The sun, source of daylight and heat is also a source of electrical power transformed for domestic use by photovoltaics. The high number of sunlight hours and radiation makes Gauteng an economically viable area to make use of active and passive solar power¹.

The average temperature and sunlight hours of Gauteng are conducive to outdoor living. When designing consider appropriate spaces to living both inside and outside, rooms that open up to the outside, courtyards, patios and pergolas. The warm summer temperatures lead to warm interior spaces that need to be cooled. The natural air movement, wind and shade on the site play an important role in the design of the house. The winter months are characterised by a great difference in the diurnal and nocturnal temperatures, but remain moderate compared to other areas in South Africa. The climate and site features can once again be utilised to moderate the temperature changes inside the house.

¹ vide 3.4.5:42

Table 3.2 - The average climatic data for Johannesburg and Pretoria (adapted from the directorate climatology of the South African Weather Bureau 2000)

STATISTIC	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	AVERAGE
Average daily number of sunshine hours	8,1	8,0	7,7	7,9	8,9	8,9	9,2	9,2	9,4	8,7	8,3	8,5	7,8
Average rainfall in millimetres for Johannesburg	125	90	91	54	13	9	4	6	27	72	117	105	619 annual
Average rainfall in millimetres for Pretoria	136	75	82	51	13	7	3	6	22	71	98	110	674 annual
Average maximum temperatures in degrees Celsius for Johannesburg	25,6	25,1	24,0	21,1	18,9	16,0	16,7	19,4	22,8	23,8	24,2	25,2	20,5
Average maximum temperatures in degrees Celsius for Pretoria	28,6	28,0	27,0	24,1	21,9	19,1	19,6	22,2	25,5	26,6	27,1	28,0	23,1
Average minimum temperatures in degrees Celsius for Johannesburg	14,7	14,1	13,1	10,3	7,2	4,1	4,1	6,2	9,3	11,2	12,7	13,9	10,0
Average minimum temperatures in degrees Celsius for Pretoria	17,5	17,2	16,0	12,2	7,8	4,5	4,5	7,6	11,7	14,2	15,7	16,8	12,4
Average minimum humidity (%)	24	25	27	22	19	16	13	10	10	12	19	23	18,3
Average maximum humidity (%)	87	96	96	97	97	97	97	97	96	97	97	97	96,7

Rainfall

The characteristic short but heavy thunderstorms requires careful planning around the natural drainage patterns of the site and house design.

Humidity

Humidity is the moisture content of the air, expressed as a percentage of the total capacity of moisture air can contain. A high humidity is experienced as warmer than a lower humidity at the same temperature.

The humidity of Gauteng can be relatively high but does not often reach uncomfortable levels in comparison to coastal areas. The dry winter weather is experienced as a

greater problem for many people. Vegetation and surface water on the site can help to alleviate the low humidity in winter.

Wind

Summer winds in Gauteng are predominately north-easterly, and winter winds are predominantly north-westerly, but there is also a fair amount of south-westerly wind. (Holm 1996:64 [see Appendix 2]).

Wind is a natural resource that can assist ventilation of a building and by mechanical means be harvested to generate power (see Figure 3.9). The construction and thermal dynamics of the building are also influenced by the wind. The strength of the wind is not substantial enough to influence the construction of buildings in Gauteng, but should be used as a passive climate control.



Figure 3.9 – The harnessing of wind energy (Pearson 1989:79)

3.4.5 Energy

The Gaia house charter states that in order to design in harmony with the planet we should: "design the house to be 'intelligent' in its use of resources and complement natural mechanisms, if necessary with efficient control systems to regulate energy, heating, cooling, water, airflow and lighting" (Pearson 1989:40).

The term energy includes a broad range of visible energy, which includes electricity that is common to urban residences and the non-visible in the form of the natural

energy fields of the earth itself. Natural sources of energy such as the sun, wind and water can be harnessed in the urban setting and are not limited to experimental use in grand scale developments. Energy conscious design avoids becoming completely dependant on the main electrical supply grid. The passive energy source from the sun and wind are viable alternatives making cost-effective use of natural renewable resources.

In South Africa conventional supply grid electricity is supplied by Eskom. Hot water and lighting are generally powered by commercial power supply. The orientation of a site that maximum use may be made of both passive and active solar energy is a priority for a sustainable solution. The use of solar panels and photovoltaic cells to generate heat and power is possible with the average of eight and a half sunlight hours per day in Gauteng.

There is not enough wind in Gauteng to generate energy but it can be used in the passive form of natural ventilation.

Geopathic stress – Natural earth energy

Check the site for electro-pollution; also know as geopathic stress. The general term geopathic stress refers to the discomfort and illness that occurs when the earth's natural magnetic field (the magnetic poles) is disturbed by natural or man-made energy fields. "Geopathic stress is an insidious phenomenon: we cannot see it or adequately explain it in current scientific terms, but the effects of it are likely to prove at least as devastating as environmental pollution" (Thurnell-Read 1995:xi). Dowsing, the alternate method to scientific measurement has proved unreliable due to charlatan practitioners. Currently the best advice is to look at signs on the natural environment of the site.

Disturbances to the earth's magnetic field include geological faults, underground ore masses, underground water especially running water and man-made disturbances include mining, deep foundations, sewerage pipes, high-tension power lines and other services. Geological energies have always been present but due to the technological advancement humans have become more exposed and therefore susceptible to the disturbances of the ever present back-ground energy field of the earth's magnetic poles (*ibid*: 1-13).

A visual analysis of the site can reveal possible energy field disturbances. The proximity of ground water to the site, surface water is not problematic. Trees often reveal if there is a disturbance as they grow unconventionally, they display gnarled or

distorted growth patterns. Tietze (1988) is quoted in the book, '*The healthy house*' (Baggs *et al* 1996: 42): "Dogs, pigs and other animals are said to avoid areas where subterranean water veins intersect. Trees will branch down towards radiation and ants will nests above radiation lines. Bees are said to produce more honey when their nests are built over such zones. Wasps tend towards zones of radiation and cats prefer to rest over them". Check the area for high-tension power lines running close to or crossing the site, radar and satellite dishes, transmission towers and nuclear stations in the surrounding area. It is worthwhile to check whether any underground tunnels cross the site as Gauteng has experienced a large amount of mining activity. (see Figure 3.6)

Geopathic stresses are important to the well-being of inhabitants and should form part of the original analysis that determines whether a site is appropriate for development.

3.4.6 Water

Water is a renewable resource but through an ever increasing demand and wastage has become a precious resource not to be squandered.

Ground water

Ground water generally provides a purer water supply on site than municipal water supply that is chemically treated. This requires an investment to assess if water is on site and whether the water table is constant and is an adequate supply. The water table should not drop significantly due to extraction of ground water and the source must be tested for possible ground pollution. If the conditions are right a bore-hole and pump will be required to bring the water to the surface. The initial costs are higher than linking to the municipal supply, however if this is a resource shared by a number of houses in a complex the long-term benefits outweigh costs.

Rainwater

Harvest rainwater from roofs to use for garden irrigation and toilet flushing. Encourage rainfall run-off through planned maximum water penetration. Eliminate erosion by designing to allow for water to penetration soil on roads and driveways of that are paved and facilitate the water to seep between rather than run over an impenetrable surface like tar.

Gardens and water

Sustainable gardens are “water-wise”, requiring minimum supplementary irrigation². Water the garden in the early morning or evening, as not to lose water to the heat of the day. Vegetation and mulch in the garden beds prevent moisture loss to evaporation and run-off.

Surface water

Surface water is found on site in the form of natural pools, river or streams or a built pond on site. The presence and extent of surface water on the site creates a natural cooling system through evaporation and air movement as well as visual variety. The temperature difference between the water and ground mass causes air movement from the cooler to the warmer mass. During the day the water heats up faster than the land mass and air moves from the cooler ground mass to the water surface. At night the earth mass radiates the heat it has retained during the day and the air movement is reversed. Careful placing of a water area in relation to the building allows for cool breezes to cool the building during the warmer summer days, and to provide air moisture during the dry winter days. (see Figure 3.7)

3.4.7 Waste

The site must be checked for pollution of old rubble from previous buildings or dumping. Pollutants such as plastic containers, tins, household waste and non-biodegradable materials do not form part of a natural condition.

Soil displaced for construction should be re-used on site. Demolishment rubble on site should be sorted and re-used if possible or disposed of according to the rubble type. Where vegetation is to be cleared re-use wood and organic waste for starting the composting system. Medium density developments provide the opportunity to centralise waste disposal into re-cyclable categories. Not only household waste but also, organic waste from the gardens can be used to make compost that can be recycled for the garden.

Vegetation tempering climatic variations

Appropriate landscaping creates external conditions that complement the internal conditions of the building, reducing energy requirements. Plants by their natural systems of absorption and

² vide 3.4.8:46

3.4.8 Fauna and Flora

The Gaia house charter states that in order to design in harmony with the planet we should: "Integrate the house with the local eco-system, by planting indigenous tree and flower species. Compost organic wastes, garden organically, and use natural pest control- no pesticides." (Pearson 1989:40)

The flora and fauna of a site contribute to the aesthetic appeal and climate of the area. A beautiful natural setting has been proved to aid healing and support a sense of well-being. Vegetation acts as a pollution filter, noise buffer, creates privacy and provides relief from the built environment. Therefore, the ratio of site to building should allow for adequate garden space. A green road edge gives the impression of open space with consequent benefits and each garden can provide a diversity of flora and fauna in the area.

A sustainable garden conserves water, protects the environment and provides a natural haven around the house. Vegetation stabilises soil; the roots that hold the soil and provide a cover over the soil prevent erosion. The root systems of the plants increase the permeability of the soil for rainwater and air. There are many benefits to retain and plant an indigenous garden.

Indigenous plants

Indigenous gardens grow fast and well in the specific climate of the location they are adapted to. Plant loss is reduced, less supplementary irrigation than exotic gardens is required thereby alleviating the pressure on the water supply, and the indigenous garden is a host to the natural wildlife in of the area.

Planning the landscape

When landscaping plan the variety of plants to create external conditions that complement living both in and outdoors. Ching (1975:1.6-1.7) advises when selecting trees in landscaping that the overall form, density and colour of the foliage, height and spread of the trees, speed and rate of growth, size and depth of root structure, soil, water, sunlight, air temperature requirements are considered relative to the site and building.

Vegetation tempering climatic variations

Appropriate landscaping creates external conditions that complement the building and can aid in conserving energy. Plants by their natural systems of absorption and

evaporation have a cooling effect. Landscaping can reduce the direct sun reaching the house facades preventing heat being transferred to the house. Depending on the position, density of foliage, size and shape of the trees they provide shade to the building. Deciduous trees shade in the summer and in winter when they lose their leaves they allow the sun to reach the surfaces of the house to provide extra warmth. Evergreen trees can provide permanent shading from the sharp west light of the setting sun. (see Figure 3.7)

Vines and creepers are effective shading devices, preventing the heat of the sun from reaching the wall mass. Trellises placed close to walls can provide support without any damage occurring to the walls. Evergreen plants can be used to shade in the summer and insulate in the winter. (see Figure 3.7)

Groundcover and vegetation can act as a reflective surface. They do not absorb heat like asphalt. They reduce the ambient temperature around the building. Groundcover, vegetation and mulch prevent excessive evaporation of ground water. (see Figure 3.7)

Trees and planting can also affect the wind, reducing the wind velocity where required by being placed as a wind block or to channel cool breezes into and around the house. (see Figure 3.8) The effective zone of protection for a windbreak can be thirty times the height of the trees. The maximum protection occurs within five to seven times the tree height. For example, if the windbreak is 5 metres tall, it should be placed from 25 to 35 metres from the house (Sustainable Building Sourcebook 1998). The amount of foliage, shape and size affects the potential for a tree to act as a wind break. Evergreen trees are effective as windbreaks all year round. Consider the position of the tree relative to the building, if planted too close to a building the roots of trees may damage or disrupt the foundations and plumbing lines.

3.1.1 Geometry of the building

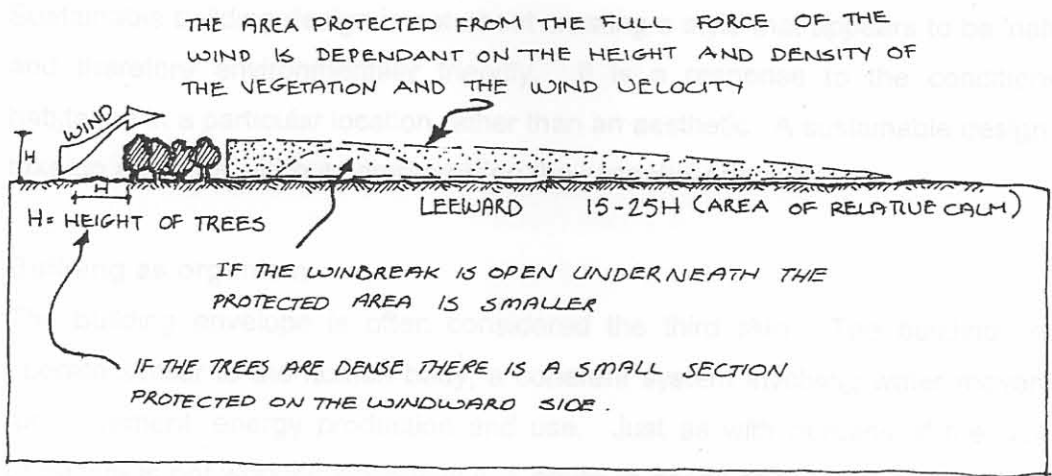


Figure 3.10 – The effect of trees on the micro climate (adapted from Ching 1975)

Pollution filters

The garden can alleviate a certain amount, though not all air and noise pollution. Vegetation filters the air and wind-blown dust in the immediate environment of the garden and home. The developed garden with its height and foliage density also forms a perceived barrier for noise. (see Figure 3.7)

Though not researched, it is believed by some that the natural vibrations (energy) of a garden can also alleviate electro-pollution. The gnarled trees in an area with geopathic stress illustrate the potential of vegetation to respond to electro-pollution. The extent to which the garden improves a situation is unknown.

Food production

Dedicating a section of the garden for growing provides a valuable fresh recourse of food. This not only provides a source of fresh seasonal fruit and vegetables but also food free of insecticides and toxins. In a permaculture the food production is one of the essential components of the system.

3.5 Ecology of the building

Sustainable building design is not about creating a style that appears to be 'natural' and therefore environmentally friendly. It is a response to the conditions of habitation in a particular location rather than an aesthetic. A sustainable design can take on any style without compromising the essential principles.

Building as organism

The building envelope is often considered the third skin. The building should operate similar to the human body, a coherent system involving water movement, air movement, energy production and use. Just as with humans, if the building organism is not working effectively it is prone to decay and infection, leading us to the concept of the sick building³.

Hugo Vanderstadt describes (1996:61) the effect of modern living environments as modern comfort that is not risk free. Sometimes there are consequent side effects such as: unnatural light, too little negative ionisation of the air, cold radiation from the surrounding walls, too little warmth comfort, disturbance of natural magnetism, artificial electromagnetic fields, stressful interior decoration, toxic surfaces and so on. He also identifies the "sick-building-syndrome" as a logical consequence of modern habitation.

The Gaia house charter states that in order to design in harmony with the planet we should: "Use 'green' materials and products - non toxic non-polluting, sustainable, and renewable, produced with low energy and low environmental and social costs, and bio-degradable or easily used and recycled...Design systems to prevent export of pollution to the air, water and soil" (Pearson 1989: 40).

3.5.1 Relationship of building to site

The ideal situation is where the building acknowledges the site and the surrounding area. The design of the sustainable building is a response to the specific location and site⁴. It is not a theoretical abstract artificially implanted on a cleared piece of ground, devoid of any reference.

³ vide 3.1:26

⁴ vide 3.4:33

A low percentage of coverage allows for a substantial garden and a maximum retention of natural features around the building. The influence of neighbouring buildings on the generic climate of the building is minimised.

use of mechanical climate control.

3.5.2 Orientation of the building

Traditionally houses and stands in South Africa acknowledge the benefits of the north facing aspect. The length of the building should be north facing to make maximum use of the sun for passive and active warmth, natural daylight and potential to make use of passive solar design.

It is influenced by the geographic location, orientation, as well as the weather's temperature.

Hugo Vanderstadt makes the following remarks about the optimal use of natural light and sunrays, "where the sun does not enter the doctor will visit" (1996:61). A good design makes maximum use of the sun for light and warmth. It can avoid the necessity for artificial lighting during the day and electric heating on colder days. Medical studies have proved that sunlight is needed for the production of Vitamin D in the human body. A shortage of vitamin D can result in lowered immunity, rickets, low blood pressure and so on. Thurnell-Read (1995:15) writes: "...during winter months some people suffer from depression and lack of energy, which has now become known as Seasonal Affective Disorder (SAD). Treatment with full spectrum light has been shown to be beneficial." Ultra violet (UV) light has an anti-bacterial working but unfortunately UV radiation does not penetrate normal glass.

Vanderstadt (1996:61) suggests that at least one window in the house allows UV penetration such as quartz glass, acrylic or perspex. Considering sustainability quartz glass is preferred. His suggestions are for the central European climate. While achieving UV penetration in the interior spaces, in Gauteng consideration must be given to avoid glare. In South Africa and specifically Gauteng the climate is mild and use can be made of a sliding door which is kept open for a few hours of sunshine to penetrate the interior spaces.

Thermal comfort

Orientation must occur so that an abundance of daylight can penetrate the depth of the home and the warmth of the sun can be utilised to warm the interior spaces in winter, yet that there is adequate shading in the summer, that the interior remains cool. A balance between sun shading and sun trapping should be achieved.

It is recommended by the body's metabolism without the excessive use of energy to keep the body temperature in equilibrium. The available energy can be used for daily activity as well as rejuvenation through sleep. The range within which the body is comfortable is called the "comfort zone".

3.5.3 Generic climate of the building

Sustainable building design makes use of the natural climatic forces of the site for natural climate control. Energy and economic savings are a result of eliminating the use of mechanical climate control.

The design and building materials used - colour and type, give the opportunity to reduce absorption of heat, use rainwater for cooling and ventilate naturally.

The internal air quality is also of importance. It is influenced by the occupants' breathing, sweating, germs, smoking as well as the emissions from the surrounding building materials and household equipment. The space must be well ventilated allowing an exchange of air. The opening sections (when opened) are adequate to ventilate as well as cool the rooms by natural air circulation.

The quality of the oxygen in the air affects one's well-being. The quality of the air is measured by the number of negative and positive ions per cubic centimetre.

2 000 ions with 60% negative and 40% positive ions is considered healthy for human functioning. Vanderstadt cites the following problems in the situation where there are too few negative ions in the air: less vitality, drowsiness, problematic breathing, headaches, irritated eyes, stress, reduced immunity and degeneration of the blood. The oxygen quality is therefore not a small problem to be ignored. Air circulation is largely determined by the layout of the rooms and relative positioning of opening sections. Ventilation must be planned so that the air circulates and there is an exchange between internal and external air supply without resulting in draughts. The SABS gives a minimum requirement for air circulation in these spaces, but direct connection to natural air circulation is always better than artificial climate control. Ventilation is promoted through the use of air bricks and positioning of the opening sections.

Thermal comfort

Comfort is the absence of discomfort. A thermal comfort zone is defined as the temperature and humidity at which a range of people feel comfortable, neither too hot nor cold. The human body responds to climatic factors. Our comfort involves the ability of the body to work optimally when the climatic factors can be accommodated by the body's metabolism without the excessive use of energy to keep the body temperature in equilibrium. The available energy can be used for daily activity as well as rejuvenation through sleep. The range within which the body is comfortable is called the "comfort zone".

The quality of the indoor climate depends greatly on the ventilation of the building. The comfort zone for relative humidity is between 40%-60%. Moisture regulated fans and natural ventilation can achieve this. Opening sections should close well to prevent air infiltration when not required so that the effects of wind and air movement can be controlled.

The building shell

The daily life cycle of the building includes the absorption and release of heat. The thermal capacity of materials is affected by the humidity and should be considered. The thermal dynamics of the building are also influenced by the wind. The wind affects the thermal performance of the materials and can cause heat loss, but can be used to moderate summer temperatures by assisting ventilation of the building⁵. The strength of the wind is not substantial enough to influence the construction of buildings greatly in Gauteng, as it does not cause substantial stresses on the structures.

Leaking plumbing, roof leaks, defective gutters, condensation, defective water proofing, defective drainage, rising damp, ground moisture and spillage can lead to a build-up of unhealthy moisture in a building that leads to decay and the growth of fungi. Natural air movement is important in preventing a moisture build-up.

Recommendations to control the effect of all the natural climatic fluctuations on the internal climate are:

- i) Plan for independent control by providing well positioned opening sections for ventilation and shading devices. Air rises externally upward against the building- known as buoyancy, affecting the air change rate. The size of windows and the rate of rise affect the air change rate.
- ii) Plant quick growing deciduous trees carefully positioned relative to the house that in the future provide shade in summer.
- iii) A broader roof overhang would provide shade in the summer when the sun is higher.
- iv) Provide insulation in the roof space
- v) A generous floor to ceiling height aids air movement.
- vi) Considering the wind directions when positioning the house on the stand

⁵ vide 3.5.4:53

vii) External weather conditions affect the internal air movement. Air bricks, ventilators, open windows, roof ventilators can improve the airflow. The airflow in a room should be encouraged to mix and change direction and not just pass on a direct path through (Singh 1994).

The various climatic constraints can give rise to an architectural style that is unique to climatic region while responding appropriately, giving a richer fabric to the built environment. The average temperature and sunlight hours of Gauteng are conducive to outdoor living. When designing consider appropriate spaces to living both inside and outside, rooms that open up to the outside, courtyards, patios and pergolas. The optimal relationship of orientation and layout results in a comfort zone that requires no additional artificial control. When the design is initially set out the living spaces such as the lounge, dining and bedrooms should be positioned to gain maximum benefit from natural light, temperature control and ventilation.

3.5.4 Energy efficiency

The sun, wind, methane gas and waste wood are all natural sources of renewable energy that should be harnessed by a sustainable building to lessen the pressure on non-renewable fossil fuels. Use renewable energy whenever possible. Use of biomass, solar energy, wind-power and photovoltaics.

Grid electricity is an expensive resource on finite minerals such as coal. Special care must be taken not to waste it. Energy efficient installations and machines must be used (refrigerator, freezers, washing machines, drying machines, dishwashers, cookers, lighting) and general saving of electrical use. Simple techniques can be used to reduce energy requirements such as:

- i) Use landscaping to conserve energy⁶.
- ii) Wind and sun can be used for drying
- iii) Heating and cooling using natural forces completed by pumps and fans
- iv) Use renewable resources such as wood for heating
- v) Use standardised quality fixtures with replaceable components. The fixtures will last longer and if necessary components to fix faults will be available.

Materials with a high thermal mass reduce energy use, as less is required to heat and cool the interior spaces. Thermal fluctuations should be avoided by using

⁶ vide 3.4.8:46

materials that display good thermal performance. Heat efficiency is achieved by good insulation of walls, windows, doors, floors and roofs. All openings should insulate well to avoid leakage when closed. The plan and form should be efficient with the control of airflow and orientation for use of passive solar power.

Energy can also be harmful to human beings. The placement of electrical lines and transformers in relation to a building is very important. Electromagnetic fields should be avoided where possible.

The glasshouse or sunroom attached to the building provides a place to cultivate food without artificial fertiliser (a place to use grey-water and compost), reduces energy use to heat the space (winter) or cool the interior spaces by pulling out cool air from shaded interior rooms and adds an area to occupy on cooler days, it can form a sound barrier. (Baggs 1996:92-93)

Materials and energy⁷

Energy is also an essential component in the manufacturing of building materials and products, known as embodied energy. Sustainable buildings make use of materials that do not require large amounts of energy to produce or alternatively have recycle or reuse potential that mitigates the initial production cost long term. Examples of these types of materials are timber and loam or mud bricks.

3.5.5 Water conservation

Domestic water supply requires purification due to the pollution of our natural water supply. Our water characteristically is filled with unnatural chemicals and bacteria that are harmful to us. It is possible to install a natural water purification system. Ponds, septic tanks, sand filters and percolation are a few of the techniques that can be used to purify water on site. To install a water purification system for one household is expensive but in a larger development a system could be installed for a number of houses, making it cost effective and viable.

Water can be conserved in the building and by changing wasteful habits. The following measures can be employed to increase water conservation:

- i) Use water efficient equipment. Select toilets with lower flush options. Low flush for liquids and standard flush for solids. Use low flow fixtures (toilets, water

⁷ vide 3.5.7:57

taps and shower heads). An option to save water usage is to install a composting toilet.

- ii) Household appliances (dishwashers, clothes washing machines) should be selected for their energy and water efficiency.
- iii) Consider greywater as a source that can be used to irrigate the garden or flush toilets⁸.
- iv) Avoid using municipal black water removal as this wastes large quantities of water⁹.
- v) Water use habits should be adjusted for minimum wastage. Some age old advice still counts in modern sustainable building use. Don't let the tap run while shaving or brushing teeth etc. Rather shower than bath. Avoid small washing loads if machine does not have a cycle for small loads. Avoid washing dishes in dishwasher if it is not full. Do not wash dishes under running tap. Do not use toilet to dispose of waste. Use nutrients from kitchen waste through composting.
- vi) The optimal position should be selected for the water heater (geyser). Avoid long distances where water is wasted while waiting for hot water. If unavoidable, divert or capture the water normally lost for use in garden or to flush toilets.
- vii) Rainwater can be collected from roofs and can be used for garden irrigation. Note that the quality of rainwater can vary according to levels of air pollution depending on the area the building is located. Barrels of all sizes and formats are available that can be linked to the gutters around the house.

3.5.6 Waste management

There are different types of waste arising from habitation. Waste water (grey water and offal water), material waste and organic waste. Waste arising from household consumables and waste from the building itself all form part of what can be considered wastage arising from habitation. The increased need for landfill areas verifies that there are too few people motivated to recycle and re-use their household waste. People must be taught why it is important to sort their waste and minimise non-degradable, non-recyclable materials or otherwise we will all be living on a giant landfill one day. Municipal waste collection should not be used as an excuse to avoid bringing the relevant waste to the recycle depot.

⁸ vide 3.5.6:55

⁹ vide 3.5.6:56,vi

Waste can be managed in the following ways

- i) The waste arising from packaging - consider refills and bio-degradable packaging when shopping for consumables.
- ii) Organic waste from the kitchen is bio-degradable can be used in a composting system for use in the garden.
- iii) Recyclable materials should be sorted and brought to the relevant depots. The household must aim to produce reusable materials not garbage. Separate rubbish at its source into glass, paper, plastic, textiles, bio-degradable, and re-usable materials.
- iv) Environmentally dangerous garbage must be eliminated in an appropriate way. Dangerous waste, such as batteries, chemical cleaning substances, fats, medicines etc. should when purchased, used conservatively.
- v) Greywater can be defined as the wastewater produced from baths and showers and washing machines. Blackwater is the wastewater from toilets, kitchen sinks and dishwashers. Grey- and blackwater must be separated for use. Greywater is usually used for irrigation in sub-surface systems in line with health regulations. The separation of black and grey waters can be problematic in existing buildings; it should be included at the design stage.
- vi) An option to save water usage and deal with human waste is to install a composting toilet. Ironically the complex sewerage system halts decomposition as the human waste enters water. Composting toilets only use a small amount of water. Human waste breaks down naturally in the presence of oxygen and other biological materials. If possible, recycle the nutrients in sewerage, kill the pathogens and bring down the biological oxygen demand. Use settlement tanks, percolation or sand filters, in combination with irrigation, re-absorption and aquaculture¹⁰.
- vii) The building itself should be designed for re-use or re-cycle at the end of its life cycle¹¹.

¹⁰ vide Appendix 3:138

¹¹ vide 3.6:62

3.5.7 Materials and construction methods

General introduction to sustainable building materials

The physical materials that all buildings are made of are generally sourced from our planet earth and are essentially either renewable or non-renewable in character. The material has at some stage been taken from the earth and through a manufacturing process rendered useful to the building industry.

Nine parameters for sustainable building materials were deduced from data in Pearson (1989), Vanderstadt (1996) and Baggs (1996). Each of the parameters for listed below are discussed on the following pages.

Sustainable building materials must comply with the following parameters:

- i) Come from a renewable resource – source of materials
- ii) Require a minimum of energy to manufacture, transport, place and demolish
- iii) Minimum impact on the natural eco-systems in the area
- iv) Non-toxic to humans and the environment i.e. environmentally friendly
- v) Acts as a third skin, i.e. it can breathe
- vi) Electrostatically, magnetically neutral and avoid geopathic stress and electromagnetic pollution
- vii) Absorptive acoustic properties
- viii) Minimal moisture content once the building is complete
- ix) Can be re-used or are bio-degradable and have a maximal life-span¹²

i, ii & iii) Source and manufacturing of materials

If a building is to be sustainable and address the effect it has on the environment from the outset sustainability must be a consideration in the design stage, material specification and ordering and site works. The responsibility does not lie with one member of the team but from the designer through to the site worker. The economics of a building work are paramount but not a reason to ignore the importance of sustainability.

There are different categories resources can be divided into. Non-critical zone renewable resources such as solar energy, tides, wind, waves, water and air

¹² vide 3.6:62

remain renewable irrespective of human activity. Critical zone renewable resources such as fauna and flora, soil and aquifers depend on the rate at which they are used in relation to their production. The critical zone is reached when recovery is slower than supply. To ensure these resources are not exhausted they must be managed carefully. A sustainable building industry is one that does not squander materials or energy. Construction that makes maximum use of materials that can be found in the immediate environment. Materials that don't require a sophisticated manufacturing process, such as mud, sand, clay, lime, wood and organic materials that are renewable such as wood, sisal, straw and cellulose products.

Non-renewable resources are those that once consumed are irreplaceable. These are the fossil fuels - oil, natural gas and coal. In terms of human life-span they are non-renewable as they have taken millions of years to form. There are also recoverable non-renewable resources which are the metals such as aluminium, chromium, copper, gold, iron, lead, magnesium, manganese, mercury, nickel, platinum, silver, sulphur, tin and zinc, which can be recovered by re-cycling.

The building trade and the components used in buildings tend towards being non-renewable. In respect of their finite character, they are often squandered without thought. Although the availability, cost and actual physical properties are of primary importance, the sustainability of the material may not be ignored. Generally building materials fall into eight main groups, these are stone, timber, brick, iron and steel, concrete, glass, plastics and natural fibres.

Stone – The “rocky Highveld” with its characteristic scattered rocks gives the opportunity to tie the building to the site in terms of using natural materials occurring on site. Features and walls can make use of the rocks recovered during site clearing. Stone requires no manufacturing related energy. Although it is critical zone non-renewable resource, if it is found on site and would be removed to accommodate the building footprint, it can be considered a sustainable building material. However it should not be removed from natural sites for use in a building somewhere else far away.

Timber is a non-critical zone renewable resource. The hardwood and softwood should both originate from a sustainable forest i.e. regulated plantation. During the manufactured process the timber must be well seasoned and non-toxic preservation techniques should be used. Effective preservatives are borax, sodium carbonate, potash, linseed oil and beeswax. (Pearson 1989:153) The exotic bluegum (eucalyptus) trees found on site that need to be removed to make way for

an indigenous garden, can be used in the structural framework of the building. Cork, linoleum, rubber, paper and composite boards are all members of the timber group. These materials if sourced from a sustainable forest are appropriate materials for use in a healthy home.

Brick – Earth is an abundant material that is moulded into bricks and tiles either naturally dried or baked in a kiln. Bricks perform well thermally and are generally the preferred wall surface for homes. Generally brick manufacturers are expected to set their own environmentally friendly standards, however there is also the option for on site brick production. Fired bricks require energy using fossil fuels while mud-bricks (raw-earth) are an on site material. Mud-bricks in turn have greater waterproofing requirements.

Iron, metal and steel - The extensive use of iron and steel in buildings should not go without special consideration for alternatives that do not make use of non-renewable resources and high embodied energy requirements. Where there is no alternative the quantity and type of steel used must be a consideration. The utilitarian pipes, plumbing fixtures, ironmongery, nails, screws, electrical cabling, etc. should be specified keeping sustainability and re-cycle possibilities in mind. Aluminium and iron have greater energy requirements to manufacture and should be used minimally. Firstly only use iron, metal and steel when there are no other alternatives and secondly choose according to the manufacturing process. Metal is highly recyclable and efforts must be made to use components that can be re-used or recycled.

Concrete is an essential part of the entire built work but the cement it contains is aggressive to the skin and contains harmful substances. Cement furthermore requires large amounts of energy to be produced. Cement is essential to reinforced concrete and the only alternative is to use ingredients concrete is composed of, the cement, sand, stone and water, from a sustainable resource. The quantities required must be calculated that there is minimum wastage. The other option is where no reinforced concrete is required to find an alternative to using cement.

Glass is produced from natural renewable resources. It is important that the process by which glass is manufactured should be sustainable with minimum impact on the environment and lowered energy requirements for production and recycle potential. Additionally the quality of the spectrum of light-waves the glass allows through is an important consideration for the well-being of the occupants¹³. Other criteria when selecting glass are the consideration that ordinary glass has

¹³ vide 3.5.2:50

very low insulation, thermal and strength properties. In terms of thermal insulation double glass may be considered. Safety glass and tinted glass are other options to consider.

Plastics are unique in being an entirely manmade material that has become an integral part of the building structure. This is a total artificial product as is not in-line with what would be considered a healthy building. Many plastics including acrylics, PVC, polystyrene, polyurethane foam and other synthetic man-made materials are harmful to the health, among the effects are eye, nose, and skin irritation. In case of fire the fumes from most plastics are highly toxic. The use of plastics is almost inevitable in modern construction and therefore products should then be selected according to the manufacturing process that supports sustainability as a principle.

Natural fibres, linen, cotton, wool, silk, kapok, jute, hemp, sisal, coir, rayon, feathers and down, skins and hairs are all natural from an abundant renewable resource. They can be widely used in the building. Their production as an annual crop or manufacture as animal by-product must be done in a sustainable way with non-toxic preservatives or additives. (*ibid*: 160-161)

iv) Non-toxic materials

Many glues, paints, preservatives and synthetic materials have toxic effects on humans and the living environment. The toxic fumes and particles are taken up through the skin and air passages and lead to ill health. Firstly such materials should be avoided and replaced with non-toxic, environmentally friendly alternatives, such as natural plant dyes, water-based paint and natural varnishes. Good ventilation also supports the removal of unwanted components in the air that have been released from toxic materials.

Rotting, insect infestation, and fire are not welcome even in a sustainable building, therefore preparation and preservation of the materials and soil are essential.

All such work undertaken must be in an environmentally friendly way with non-toxic preparations.

v) Acts as a third skin, i.e. it can breathe

The human skin supports a healthy body by breathing, transpiration and absorption. People clad themselves in clothes as a second skin that protects and insulates while allowing the body balancing processes to continue. The building forms the third skin of human protection. The building must not harm the human occupant, but assist in maintaining well-being. So too, the building structure must maintain a

balance between dry and moist, warm and cold, protection and absorption, air exchange and so on. Just as the skin regenerates and new clothes are bought the building shell must also have the potential to regenerate. The comparison of building to a third skin is a study in itself. It is sufficient to use the metaphor as a reminder when considering which materials and finishes to specify for a building.

vi) **Electrostatically and magnetically neutral and avoid geopathic stress and electromagnetic pollution**

Static disturbs the natural electro-chemical system of the body. Synthetic materials characteristically carry a higher static charge compared to natural materials that naturally balance their static charge. Static affects the ion percentage of the air as discussed earlier. Vanderstadt (1996) recommends the following practical measures to reduce excess static – avoid synthetic carpets, wall coverings and furniture. Cover concrete and metal with solid wood. Replace synthetic material with cork, coconut fibre, felt, sisal, straw, reeds, seagrass, hennop, jute, natural paints, natural linoleum, beeswax and oils.

The general term geopathic stress refers to the discomfort and illness that occurs when the earth's natural magnetic field is disturbed by natural or man-made energy fields. Just as the body has an electro-chemical balance so too the human body has its own unique magnetic charge. Magnetical fields around equipment and arising from materials should be prevented from adversely affect the health of the body. The accepted safe level of exposure to electromagnetic fields is constantly being revised by scientists. Currently there is a great debate as to the effect of cell-phone magnetism on the brain. Electromagnetic pollution is the negative effects of electric and magnetic fields arising from for example microwaves that are used for satellite communication and microwave ovens. Modern technological devices must be recognised for both their positive and negative effects¹⁴.

The hazardous gasses ozone and radon also contribute to poisoning the home environment. Ozone is an unstable poisonous gas present in small amounts in the air, and it is responsible for the protective atmospheric layer shielding the earth from ultraviolet radiation. Smog is a result of high ozone levels. Radon is an invisible, odourless, colourless, radioactive gas found naturally in the earth's crust and in certain building materials. When radon decays it forms a harmful radioactive

¹⁴ vide 3.4.5:42

substance (*ibid*: 49-101). Radon occurs in higher concentrations in certain locations according to the ground composition. These areas are not suitable for building houses on.

vii) **Absorptive acoustic properties**

Noise pollution is a common phenomenon in the urban setting. An excess of noise is not conducive to human health. Where possible, noise pollution should be brought to minimum acceptable level. Simply stated, solid hard materials reflect, while soft materials absorb sound waves. Solid materials are concrete, metal, bricks, glass surfaces and stone. Organic materials such as straw, reeds, wood, and cork absorb sound due to their cellular structure. Internally soft furnishings aid the internal absorption of sound while externally vegetation works as a buffer and absorber of noise from the broader environment.

viii) **Minimal moisture content once the building is complete**

A moisture problem in buildings is recognised by experts as one of the main contributors of the 'sick building syndrome'. Water is a major component of the building construction process and materials. It is used in the mortar, concrete, forms part of bricks, is an essential part of timber and so on. The building may take several years to dry out completely. A moist third skin results in a moist cold space. Compare the physical response to wearing wet clothing, transfer this to the building shell, excess moisture contributes to ill health. Moist walls also cause heat loss when spaces are heated. The best solution is to use dry rather than wet building construction. Use mortar and other materials that dry quickly and allow for good ventilation of the new building structure.

ix) **Can be re-used or are bio-degradable and have a maximal life-span**¹⁵

3.6 **Life cycle of the building**

"To choose healthy materials is quite difficult. We are also concerned with the life-cycle of the materials, how much energy and environmental damages it takes to produce them, how the production influences nature and people working with the material, and what you can do with the material when you don't need it any more, and how the ecosystems are influenced by the use of the material" (Berström & Steinwell 1992:3).

¹⁵ *vide* 3.5.2:50

Large amounts of landfill may be attributed to building rubble. Re-use and recycling of building materials would greatly reduce these amounts. The modular co-ordination of components reduces waste. The more artificial and processed a building material becomes the more difficult it becomes to recycle or re-use. Asbestos is one such product greatly used in the seventies and now a problem during demolition. It is expensive to destroy and toxic as landfill. Timber painted with toxic paints can not be burnt due to the toxic fumes that would be emitted during such a process.

3.6.1 Life-cycle of building materials

The quality of the materials is important, the better the quality the longer the building life-span. Avoid materials that are produced only to last a few years and then require replacement. Natural renewable materials are the most appropriate for use in a sustainable design.

Maintenance should be thought about from the planning phase. Maintain the building well to extend its life, for example where timber frames are used, oil these yearly to avoid rot or drying and cracking. Where materials require preservation, such as wood, use natural preservatives.

3.6.2 Re-use of building materials

Materials should be used in such a way that they can be re-used if the building is demolished. Vanderstadt (1996:90) suggest using materials that can easily be disassembled and re-used, such as logs stones and stacked bricks. Use mortar sand fixtures that allow easily disassembling for re-use.

3.6.3 Re-cycling of building materials

Vanderstadt (1996:90) states that sustainable building uses materials that can be re-cycled by nature herself. These are materials such as natural preserved timber, straw and organic materials such as wool. Sun-dried clay bricks (adobe type), mixed of straw and other organic materials also have a good insulation value as well as recycle value.

Where possible, use materials that can be recycled or are bio-degradable once they have reached the end of their usefulness to the building.

3.7 Summary

Chapter three defines and discusses sustainable building design by identification of principles that contribute towards achieving a sustainable built environment.

The need to present information clearly and avoiding alienating jargon requires the sub-division of the information into logical inter-linked topics. Berström & Steinwell (1992:47) identify the inter-linked character of sustainability when they say: "Instead of maximising the function of single elements without any interrelationship to one another, we optimise the overall result by creating the largest number of useful links". The division of the information takes the lead from the Gaia principle of the house as a micro-ecosystem that interacts with the wider ecosystem of planet earth. The exploration of the principles is divided into the various interacting ecosystems between man, nature and the building hence the headings - the ecology of user, ecology of the site and ecology of the building. Each heading explores principles that contribute towards achieving sustainability in these aspects of human habitation.

3.8 Conclusion

Sustainability in the context of the building environment requires a broad range of guiding principles that will assist designers, developers and users alike, how to work towards achieving a sustainable building. The dissertation written by C du Plessis (1998) lists the numerous definitions for sustainable development (see Appendix 1) and identifies the need for a broader definition than a few definitive words. Chapter three acknowledges the need to address sustainability in the built environment as broader than a single definition by analysing sustainability as a set of principles that contribute to achieving that aim.

Research into SBDP that links the ecology of user, site and building reveals that information is broad and specific data relevant to both climatic region and house type is difficult, if not possible, to find. The available scientific facts can not quickly be interpreted to solve problems in the field. The research revealed that outside of the information on the Highveld climatic zone in the *Manual for Energy Conscious Design* (Holm 1996:64-73) there is currently no other specific information available that can readily be applied to the FOURways house. If a sustainable building environment is to become a reality in the near future for the occupants of the FOURways house a real need exists for information specifically geared to address the needs of this group.

CHAPTER IV

4 ADAPTING THE SUSTAINABLE BUILDING ASSESSMENT TOOL (SBAT)

Sub-problem 2 The second sub-problem is to test the SBAT towards achieving sustainable building design principles for medium density, middle-income housing in Gauteng (the FOURways house).

Hypotheses 2 The second hypothesis is that the adapted SBAT will produce criteria towards achieving sustainable building design principles for the FOURways house.

4.1 Evolution of the SBAT

The Green Buildings for Africa (GBFA) launched in 1998 by the CSIR Boutek takes into action the Green Building Initiative by assessing projects for their environmentally responsible usage.

The GBFA represents South Africa in the Green Buildings Challenge (GBC) and is developing the GBTool for local use. Furthermore, the July 28 issue of Engineering news reports (2000:21), "The programme has also seen the development of an assessment tool, known as the building environmental assessment rating system, which measures the effect of building have on the environments, as well as the various indoor components of the building". The tool originally known as the BEARS (Building Environmental Assessment Rating System) has developed into the current prototype Sustainable Building Assessment Tool (SBAT) (see Appendix 4).

The CSIR currently offers two tools for assessing the sustainability of a building, the GBTool and the prototype (still under development) SBAT. The CSIR is developing the SBAT as a local, widely accessible derivative of the GBTool. SBAT is identified by Neil Oliver of the CSIR as, "a high-level, quick and easy sustainable buildings assessment tool". It is being developed as a tool that stimulates and guides discussion from the outset of a project by the whole project team including the client, architect, developer etc. It does not require specific tools of measurement, but rather sets out parameters when adhered to achieve a more sustainable building.

The SBAT uses three column definition of sustainability (see Appendix 4) which separates criteria into the categories, "social", "economic" and the obvious "environmental issues". The CSIR Boutek recommends that: "the SBAT forms an integral part of the briefing process at project initiation, and can be equally usefully applied during design development" (SBAT prototype 2001).

It is the prototype that forms the focus of this chapter. With kind permission of the CSIR the tool may be used for academic purposes even though the SBAT is still being developed further and not currently commercially available.

4.2 The SBAT and the three target criteria descriptors

The target criteria descriptors have been allocated under the three main headings as per the three column definition being “social”, “economic” and “environmental” criteria. The three criteria are each sub-divided into five specific criteria. The SBAT Diagram divides a circle into three sectors and lists the headings under each criterion. Concentric division into segments will allow for future rating of criteria once the prototype is further developed. The original SBAT diagram illustrated in Figure 4.1 shows the division of the various social, economic and environmental criteria.

The SBAT has been converted to a typed format for the purpose of this study but the original computer version inter-links the responses. The opportunity is given to rate priority of the particular description according to target values described as: “*none, low, medium, high, essential*”, criteria for achieving sustainability of a building.

The full unchanged SBAT is shown in Appendix 4.

The criteria have been tabulated for comparative purposes in Table 4.1.

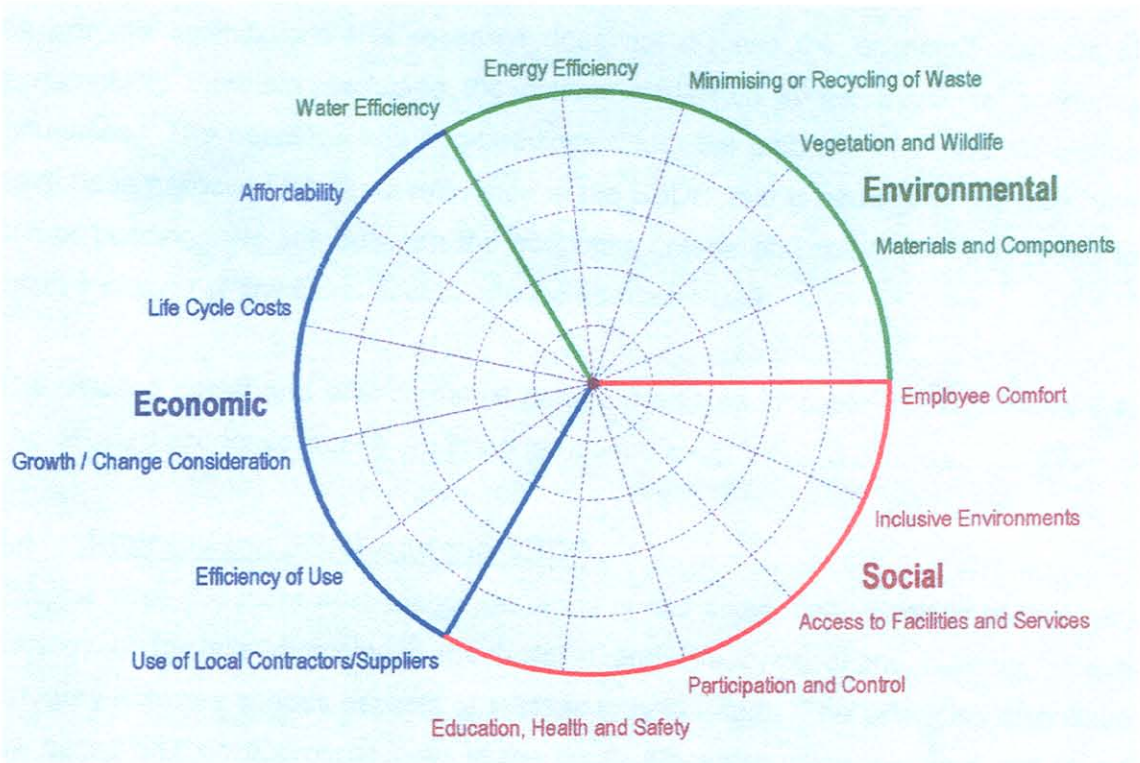


Figure 4.1 – The original SBAT Diagram (CSIR 2001)

Table 4.1 - SBAT category definition

<u>Social Criteria</u>	<u>Economic Criteria</u>	<u>Environmental Criteria</u>
Employee Comfort	Use of Local Contractors/Suppliers	Water Efficiency
Inclusive Environments	Efficiency of Use	Energy Efficiency
Access to Facilities and Services	Growth / Change Consideration	Minimising or Recycling of Waste
Participation and Control	Life Cycle Costs	Vegetation and Wildlife
Education, Health and Safety	Affordability	Materials and Components

4.3 Criteria for inclusion and exclusion of criteria

Each of the sub-headings in the categories social, economic and environmental criteria as listed in Table 4.1 form an integral part of sustainability.

The first criterion for inclusion is appropriateness to the South African situation. The SBAT is developed in South Africa by one of the foremost research facilities in the country, the CSIR, and can be accepted as applicable towards achieving sustainability of the FOURways house.

As per the delimitations this research does not discuss the economic aspects of sustainability therefore excluding the column dedicated in the SBAT to economic influences. The headings and sub-headings under the umbrella of economic criteria have been assessed for direct relevance to the SBDP, that is ecology of the user, site and/or building. No link between the economic criteria and the SBDP was found to justify inclusion of any items directly into the adapted SBAT.

The detailed social and environmental criteria are listed in Table 4.3 and Table 4.4. The detailed economic criteria are listed in Appendix 4.

4.4 Inter-linking SBAT and the SBDP

Chapter three describes sustainability in terms of four categories - Ecology of the user, Ecology of the site, Ecology of the building and Life cycle of the building. Each category explores various aspects of sustainability in depth. The principles discussed are based on their appropriateness to the South African situation, but have not as yet focused on the FOURways house.

The two SBAT target criteria “social” and “environmental” that will be used in this study have many synergies with the SBDP. The social criteria are seen as inter-linked with the living environment. A healthy living environment supports and promotes well-being and therefore is not dealt with separately in the research of SBDP. The social criteria dealt with separately in the SBAT from part of the body of information as integrated in the SBDP.

The SBAT, while being a specifically South African document remains generally applicable to a broad spectrum of building types and is currently not available with guidelines.

There is a correlation between the SBAT as a discussion tool that introduces important criteria and the body of information in the SBDP that discusses the criteria in greater depth. Chapter three, together with the SBAT will be adapted for use on the FOURways house and be tested in chapter five on a case study.

Table 4.2 - Categories arising from GSBDP research

Ecology of the User	Ecology of the Site	Ecology of the Building	Life Cycle of the Building
	Location	Relationship of Building to Site	Life-cycle of building materials
	Site Features and Natural Environment	Orientation of the building	Re-use of building materials
	Orientation	Generic Climate	Re-cycling of building materials
	Climate	Energy of the building	
	Energy	Water and the building	
	Water	Waste and the building	
	Waste	Building Materials	
	Fauna and Flora	Construction Methods	

Table 4.3 - Comparative analysis of “social” criteria

<u>SBAT</u> <u>Employee</u> <u>Comfort</u>	Natural lighting	Natural ventilation	Low noise	Views (all work positions min 6m from external window)	Access to amenities: WC, refreshments (tea making point)
<u>GSBDP</u>	3.4.3 & 3.5.2	3.4.4 & 3.5.3	3.4.1 & 3.5	Figure 3.6	no
<u>FOURways</u>	Relevant	Relevant	Relevant	Review	Review
<u>SBATI</u> <u>Inclusive</u> <u>Environments</u>	Easy access to disabled friendly public transport	All routes in and between buildings smooth and even (i.e. wheelchair accessible)	All changes in levels routes in and between buildings include ramps with 1:12 fall, hand rails and/or lifts	Required number of disabled accessible WC(s) available	Edges (i.e. between walls and floors) and stair nosing clearly distinguished with contrasting colours
<u>GSBDP</u>	Not a focus in this research, however, all urban design should consider these criteria.				
<u>FOURways</u>	Specific houses for the disabled must be designed accordingly				
<u>SBAT</u> <u>Access to</u> <u>Facilities and</u> <u>Services</u>	Crèche	Banking	Shops	Communication Facilities (Post, Public Telephone, email)	Government / tax / licensing information
<u>GSBDP</u>	3.4.1	3.4.1	3.4.1	3.4.1	3.4.1
<u>FOURways</u>	Relevant	Relevant	Relevant	Relevant	Relevant
<u>SBAT</u> <u>Participation</u> <u>and Control</u>	Personal control over light, temp and ventilation levels	Users involved in design / construction process	Users involved in the design, refurbishment of their spaces	Users able to adapt their spaces to suit themselves (i.e. furniture / privacy)	Space and / or equipment shared with local community
<u>GSBDP</u>	3.3	3.3	3.3	3.3	3.3
<u>FOURways</u>	Relevant	Relevant	Relevant	Relevant	Relevant
<u>SBAT</u> <u>Education,</u> <u>Health and</u> <u>Safety</u>	Space available for group training sessions/accesses to learning packages	Fully compliant with fire escape requirements	Access to Sports facilities	Access to nutritious food (restaurant, vegetable gardens etc)	Materials used, screened for hazardous compounds (i.e. VOCs)
<u>GSBDP</u>	Not applicable	Pre-requisite	3.4.1	3.4.1 & 3.4.2	3.5.7
<u>FOURways</u>	Not Relevant	Relevant	Relevant	Relevant	Relevant

Table 4.4 - Comparative analysis of “environmental” criteria

<u>SBAT</u> <u>Water</u> <u>Efficiency</u>	Rainwater harvesting	Water efficient devices: low flush WCs and urinals	Greywater reuse	Minimising runoff: absorbent external surfaces	Low water demand landscaping
<u>GSBDP</u>	3.4.6	3.5.5	3.5.6	3.5.1	3.4.8
<u>FOURway</u>	Relevant	Relevant	Relevant	Relevant	Relevant
<u>SBAT</u> <u>Energy</u> <u>Efficiency</u>	Located near public transport / all users within walking distance (4km)	Passive environmental control system for ventilation	Passive environmental control systems for heating and cooling	Low energy appliances / fittings	Solar control
<u>GSBDP</u>	3.4.1	3.4.4	3.4.3	3.5.4	3.4.3
<u>FOURway</u>	Relevant	Relevant	Relevant	Relevant	Relevant
<u>Minimising or Recycling of Waste</u>	System for recycling	System for reusing	Sewerage	Provision for dangerous toxic waste	Systems set up to minimise/reuse waste produced during construction process
<u>GSBDP</u>	3.5.6	3.5.6	3.5.6	3.5.6	3.5.6
<u>FOURway</u>	Relevant	Relevant	Relevant	Relevant	Relevant
<u>SBAT</u> <u>Vegetation and Wildlife</u>	Use of a 'brownfield' site	Range of plants	Range of habitats provided	Effect on neighbouring buildings: light etc (buildings kept apart minimum 10m for 1 s, 15m for 2s+)	Minimal external inputs required for maintenance of landscaping (i.e. fertilizers/ pesticides)
<u>GSBDP</u>	Relevant	3.4.8	Relevant	3.5.1	3.4.8
<u>FOURway</u>	Relevant	Relevant	Relevant	Relevant	Relevant
<u>SBAT</u> <u>Materials and Components</u>	80% of materials have low embodied energy	No material / component used manufactured through process which harms the environment	All materials / components produced using only renewable energy sources	80% of materials and components for the buildings recycled / refurbished	80% materials and components from renewable resources
<u>GSBDP</u>	3.5.7	3.5.7	3.5.6	3.5.7	3.5.7
<u>FOURway</u>	Relevant	Relevant	Relevant	Relevant	Relevant

4.6 The GSBDP and the adapted SBAT

The research illustrates that the two bodies of information, SBDP and SBAT are complementary. Refinement towards a sustainable built environment in the medium density, middle-income house in Gauteng can be achieved using tools that introduce the criteria and then discuss the requirements of sustainability.

The prototype SBAT is recognised as a compact document introduced at the project outset in order to stimulate discussion on the topic of sustainability and work towards achieving a sustainable building design. Due to the continued disregard of sustainable principles by the project team, the introductory role of the adapted SBAT must be recognised as essential towards achieving sustainability in the building industry.

To avoid becoming cumbersome, the brevity of the initial discussion document, the adapted SBAT, is essential. The adapted table of criteria will consequently be edited to fit on one A4 page, supplemented by the adapted SBAT diagram (see Figure 4.3). Table 4.5 lists the adapted categories and points of discussion.

The SBAT diagram makes use of three parts divided into five segments each. Each segment has five concentric divisions. The five requirements under each criterion of the original SBAT can be rated in priority as: “essential, high, medium, low, none” (SBAT Prototype, 2000). The adapted SBAT makes use of the original diagram with adaptations as listed above. The original division of criteria into five requirements has been maintained but the three parts have been removed. The priority rating is removed in the adapted SBAT as it is postulated that all criteria and each subsequent requirement must be met to achieve a sustainable building.

The prototype SBAT and original SBAT documents and diagram are adapted as follows:

- i) The economic criteria are excluded.
- ii) The criteria are adapted to the domestic market, specifically the FOURways house.
- iii) The place specific criteria is introduced, i.e. Gauteng.

The petal principle

The adapted SBAT diagram includes a scoring illustration of a flower with a petal representing each criterion. Every criterion is rated out of five. If all five criteria requirements are met then the rating is five out of five (5/5) if none are met the total is

zero out of five (0/5). A score of three or less renders that criterion not sustainable and will render the whole not sustainable.

The petals, as the original diagram, are divided into five concentric rings. Starting at the centre of the flower, a division is coloured in, on the specific petal for that criterion, for each requirement met. No requirement has priority over another. The sustainability of a building is measured by assessing to what extent each criterion has been met. The various requirements as listed are scored on the criteria (petals).

The more complete the flower, the greater the sustainability of the building. Figure 4.4 illustrates different scenarios to show the effectiveness of using the flower diagram known as the petal principle to quickly assess the sustainability of a building.

Table 4.6 list random results for four different possible scenarios. Figure 4.4 illustrates the results and visual effect of the petal principle when different results are compared.

The metaphor is taken from nature (Figure 4.2), the more complete the flower is the greater chance of survival there is, that is to say, the more completely the requirements of the criteria are met, the greater the sustainability of the assessed building.

The flower can also be used as a measure whether or not the building supports overall well-being by its sustainability.

Table 4.5 – The adapted SBAT including “social” and “environmental” criteria

CRITERIA (a –j)	Requirement A	Requirement B	Requirement C	Requirement D	Requirement E	SCORE
a) <u>Occupant Comfort</u>	Natural lighting	Natural ventilation (air quality)	Low noise	Views (all rooms external window)	Access to amenities, compact layout	— 5
b) <u>Access to Facilities and Services</u>	Crèche Schools	Banking, Shops, Restaurant	Proximity to parks and sports facilities	Communication Facilities (Post, Public phone, email)	Government / tax / licensing information	— 5
c) <u>Participation and Control</u>	Educate to control over light, temp and ventilation levels	Users involved in design / construction process	Users involved in the design, refurbishment of their spaces	Public and privacy parameters set-up	Space and / or equipment shared with local community e.g. Swim pool	— 5
d) <u>Health and Safety</u>	Community centre and community spaces	Fully compliant with fire requirements	Proximity to Police station, Fire station, hospital etc.	Access to nutritious food (restaurant, vegetable gardens etc)	Free of air, electro, ground, noise, and water pollution	— 5
e) <u>Water Efficiency</u>	Rainwater harvesting	Water efficient devices: low flush WCs and urinals	Greywater reuse	Minimising runoff: external surfaces absorbent	Low water demand landscaping	— 5
f) <u>Energy Efficiency</u>	Located near public transport / all users within secure walking distance (4km)	Passive environmental control system for ventilation (thermal comfort)	Passive environmental control systems for heating and cooling (thermal comfort)	Low energy appliances / fittings	Solar control (including thermal comfort)	— 5
g) <u>Minimising or Recycling of Waste</u>	System for recycling (recycle depots)	System for reusing	Sewerage	Provision for dangerous toxic waste removal	Minimise construction waste	— 5
h) <u>Vegetation and Wildlife</u>	Use of a 'brownfield' site	Range of plants that are indigenous	Diversity in flora and fauna habitats	Effect on neighbouring buildings: light etc	Low maintenance landscaping (e.g. fertilizers)	— 5
i) <u>Materials and Components</u>	80% of materials have low embodied energy	Environmentally friendly material and component used	All materials / components produced using only renewable energy sources	80% of materials and components for the buildings recycled / refurbished	80% materials and components from renewable resources	— 5
j) <u>Location identification</u>	Site features and natural environment	Identify existing flora and fauna	Climate and orientation	Natural water	Area Layout (incl. inclusive environments)	— 5

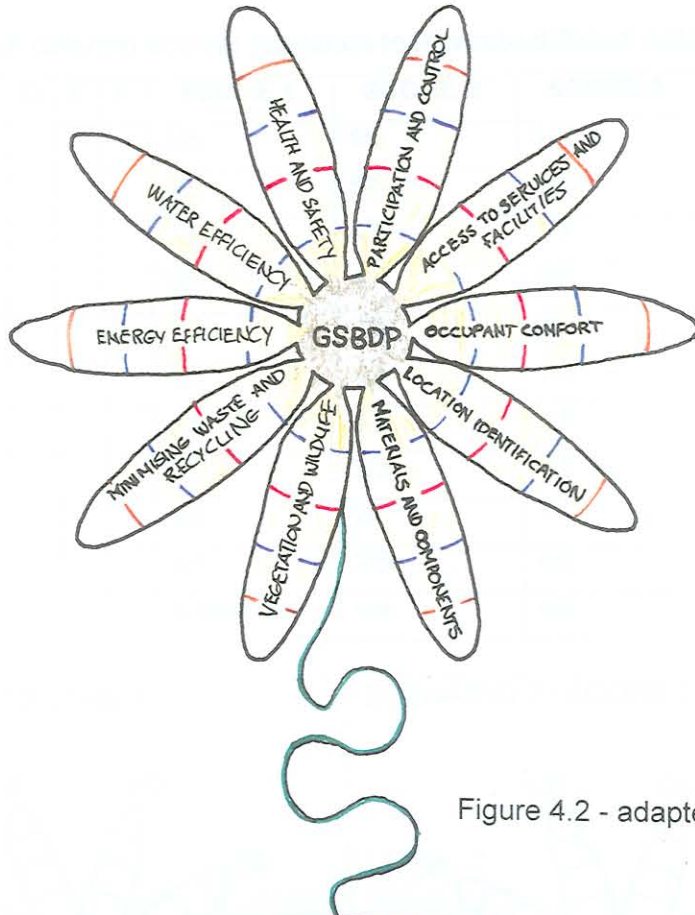


Figure 4.2 - adapted SBAT diagram

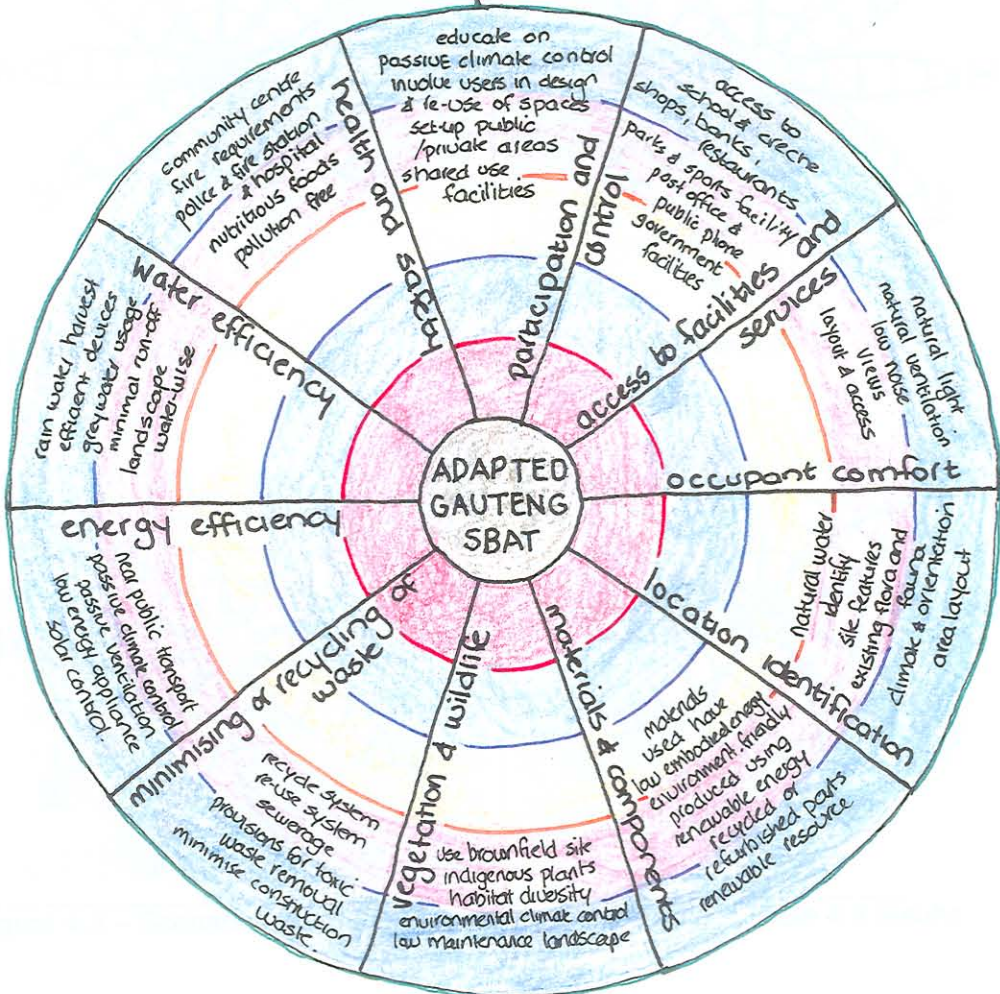


Table 4.6 – Four different scoring scenarios to illustrate different petal principle results

	A	B	C	D	E	F	SCORE 1	SCORE 2	SCORE 3	SCORE 4
a)							4/5	5/5	1/5	3/5
b)							4/5	5/5	4/5	3/5
c)							3/5	4/5	2/5	3/5
d)							3/5	4/5	5/5	4/5
e)							4/5	3/5	2/5	4/5
f)							4/5	4/5	1/5	4/5
g)							4/5	4/5	4/5	3/5
h)							5/5	3/5	5/5	5/5
i)							3/5	2/5	1/5	3/5
j)							4/5	2/5	4/5	3/5
Results							sustainable	not	not	sustainable

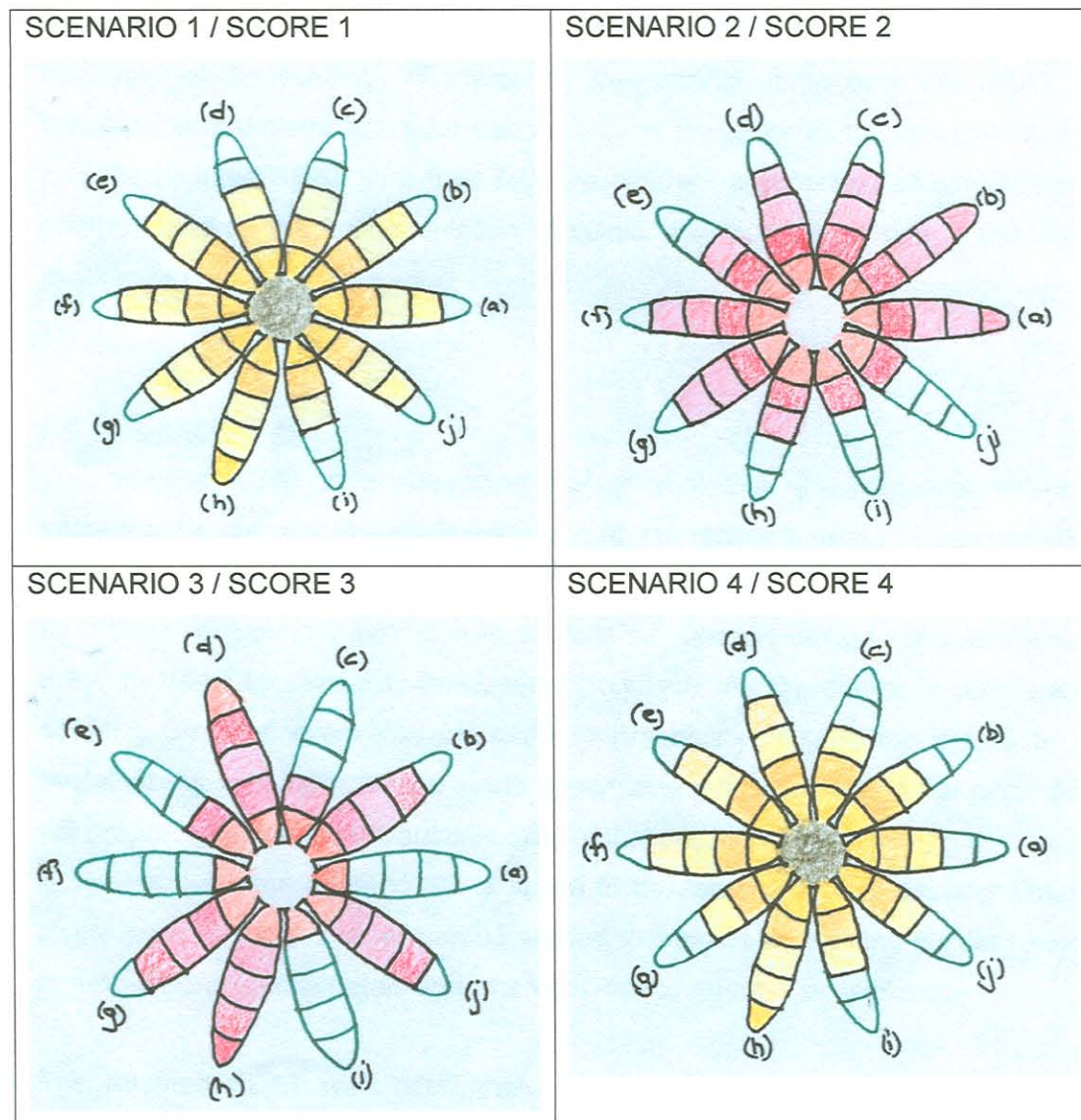


Figure 4.3 – Scenarios illustrating the petal principle as per Table 4.6 results

4.7 Summary

The fourth chapter analyses the SBAT in relation to the discussion of working towards principles for sustainable building design in chapter three. The SBAT is tested for relevance to location and house-type, specifically the FOURways house.

The SBAT is based on the three column definition of sustainable development that includes social, economic and environmental criteria. The SBAT is a systematic and symmetrical analysis of criteria deemed important to sustainable design. It has (as yet) not been made specific to location nor house type.

The original SBAT has been adapted in this chapter for criteria relevant to the FOURways house and has been developed graphically to inter-link the two bodies of information. In chapter three sustainable design is discussed broadly under the inter-linked headings of ecology of the user, ecology of the site, ecology of the building and life cycle of the building. Considering the original purpose of the SBAT as an introduction to present topics for discussion, the principles as background information and the adapted SBAT as a final test, the different approaches all complement one another towards the implementation of sustainable building design in the domestic building market.

4.8 Conclusion

The adapted SBAT is a discussion tool presented at the outset of a design to introduce the concept of sustainability and all the relevant issues to be considered in the design. The sustainable building design principles (discussed in chapter three) form the background information to explore the detailed design considerations once the concept of sustainability has been introduced. As the design is developed, the adapted SBAT diagram can be used to graphically assess the extent to which sustainability is being achieved in the design and a final test using the petal diagram will graphically illustrate the sustainability of that situation.

A system using the adapted SBAT tables to assess and test an existing situation is also relevant. The principles can be applied to improve an existing building according to the weakest criteria/petals and wherever improvement is possible.

The adapted SBAT with background information and graphic testing provides a complete tool to implement and test an envisaged or completed house design for its sustainability.

CHAPTER V –

5 THE ADAPTED SBAT ANALYSIS OF THE FOURways CASE STUDY

Sub-problem 3 The third sub-problem makes use of the first and second sub-problem findings to analyse the use (or lack) of sustainable building design principles in current examples of the FOURways house. This sub-problem highlights the difference between buildings that do and do not make use of sustainable building principles.

Hypotheses 3 The third hypothesis is that typical FOURways houses in Gauteng currently do not make use of sustainable building design and construction.

5.1 General Introduction to the FOURways case study

The development Ravenna arose out of an independent feasibility study conducted by the developers. No general feasibility studies conducted by a research body are available for the area. Each new development is approached independently by the various developers who generally base the final decision on their personal experience and intuition of the building market.

The selected growth point is typified by new medium density developments of townhouses and cluster houses. The availability and affordability of land in this area has made it popular for developing homes in the price category R100 000 to R600 000. The majority of the developments are aimed at the first time homebuyer with prices between R100 000 and R250 000. Houses are single or double storey, with lofts being very popular as additional space which is otherwise lost as roof space.

The Ravenna development is composed of simplex cluster homes with a variety of two and three bedroom layouts with the option for a loft area. Stands vary in size from 440 square metres to 750 square metres. The designs are completed before any property is sold. Following a sale the selected site and house type is positioned and the design adapted to the individual needs of the purchaser. (see Figure 5.1). An average limit of three variations for each house type cuts design costs. The house size varies between 50 and 150 square metres.



Figure 5.1 - Example of two available house designs in the development Ravenna.

5.2 Introduction to the case study

Two examples have been selected from the development for further study. The buildings are typical examples of the house type being developed in the area. The first example will be studied in depth with a final test of sustainability being done using the adapted SBAT. The same criteria apply to both examples and since the two buildings are within close proximity, with only an orientation variation, the sustainability of the second example will be tested using only the adapted SBAT.

5.3 Case study – Use of the adapted SBAT on a FOURways house

The application of sustainable building design principles can be applied from the outset of a project as design philosophy or as retrofit. Both the retrofit possibilities for completed houses and the principles applied at the design stage are considered in this analysis.

In the case of the examples of Ravenna homes analysed the delivered building is often incomplete with the non-essential finishes being purchaser's prerogative. Fortunately this provides an opportunity to improve the living environment after delivery of the building, however, many parts are complete and can not be reversed without substantial retrofit costs being involved.

Firstly, case study one will be analysed in depth according to the sustainable building design principles (SBDP) discussed in chapter three followed by the adapted sustainable building assessment tool (SBAT) test. Case study two is assessed using only the adapted SBAT. Where relevant illustrations of case study two will be included in the first analysis for reference purposes.

5.4 Ecology of the user

Any concern with sustainability by an occupant will be on a personal level. Sustainability did not form any part of the marketing or building principles employed by the developers.

The home owner must be educated as to the long term benefits of both energy efficient installations and finishes to facilitate an informed choice with respect to insulation, fixtures and even materials. Other important points to stress when encouraging sustainable living are the role the garden plays as a setting to living in and not against the environment. There are numerous aspects such as re-cycling, air flow regulation, rainwater penetration and small scale ecological cycles of insects, birds, lizards and so on that must be brought to the attention of the homeowner.

Users of a house can be generally defined as human beings functioning in a modern world. This entails both commercial and physiological needs. That is requirements dictated by the monetary nature of building possession and also the needs of the human body as an organ.

The commercial aspect of home ownership

First time homeowners are no longer satisfied with basic accommodation, as urban dwellers and consumers the economic value and a variety choice are important. The homebuyer's choice is guided by the basic requirement for a specific number and type of rooms as well as aesthetic and lifestyle preferences.

The selected case study is a typical example of current development aimed at the market priced from R149 000 (price for 1998). The house is sold as a package price inclusive of transfer costs, stand, house, open brick-patio, single carport with facade, paved driveway, walling, lawn street frontage and intercom. The development satisfies the current requirement for increased security in the form of an area that is secured i.e. in an enclosed medium density development with central facilities (see Figure 5.2).



Figure 5.2 - The secured property development

The occupants of the houses in Ravenna generally fall into the category middle-income earners¹⁶. The houses are designed to accommodate the definition of type, for example to include space for the washing machine, microwave and so on.

Modern urban people are continually increasing their basic demands and thereby increasing the pressure to produce consumable goods. The increase in production is directly related to the pressure on both renewable and non-renewable resources. This case study is one example, of many developments, where the developer has tried to satisfy the consumer orientated needs of the purchaser and disregarded any notion of sustainability. Often the consumer attitude is to the detriment of the natural environment. South African consumers are only slowly warming to the idea of sustainability. Housing is a basic requirement and cannot be negated, but the preservation of nature is also very important. Human survival is essential and must go hand in hand with sustainable development.

5.5 Ecology of the site

The first step to living sustainably is to choose a healthy location free from the influence of air, electro-, ground, noise, water pollution and geopathic stress. Logically it is senseless to build a structure of sustainable materials if the area itself is poisonous to the occupants. Conversations with the developers did not reveal any concern with sustainability.

The area must also display a balance between public and private, open spaces and built forms and accommodate a mixed group from singles, young families through

to the aged young and old. Mixed use areas with schools, shopping centres, recreation areas, playgrounds and homes are not within walking distance. Ravenna is located within driving distance of all the above with the car being an essential component of living in this development. There is no social control through mixed use. It is a modern South African enclosure that is occupied by fear of the outside world. Modern living environments appear to be socially a giant step backwards with developments displaying a return to mediaeval life with electric fences and access control gates instead of fortified walls and draw-bridges. Ravenna is a typical example of the modern idiom of the homes as a cocoon.

The case study displays disinterest in the specifics of the particular environment where the development is situated. The buildings are not a response to the site, merely a market reaction to the need for housing in this specific sector. The quality of the living environment appears not to have played a role in the design and construction process. The cleared site provides a clean canvas for building on with houses that sit on the site and are not an integrated part of this piece of land.

5.5.1 Location

The area was until recently a farming area outside of the city but has become a hot spot for housing and related developments. People are travelling greater distances with increased traffic resulting in more road infrastructure and traffic jams, expensive energy wastage on transport, rendering areas unsafe traffic zones not suitable for domestic life. The mobility results in separating life into zones around the city for homes, office parks, recreational facilities, shopping centres and so on. Figure 5.3 illustrates the trend where the city is vacated and natural surrounding areas are being encroached upon

The area north-west of Johannesburg is mostly characterised by large-scale development in the medium density house type. Developments in this area are growing towards the natural area, the Magaliesberg. Development should be restricted, as this is a natural, physical and visual haven from the urban area that must be preserved for future generations to appreciate, enjoy and benefit from. The local authority should make requirements to maintain a percentage of open natural space before a situation arises where buildings dominate the whole area.

¹⁶ vide 2.5.3:23

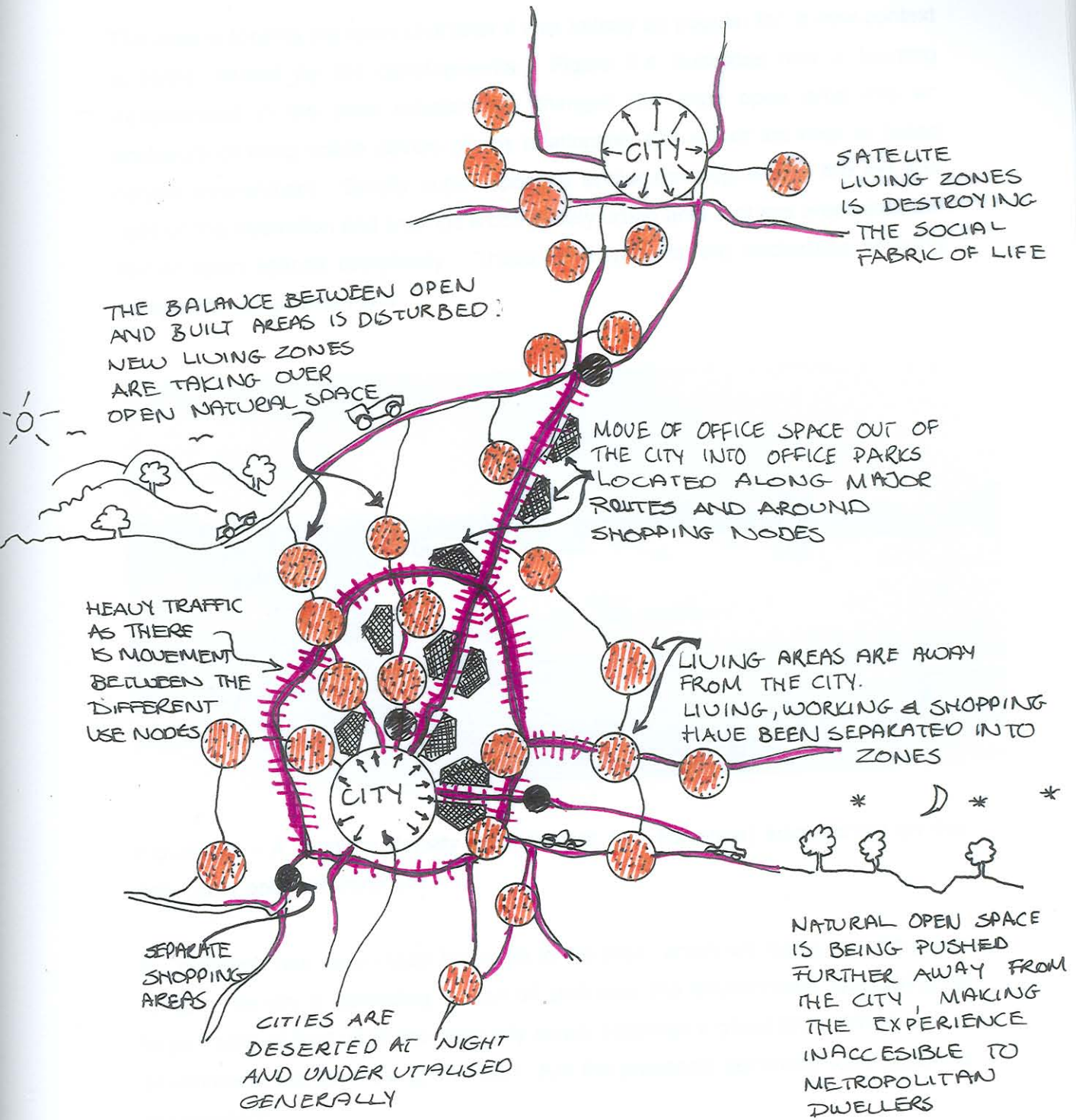


Figure 5.3 - Illustrates the trend where the city is vacated and natural surrounding areas are being encouraged upon.

The area is losing the open character it was initially so popular for, a new context is being created by the developments. Figure 5.4 illustrates how a housing development in the area substantially changes the once open area into an enclosure of living space devoid of any relationship with either the near or broad natural environment. Simply superimpose a similar development to the left and right on the illustration and one has a completely urban area that has eradicated the former open spaces completely. These developments are enclosures of living comparable to a human zoo.



Figure 5.4 - A medium density development (not Ravenna) encroaching on the previously open environment

No provision has been made for parks in the area, which will retain specific green lungs. The city is spreading like an oil slick over the environment, swallowing up large tracks of land while the inner city slowly becomes a ghost town. What kind of environment are we moving towards? Are the prospects becoming too frightening to consider?

An analysis of the area revealed that fortunately the site is not toxic. This analysis should have taken place before any detailed planning took place. The site situation has no immediate air, noise, ground or electro pollution problems. The nearby industrial area must maintain the light industry character to avoid future problems from developing. The highway does not carry audible noise pollution to the site but

should be considered a source of air pollution, especially as traffic increases. Figure 5.5 analyses the services in the area of the development.

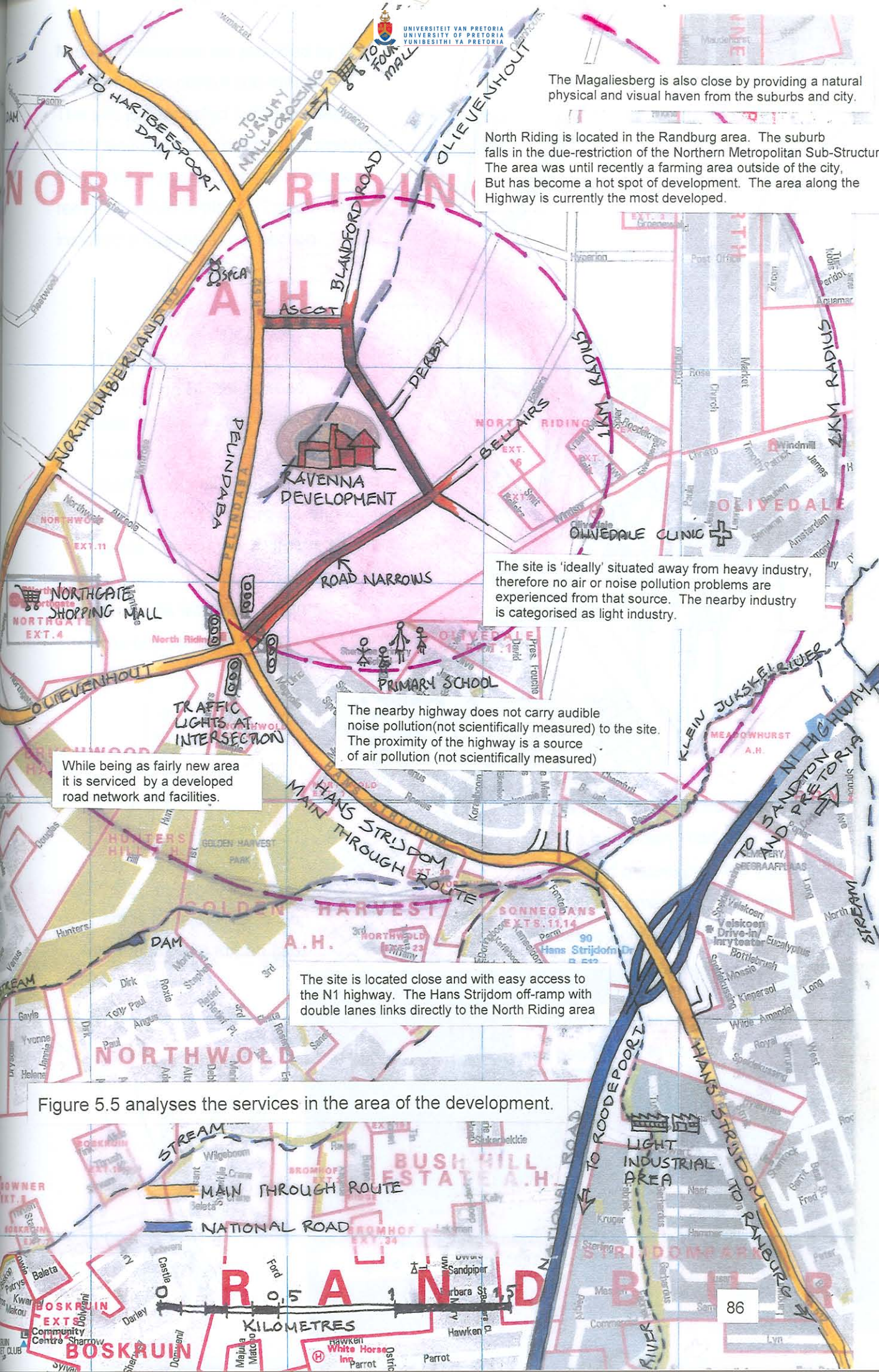
Vegetation, ponds and open areas established on the site provide filters for pollution. Adjacent to the site is a perennial stream, however it appears to flow with very heavy rainfall only. The streambed supports a variety of plants and provides a natural zone of visual and natural relief in this fast developing area.

The nuclear power station Pelindaba even though many kilometres away, could be considered a health hazard, as it has not been fully dismantled. Individuals have different varying resistance to radiation and the individual must decide if they wish to consider the effects of the Pelindaba nuclear plant or not.

A developed infrastructure services the site and makes access possible but, attention must be paid to the quality of the roads in terms of dealing with rainwater run-off. In an area such as this which is partially disowned farmland juxtaposed with fully developed sites the quantity of rainwater run-off must be actively managed. Currently dirt roads and cleared but undeveloped sites are leading to erosion and the loss of valuable top-soil. (see Figure 5.6)

No provisions have been made for pedestrian or bicycle traffic. There are no parks in the area or a play area in the vicinity or within the development. Fortunately enough open areas remain that can be dedicated for parks and recreational areas. The area has not been developed considering the needs of children, elderly or infirm but for the childless, mobile executives that commute to their workplaces each in their own vehicle, which is reinforced by the absence of a connection to the public transport system.

Developments such as this case study provide an opportunity to reduce traffic. The security controlled entrance ensures that vehicles that have no business in the development can not drive through the area. Traffic can be laid out to slow traffic and restricted to single, one way traffic or alternatively the car can even be eliminated by creating a central car park that gives pedestrian access to the homes.



The Magaliesberg is also close by providing a natural physical and visual haven from the suburbs and city.

North Riding is located in the Randburg area. The suburb falls in the due-restriction of the Northern Metropolitan Sub-Structure. The area was until recently a farming area outside of the city, But has become a hot spot of development. The area along the Highway is currently the most developed.

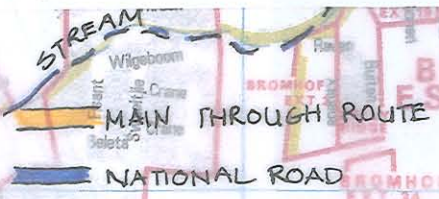
The site is 'ideally' situated away from heavy industry, therefore no air or noise pollution problems are experienced from that source. The nearby industry is categorised as light industry.

The nearby highway does not carry audible noise pollution (not scientifically measured) to the site. The proximity of the highway is a source of air pollution (not scientifically measured)

While being as fairly new area it is serviced by a developed road network and facilities.

The site is located close and with easy access to the N1 highway. The Hans Strijdom off-ramp with double lanes links directly to the North Riding area

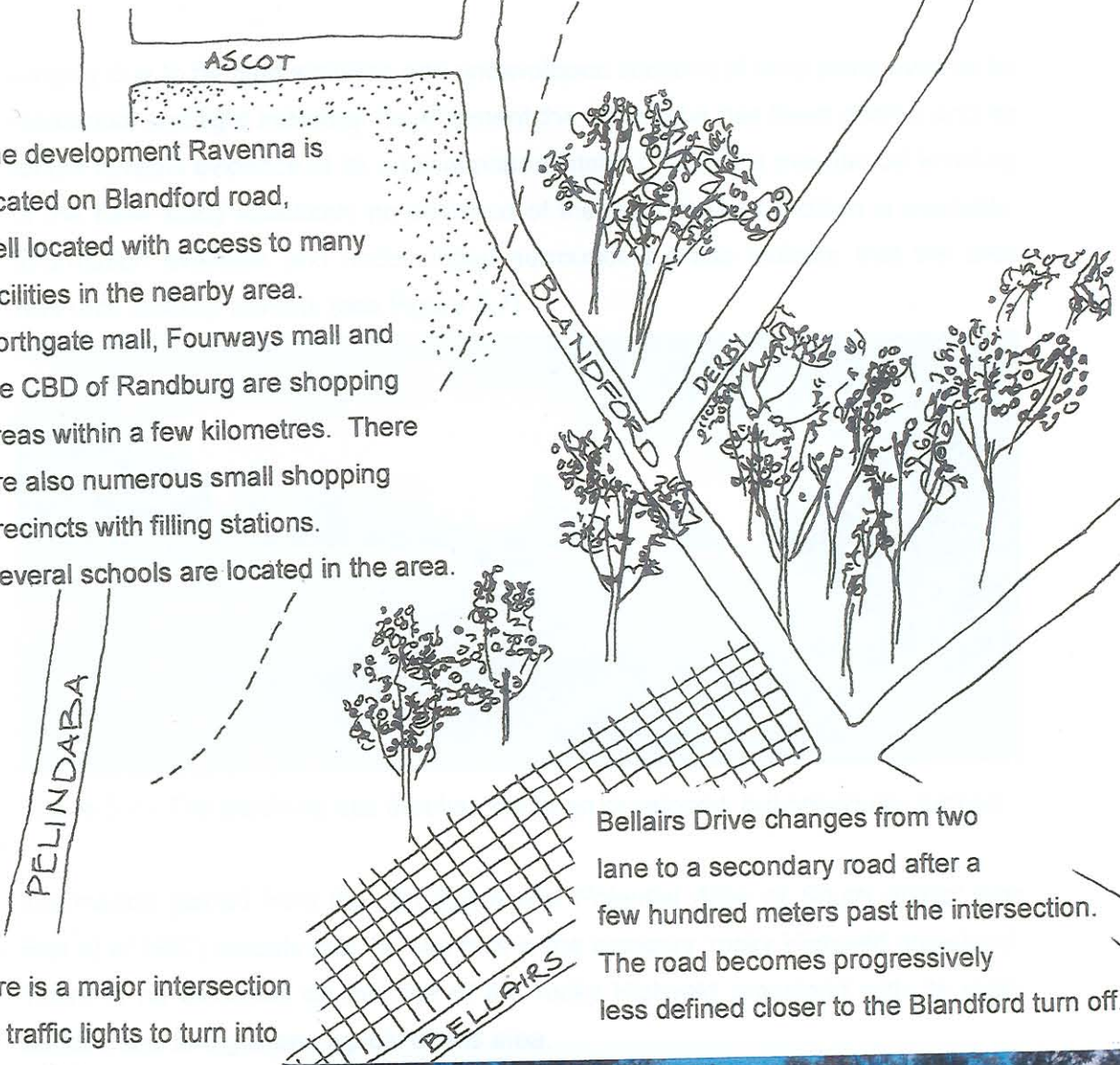
Figure 5.5 analyses the services in the area of the development.



LIGHT INDUSTRIAL AREA

Municipal services are provided by the northern metropolitan sub-structure. The site is connected to the municipal water and electricity supply and sewerage links. The municipal service of refuse removal is also in place. Telkom has installed a telephone connection.

The development Ravenna is located on Blandford road, well located with access to many facilities in the nearby area. Northgate mall, Fourways mall and the CBD of Randburg are shopping areas within a few kilometres. There are also numerous small shopping precincts with filling stations. Several schools are located in the area.



There is a major intersection with traffic lights to turn into Bellairs Drive.

Bellairs Drive changes from two lane to a secondary road after a few hundred meters past the intersection. The road becomes progressively less defined closer to the Blandford turn off.

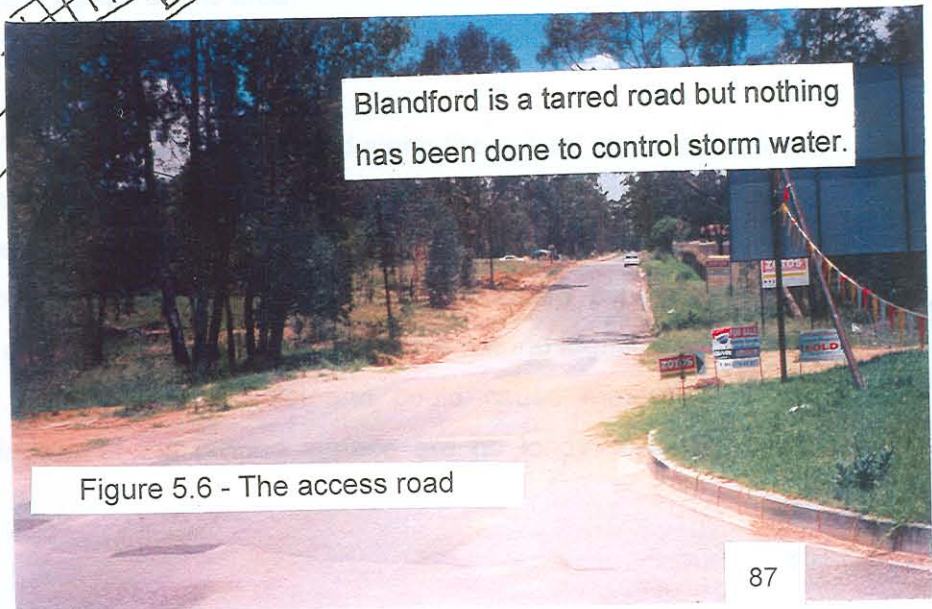
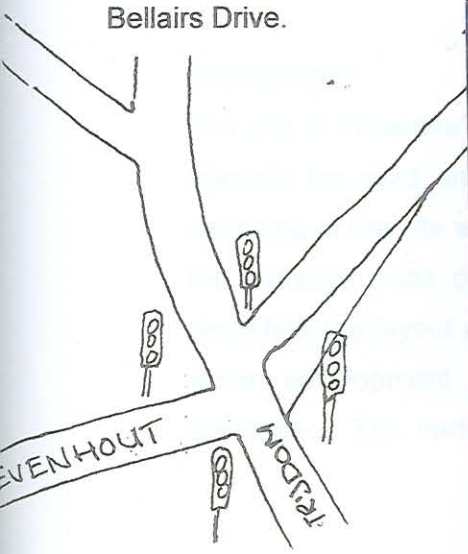


Figure 5.6 - The access road

5.5.2 Site features and natural environment

The natural state of the site and the immediate environment aid the designer in locating the appropriate position of the building on the site to reap the benefits of natural rain-water run-off with maximum penetration and minimum erosion, shade from trees and so on.

Largely due to farming activities and undeveloped sections of land being overrun by residential and light industrial development the landscape has been altered and no longer reveals evidence of its original natural state. Due to the mechanical levelling of the case study absolutely no evidence of the original site condition is available. Information available and undeveloped surrounding areas indicate that the area was until recently farmed. (see Figure 5.7)



Figure 5.7 - The adjoining site that has not been developed, but previously farmed

Information gained from the “*Environmental Potential Atlas of South Africa*” (van Riet *et al.* 1997) reveals that the site falls in the category 'rocky Highveld grassland'. There is no evidence on the site of the rocky Highveld grassland with its rocky surface bed and grasses typical of this area.

Topography

The site of 'Ravenna' was mechanically levelled along the natural slope of the land towards the road and retaining the natural fall towards the entrance. Complete flattening of the site would have resulted in too great a difference in height between the extreme ends of the development. The levelling eased construction and simplified the layout of the site but has stripped it of a natural identity. Across the entire development the fall is substantial and could cause rain-water run-off problems. The variations of the ground surface are no longer evident as the

mechanical levelling has created one inclined surface of compacted soil without variation, which reduced the porosity and is resulting in erosion.

There is a loss of variety of appearance and landscaping opportunities due to the removal of rocks and land undulations. No large trees or for that matter any vegetation was retained on the site. The natural drainage patterns are replaced by roads that channel the rainwater run-off. The internal road is tarred and does not provide the opportunity to assist water penetration, resulting in the road becoming a rain water channel that flows out onto the yet no tarred public road. The porosity of the soil has been reduced due to compaction and the natural contours for run-off have been eradicated resulting in an increased risk of erosion. A site visit on a rainy day revealed that no attempt had been made to prevent erosion in the area. The topsoil was running off the undeveloped sites along the newly tarred roads, out onto the public dirt road, lost to the site. The site does not fall in a high-risk area for erosion but wastage of soil is nevertheless senseless.

The creation of a clean palette to build on robs the site of any natural vegetation that might have given it a unique character as well as beneficial natural environment. Retaining the character of the site and adapting the layout to the specific features present would have allowed for the drainage patterns, natural rocky outcrops and vegetation to be incorporated in the new purpose of the land, namely residential use. An individual response to demarcated sites would have resulted in greater visual and ecological variety in the complex. Each stand on the site would have a unique character resulting from the response of building to the site that respected existing features present.

The road edge of the development has been grassed over. Each sale includes a small amount for landscaping, which is only adequate to cover the cost of grass and a few plants. Fortunately most completed stands have lawns and a few plants reducing run-off. (see Figure 5.8) The undeveloped sites are ready for construction. When the area is further developed the planted areas will hopefully reduce the risk of erosion.

Paving the internal road instead of the impenetrable tarred surface would promote water penetration rather than erosion. The site does not fall in a high-risk area for erosion due to the clearing it has become a problem on the undeveloped stands on

the site. Wastage of top soil is a senseless loss of available resources and reduces the ability for new gardens to establish.



Figure 5.8 - The developed and undeveloped stand

The opportunity to study the local geo-hydrology was not taken. Information such as good soil areas for planting, where drinking water can be found, possibilities for local rainwater disposal and local sewage treatment should be viewed not as constraints, but rather as the information that can assist in allowing the building and its occupants to respond to their immediate environment.

5.5.3 Orientation

The clearing of the site gave the planners free range to layout the site on a theoretical basis, enabling the north frontage to dictate the layout and making maximum use of the east-west path of the sun in the house designs. The triangular shape of the site and road layout has also ensured that each site is located with the longest side facing north (see Figure 5.9). In reality the perpendicular/parallel placement of buildings to the road has taken precedence over the maximum use of the sun's daily path. Theoretically the siting of building on the stand should be influenced by the presence of developed trees that create shade areas providing welcome relief in this warm climatic region, but this was no longer an option.

The site's exposed surface slopes towards the north with maximum solar radiation reaching the extent of the site. The houses are all small relative to the stand size and the positioning avoid any shadow to be cast onto adjacent sites.

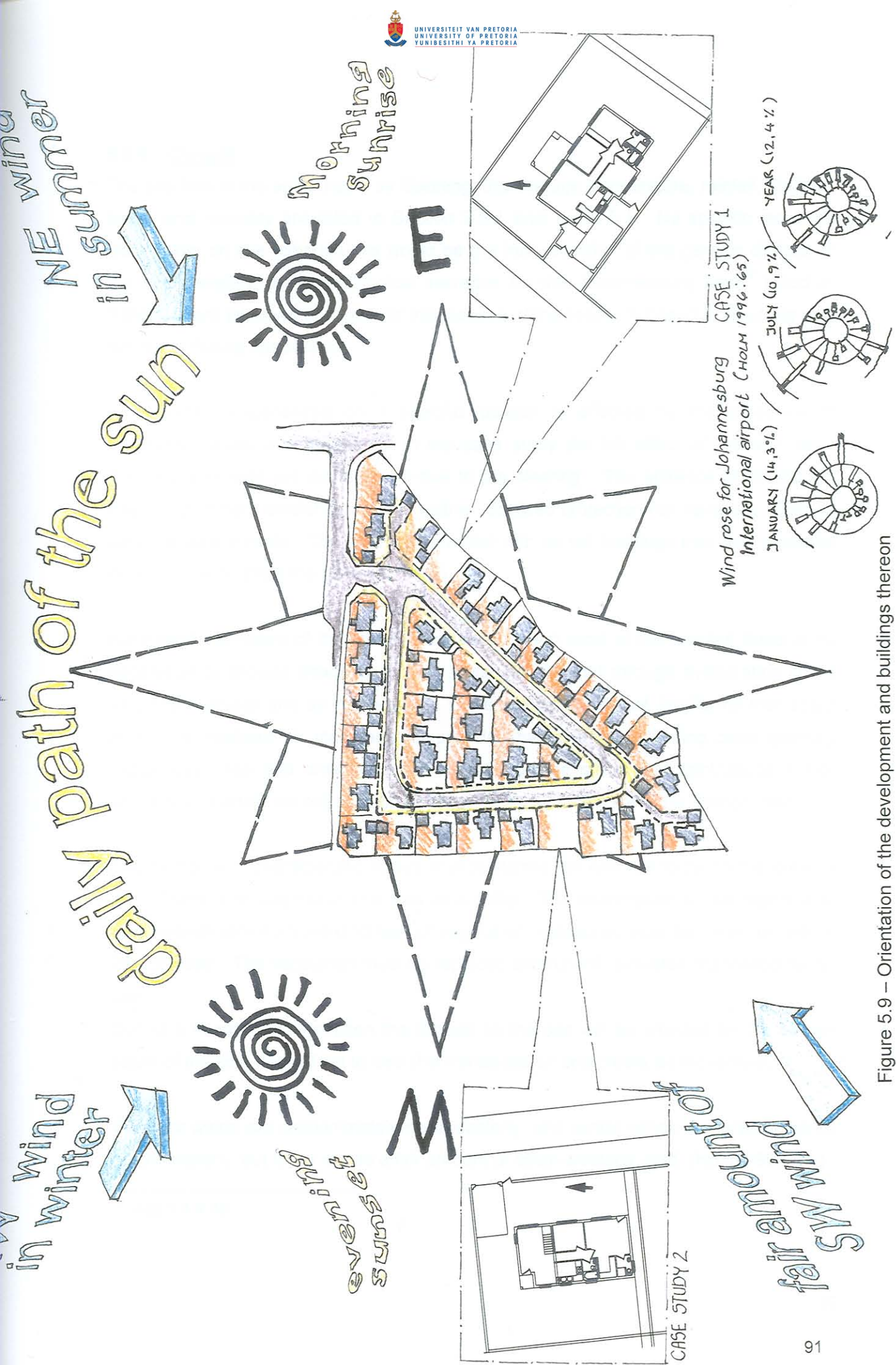


Figure 5.9 – Orientation of the development and buildings thereon

5.5.4 Climate

The site falls in the area known as Gauteng, the average temperature, rainfall, sunlight hours and humidity are listed in Section 2.5.1 and Table 5.1. No specific readings were taken on site although this would be the true reflection of the generic climate of the site therefore the climatological averages for the Johannesburg area¹⁷ listed in Table 3.2 are taken as accurate for the purpose of the research based in Gauteng and not North Riding specifically.

The climate experienced on a specific location is affected by the presence of vegetation, water and landforms. In the case study the full effect of the sun, rain, humidity and wind are experienced due to the clearing. The absence of developed trees or dominant landforms provide neither localised protection nor have any effect to vary the local climate. The area is residential with no tall buildings that cast shadows over the site or affect the generic climate.

Northward orientated of the stands facilitates full sun most of the day but there is no vegetation to provide shade or surface water on site that through evaporation could vary the humidity and air movement. There are no significant landforms that could affect the localised air movement or provide shaded area. Planting quick growing indigenous trees and creating water features on the site would reintroduce a biodiversity and affect the relationship between the new building and the environment.

The rainfall and characteristic heavy thunderstorms fall with full force on the cleared site. There is no vegetation that acts as a buffer. The evaporation will be high due to the impenetrable surfaces and lack of vegetation; measures must be taken to reduce loss of water. The vegetation must be replaced and run-off rainwater channelled for re-use.

During a heavy rainfall season the climate on the site will be affected by the stream south of the site, this will act to cool the immediate air and create air movement.

Summer winds are predominately north-easterly, and winter winds are predominantly north-westerly, but there is also a fair amount of south-westerly wind. (Holm 1996: 64)

¹⁷ vide 3.4.4:40

5.5.5 Energy

This section looks at the presence and use of both artificial and natural energy on the site including grid electricity and the natural sources of energy such as solar power.

Geopathic stress

The geopathic stress of the site has not been scientifically measured field, as this would require a specialist with a magnetometer, which is beyond the financial constraints of this research. Indications of geopathic stress can be derived from the surroundings but due to the clearing, no visual clues can be gained on site.

Analysis of the broader environment did not reveal disturbances to the energy field, there were no gnarled trees or distorted growth patterns. There are also no deep foundations, high-tension power lines or other man-made disturbances in the immediate area. The site was not checked for underground water, which can also disrupt the natural magnetic force of the site. Evidence of boreholes in the area indicates that underground water is available. The Olivienhoutspruit is in close proximity to the site but is surface water and therefore not problematic.

Though no natural features reveal any evidence, the characteristic underground mining in the area can be considered problematic. Man-made equipment can distort natural magnetic fields and render them malignant, possible influences should be identified and assessed for effect. The transmission station Sentech at Radiokop, a few kilometres west of the site, are another potential hazard with satellite dishes and transmission towers. Since they are further than two kilometres away do not affect this particular site. The site services such as water, sewerage and electricity run underground around the site but do not cross the stands. The transformer house is located a substantial distance from the site and will not cause problems. None of the possible man-made equipment appears to be problematic.

These stresses are important to the well-being of those occupying the area. They should form part of the original analysis that determines whether a site is appropriate for development and the measures to be taken to reduce the risks involved in living in an area experiencing geopathic stress. The purchaser/user should be aware of the different forces in the area and make an educated choice of situating their home.

5.5.6 Water

Water, essential to the survival of humans on this planet is a renewable resource, but nevertheless must be considered a precious resource not to be squandered since it depends on the average rainfall. A decrease in natural catchment areas due to urban sprawl and changing climatic conditions can render it a scarce resource. Water provision and usage should be well managed.

The site receives water from the rainfall and the municipal supply of purified water.

Surface water

No surface water is present on site. North of the site is a natural stream with a dam. The dam is not for domestic water supply and is too far away to be a viable supply for other purposes than consumption. The stream south of the site (see Figure 5.10) appears to only flow with very heavy rainfall (seasonal) and is not a reliable source.

Ground water

The site was not checked for underground water and no use is made of a bore-hole and ground water. A comprehensive site analysis should have investigated the possibilities especially since evidence in the area such as old tanks and wind-mills suggest the presence of underground water. To drill a borehole or purify stream water is expensive for a single home, however, a larger development such as Ravenna can cost effectively make use of available alternatives.

Rainwater

No attempt has been made on site to reduce or harvest rainwater run-off. The initial layout should have provided for harvested rainwater for reuse in a central system to irrigate gardens and flush toilets with this resource. Individual households can still install a purification system to make use of harvested rainwater in the house but this is an expensive alternative. Gutters and water tanks can be installed retrofit to still in the future benefit from harvested rainwater for use in the garden.

The altered drainage pattern channels rainwater along the tarred internal road and off the site (see Figure 5.10) where it becomes useless to the occupants. Alternatively paving which allows for water penetration on site could benefit the gardens and prevent erosion where there is no infrastructure or planting. In this development, the gardens of

the developed sites are lawned reducing run-off and promoting rainfall water penetration. A dam constructed to collect the run-off from the storm water drain would allow for additional garden irrigation.



Figure 5.10 - The non-perennial stream south of the site

Gardens and water

Landscaping can reduce the amount of erosion caused by run-off. Gardens should be planned to use a minimum of supplementary irrigation and reduce loss of ground moisture to evaporation. Plants should be chosen appropriate to the climate and naturally available water.

Surface water can temper the climate. Water features should be incorporated in the layout of the site. The individual garden layouts should incorporate ponds and pools. The swimming pools should not use harmful chlorine systems but rather make use of alternatives such as salt systems or natural pond ecosystems. Unsold stands should be developed as open green space with ponds or vegetable gardens in the complex.

5.5.7 Waste

The condition of the original state of the site, if there was any waste dumped, is unknown to the researcher due to site clearing. The developers have removed all rubble and vegetation from the site. No site rubble was re-used on site. The developer claims to distribute the rubble according to where it is required on one of their projects and never to dispose of it as land-fill. Where necessary soil can be shifted on site for

cut and fill. It is recommendable to avoid disturbing the surface bed. Working with the site as a given area rather than clearing it completely would result in far less waste on site.

The sewerage pipes supplied and maintained by the municipality are in place and service the site. The refuse removal is also a weekly service provided by the local authority.

Garbage

Households produce waste in the form of black and grey water, garbage and garden refuse. Modern lifestyles often do not consider waste beyond its removal from site. Waste is not totally useless. It is not the sole purpose of a landfill to fill it as quickly as possible. The central waste area is a requirement set by the authorities for this site. The waste area is a simple enclosure for garbage bins with street access for collection. No provision has been made in the enclosure for a composting facility or collection of re-cycleable waste products. The initiative to re-cycle depends on the individual.

Occupants of the development should be educated to the benefits of re-cycling. The waste area should be divided into zones to facilitate the disposal of waste according to type and re-cycling potential. Establish a plastic, paper, glass and compost zone in the waste area and encourage the use thereof. The regular removal of waste by various organisations only requires prior arrangement; it should not be a deterrent to living in an environmentally conscious way.

5.5.8 Fauna and flora

The fauna and flora of a site contribute to the aesthetic appeal and climate of the area. It provides the site with both character and protection from the natural elements. The clearing of the site has destroyed the possibility to retaining original planting; especially the developed trees which provided shade, wind buffers, pollution filter and promote privacy. Ideally, the site retained existing vegetation giving character and prevented erosion as well as being a natural design generator.

Continuous development with site clearing is encroaching on natural areas and a subsequent developed ecology of flora and fauna is lost (see Figure 5.11).

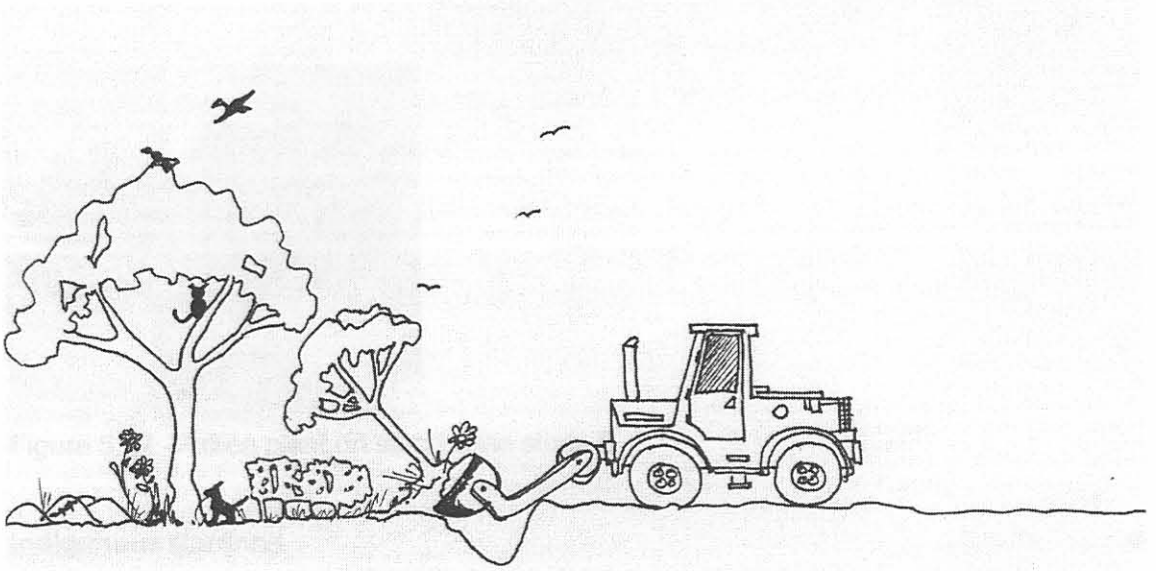


Figure 5.11 – The clearing of the site

The area has been cleared in the past for farming, which changed the pristine natural habitat, however a substantial portion of untouched nature was always retaining. The developments are clearing the last of the untouched areas at a frenzied rate and eradicating the natural feel that first made this area so popular. The result of the extensive, uncontrolled development is a loss of bio-diversity. The natural fauna and flora are forced increasingly further away from the urban core and becoming alien to urban dwellers.

The surrounding vegetation in the area reveals limited clues about the original condition of the soil, flora and fauna with no evidence on the site of the rocky Highveld grassland with its rocky surface bed and grasses typical of this area. The tree guide to the Highveld gives many examples of trees indigenous to this area, however none could be identified in the area. The only original plant is a lonely Protea plant illustrated in Figure 5.12.

There is ample space for planting gardens as the ratio of site to building is balanced. The maximum coverage remains very low as the buildings are relatively small compared to the stand size. Flanking the road edge are wide grassed areas fronting the garden wall of the individual stands giving the impression of open space and greenery. If well managed the whole development has the potential to become green.



Figure 5.12 -Protea plant on stand case study B

Indigenous gardens

The gardens are new and therefore only act at a fraction of their true value to the environment¹⁸. In time as the gardens develop this situation hopefully will improve.

No policy to plant an indigenous or water-wise garden has been adopted by the developers. Generally, people are not aware of the variety of indigenous plants available and that these plants can be used in a variety of landscaping styles. Indigenous gardens have the benefit of growing quickly, having a low plant loss as the plants are suited to the soil and climate, require less water than exotic gardens and attract natural wildlife. The newly planted trees and plants are mostly exotic. The few stands that have adopted an indigenous approach are flourishing while the exotic gardens are battling to develop. This in itself is evidence of which garden type is more appropriate.

Lawns on the road edge/ and gardens are also an integral part of the developments landscaping. Different grass types require different climates and irrigation. The grassed road edge should be of a suitable grass type that requires a minimum of supplementary irrigation and is hardy to the climate.

Food production – Permaculture

This is a commercial development and carries none of the perm-culture motivations. No specific area in the complex has been set aside for vegetable or fruit propagation; this concern is for individuals to integrate on their property.

¹⁸ *vide* 3.4.8:46

5.6 Ecology of the building

The individual houses built in the development are mostly adaptations of the original marketing designs that have been revised according to the needs and budget of the purchaser. The building structures of this development all fall within the same aesthetic style which gives the complex a unified appearance. This complex of houses could be categorised popularly as the Tuscan aesthetic, even though it is a simplified version thereof, with terracotta painted plaster finish, orange/ terracotta tiled roofs with overhang. All windows of living spaces are large timber window and door frames. There are many standardised elements recognisable throughout the development such as standard height garden walls.

A single style development such as Ravenna standardises the building structures of providing the opportunity to build a prototype sustainable, eco-friendly home and repeat the lessons learnt. Such an initiative would make a sustainable home cost-effective and not a one-off experiment.

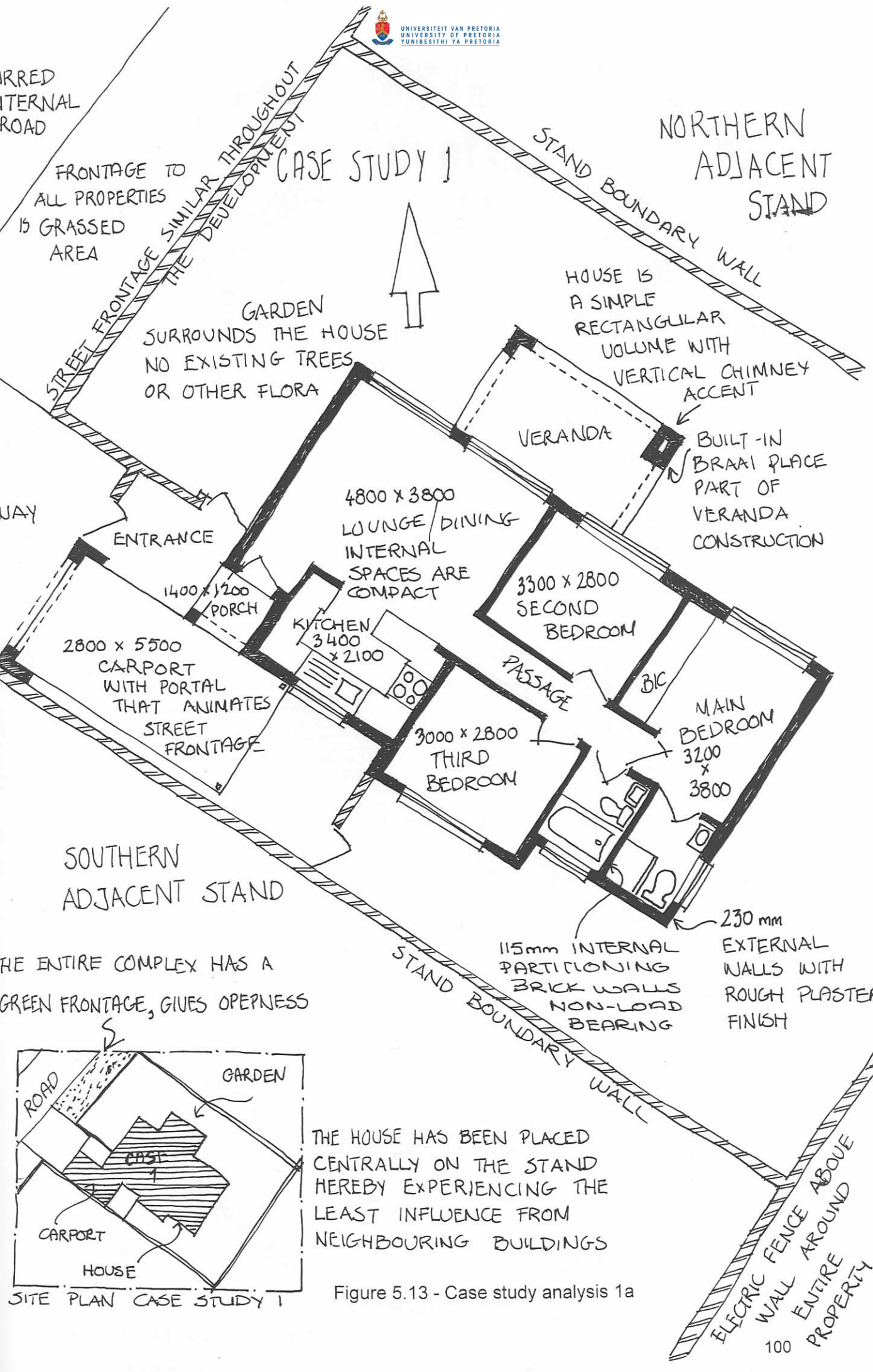
The case study is analysed in Figure 5.13 and Figure 5.14

5.6.1 Relationship of building to site

Ideally the building acknowledges the site and the surrounding area. This design should be a response to the area specific and not a theoretical abstract artificially implanted on a cleared piece of ground, devoid of any reference.

Further than acknowledging the benefits of north frontage the case studies make no other reference to the specifics of the location. The stands are small and due to the levelling process provide no tangible reference to the location of the site in the broader environment that surrounds the development. The buildings stand within their own context devoid of any relationship with the natural environment.

The individual buildings are placed on a concrete platform to accommodate the fall on each stand by superimposing an artificial level. Neither the base of the building, nor the floor layout makes reference to the slope of the ground. A design that responds to the site would facilitate a link to the original natural contours and features with appropriate construction for the conditions.



The limited size of the sites is balanced by the smaller house size. Site coverage is between 18 and 37% depending on the house and stand size chosen. This low percentage of coverage allows for a substantial garden around the building and minimises the influence neighbouring buildings could have on the shade versus sunlight of the building. There is no crowding of the sites, maintaining a sense of openness on this site. The balance between open area and built forms in the whole complex must not be allowed to erode through time by continued extensions.

The position of case study A and B are illustrated in Figure 5.9.

The absence of any growth or landscape features such as rocky outcrops facilitates the theoretical placement of the house on the stand from the viewpoint of the site drawing and does not require understanding of the real site situation in its natural form. The site was divided into stands as defined on the site plan. Each house was laid out on the stand making reference to that specific stand's boundaries.

5.6.2 Orientation

All houses are situated on the stands to make maximum use of the north facing facade. There is no view to acknowledge, or landscape feature to give reference to. To keep the houses affordable the layout is compact resulting in certain spaces facing unfavourably.

Certain months of the year are more windy or cold. The south-west facing rooms cannot enjoy much passive solar benefit. The limited stand size and the mild average Highveld climate were given as justification by the architect for unfavourably placed rooms. Limited financial resources for the purpose of design results in the minimum time being spent on finding solutions to potential problems. Economic and spatial constraints also make it impossible to solve certain design problems

Hugo Vanderstadt (1996:61) suggests that at least one window in the house allows UV penetration. His suggestions are for the central European climate. In South Africa and specifically Gauteng the climate is mild and use can be made of a sliding door which is kept open for a few hours of sunshine to penetrate the interior spaces. Both case studies have sliding doors that can be utilised to allow the full sun spectrum to enter the lounge area.

5.6.3 Generic climate

No conscious decision was made to use the natural climatic forces of the site for natural climate control.

The layout of the case studies are conducive to air circulation and the bathrooms are located on exterior walls with opening sections allowing ventilation without requiring a ventilation fan system. Thermal comfort - the range of temperature versus humidity within which the body is comfortable¹⁹ is partially achieved in a sustainable way by the case studies. Two of the three bedrooms and the living spaces are orientated northwards. The north orientation and window size relative to the width and depth of the room allows the maximum sunlight to warm and light the internal spaces.

The wind can be used as a design tool to aid ventilation of the homes. The current ventilation of the home is merely a coincidence. Air movement where the wind and openings are used to facilitate ventilation and exchange air must be given conscious consideration. This can act as a natural cooling method in summer, and by careful planning be prevented from removing the warmed internal air in winter. Every room has opening sections which when regularly opened are adequate to ventilate as well as cool the rooms by natural air circulation.

Walls are often referred to as the third skin. Standard 230mm thick walls enclose the externally and internal walls are 115mm. The wall thickness was determined structurally. No consideration was given to the thermal properties of this third skin.

The location of the main rooms on the north side allows for the use of passive solar energy that assists in maintaining an interior temperature that falls within the 'comfort zone'. Considering the high number of sunshine hours in Gauteng, the optimal relationship of orientation and layout results in a comfort zone that requires no additional artificial control. There should not be many times in year that an additional source of warmth energy or cooling is required.

The orientation and layout can be further be optimised by consideration and use of thermal insulation principles in the ceiling space, walls and openings. Insulation keeps out the heat in summer and retains the internal heat in winter. A lack of

¹⁹ vide 3.5.3:51

insulation allows the heat to escape. In winter when heat gained from solar energy is lost it must be compensated by an artificial produced source of heat which requires the use of other forms of energy, which have cost and resource implications. In order to save building costs no use has been made of insulation principles in this building development.

The house style does not have large overhangs therefore no significant shade is provided for the windows during summer. There are no developed trees on site provide shade either. The building experiences the full effect of all the natural climatic fluctuations.

5.6.4 Energy

Conventional electrical supply

All energy on site is supplied by the main electrical grid supply, Eskom. No use is made of alternate forms of energy such as passive or active solar power. Wind strength is insufficient to generate energy but is passively used for ventilation.

Solar energy

The case studies are north facing therefore cut cost of heating the space during the colder winter period, however the lack of insulation results in the loss of heat gained from passive solar heating. There is no venting system of the roof space that allows heat to escape in summer. To cut cost on the house price no insulation products have been used to assist in the energy performance of the house. No use has been made of the possible building construction details that could assist in reducing the energy requirements of this building. The individual home owners are expected to complete the house as requirements arise out of habitation, implying further expenditure.

Sustainable living means not wasting energy on artificial climate control. To achieve the comfort zone the occupants should install an insulation layer. When supplementary heating is required use should be made of the most energy efficient heating equipment.

Use can be made of both passive and active solar power, as there is an average of eight sunshine hours per day in Gauteng. Photovoltaic cells can be installed retrofit as a supplementary source of energy. They can be linked to the electric supply for artificial lighting necessary at night. There are no solar water heaters used in the houses. Solar panels can be installed to heat the water for the household, saving energy supplied by the use of non-renewable resources.

A central lighting system fitted with standard electrical light fittings is used along the roads of the site (see Figure 5.15). This system could also have been operated using photovoltaic cells.



Figure 5.15 - The development with tarred road and central lighting, grassed frontage and new planting. The electrical supply and telephone exchange box are visible

Electrical energy for mechanical lighting

Consideration must be given to the type of electric fittings selected. There are fixtures available that require less energy to operate. Vanderstadt states that our eyes use 60% of or energy warning that low energy use lighting must be considered carefully as it cuts out a portion of the light spectrum which is actually necessary for a sense of well being. It is therefore important to have a high light quality. Unfortunately energy saving lamps should be avoided as they cut out a portion of the light spectrum and in so doing tier the eyes.

The windows are large relative to the room area and wall surface therefore ample light fills the interior during the day. Spotlights have been installed as electrical light fixtures in this case study. The choice of light fixtures is from the pre-selection of the developers. No provision has been made to provide a choice of energy efficient light fixtures. The initiative to request these has been left to the potential purchaser.

Electrical energy for heating

The provision of hot water is by means of a geyser. The geyser has been placed centrally in the roof space, as this is the most economical position for pipe distances to the supply points of the kitchen and bathrooms. The positioning is determined by a concern for building costs alone and not environmental issues such as the distance versus energy and water wastage and to supply hot water to the outlet. The geyser type was selected based on price and availability and not energy efficiency and long term cost benefits. Certain producers have set their own environmental standards, which are passed on as a benefit to the new home owner, though they may be unaware of the benefits.

Embodied energy

Energy is also an essential component in the manufacturing of building materials and products²⁰. Sustainable buildings make use of materials that do not require large amounts of energy to produce for example timber and loam or mud bricks.

5.6.5 Water

Water, though renewable, is a precious commodity. The conservation of water has not played a role in the development layout or the house designs and there appears to be no attempt to conserve water on the site. Rainfall runoff is not captured for use in the home and garden. There is also no borehole on the property.

An ambivalent attitude has been applied to resource management. The essential issue at hand is to cut building costs in order to provide affordable housing. Sanitary fittings are once again from the developer's showroom with the purchaser selecting fixtures from the available selection. No provision has been made to include water saving fixtures in the standard range of available products.

Domestic water supply requires in-house purification due to the pollution of our natural water supply. Our water characteristically is filled with chemicals and unnatural bacteria that are harmful to us. It is possible to install a natural water purification system. Ponds, septic tanks, sand filters and percolation are a few of the techniques that can be used to purify water on site. Installation of a water purification system for one household is expensive, shared in the complex by a number of houses it becomes a cost effective and viable alternative.

²⁰ *vide* 3.5.7:57

5.6.7 Materials and construction materials

Household waste water enters the municipal sewer system and no provision has been made to re-cycle water. The geyser's position minimises distance to outlets reducing the wastage required to provide hot water to the outlet.

5.6.6 Waste

There are different types of waste arising from habitation such as water, material and organic waste. Grey and offal water were discussed in the previous section. Waste arising from household consumables and from the building itself all form part of what can be considered wastage arising from habitation. Organic waste from the kitchen can be used in a composting system for use in the garden. Recyclable materials should be sorted and brought to the relevant depots. Dangerous waste, such as batteries, chemical cleaning substances, fats, medicines etc. should be purchased and used conservatively. Unfortunately the municipal waste collection is an excuse not to bring the relevant waste to the recycle depot, as this requires an effort. Provision should be made on a complex such as this for glass, paper, tin, plastic and organic disposal and collection facilities.

The building site after the mechanical clearance and building construction was strikingly clean and tidy. The company policy of the developer is to keep the site clear of building rubble. Building rubble is used as fill where required on site or is removed to be used by the same construction company on other projects. The rubble is generally used and never sent to a dumping site. The rubble is not sorted to remove elements that could be harmful to the natural environment if used as fill.

The focus of the company is to build affordable houses therefore all forms of waste and damage of materials and components is cut to the minimum. Building material is purchased in bulk as all buildings on site are built by the same contractor avoiding unnecessary expenditure on over-supply of material. Extra material can always be used on other projects

In specifying building components no consideration is given to the original source and process of manufacture. Whether these processes were wasteful and come from a non-renewable resource does not play a role in the structural design of the buildings. The building itself should also have the potential to be recycled at the end of its life cycle²¹.

²¹ vide 5.7:111

5.6.7 Materials and construction methods

All buildings are made up of physical materials suitable for the purpose of constructing walls, floors and roofs which are sourced from various suppliers and manufactures. The availability, cost and actual physical properties are of primary importance, their sustainability has not been considered.

The homogenous finish of the whole development simplifies the building process for the contractor. To summarise the construction aesthetic is rough brushed plaster on stock brick walls concrete tiled roofs with an overhang. The colour finished is orange/ terracotta with timber window and door frames. The primary choice of finishes (carpets, tiles, sanitary fixtures and so on) is made by the construction company. The secondary choice lies with the purchaser who makes his/her selection within the predetermined budget from the developer's showroom. If the client wishes to have alternatives is possible at an extra cost.

The building trade and the components used in buildings tend towards being non-renewable with most materials falling into the seven main groups stone, timber, brick, iron and steel, concrete, glass and plastics²². A general description of the building materials and construction indicates that standard building practices are followed without any attention given to building in a sustainable way with materials that are environmentally friendly (see Figure 5.16). The timber frames for example were bought from a local supplier with the source of the timber unknown. Any material or process that could be considered sustainable is purely incidental. The economic aspect is the most predominant factor in determining the choice of all building materials required for this development.

The first house built is essentially the prototype for the whole development. The site is deemed to have the same soil type and stability as the prototype stand. The construction process with its required concrete strength and so on are to South African Bureau of Standards (SABS) minimum requirements.

Site preparation

The site preparation was composed of a soil test and the mechanical clearing of the entire site with no filling or cutting took place. The property retains a gentle natural slope but the natural contouring variations have been removed. The houses are

²² vide 3.5.7:57

designed using only one level with the base on a single platform without any steps to accommodate the slight natural slope.

Before any construction work is commenced insecticide is sprayed where any signs of termite activity is identified. The soil poisoning must legally be carried out in terms of SABS 0124, however this standard makes no reference to protecting the natural environment or being environmentally friendly.

The prior site clearance and simplicity of design facilitated the layout using a basic system of pegs, rope and spirit-level. The foundation trenches were dug manually.

Building the platform

Pre-mixed concrete was used for the strip foundation footing and floor slab and mortar for the walls and the plaster mixture were hand mixed on site using Portland cement. A hardcore fill was compacted in layers to form the base of the floor. The hardcore layer is composed of material originating from the mechanical clearance of the site. A 100mm thick concrete floor of pre-mixed concrete with a screed was cast on top of the standard plastic damp proof membrane.

Building the shell (see Figure 5.16)

All brickwork (footings, structural walls, internal walls, sills, lintels, and beam filling) is concrete stock bricks. The 230mm exterior walls are the only structural walls and are built in stretcher bond with no cavity. No special reinforcement being required as the soil is stable and the walls are standard single and double brick walls. The internal spaces are divided into rooms with single brick 115mm stretcher bond walls that are non-load bearing. All walls have been plastered and finished in a rough brushed texture. Walls are finished with plaster and paint or tiles. The plastered wall surface is prepared with a universal undercoat followed by two coats of PVA. Standard tile adhesive is used to fix the tiles. The floor/wall edge has been finished off with hardwood Meranti skirting.

Timber trusses were manufactured off-site and designed for the maximum spacing and minimum pitch specified by the tile manufacturer. No use has been made of a waterproofing sheet or any other insulation material. The 600mm roof overhang provides some shade. Nailed rhinoboard ceilings are finished with rhinoboard cornices.

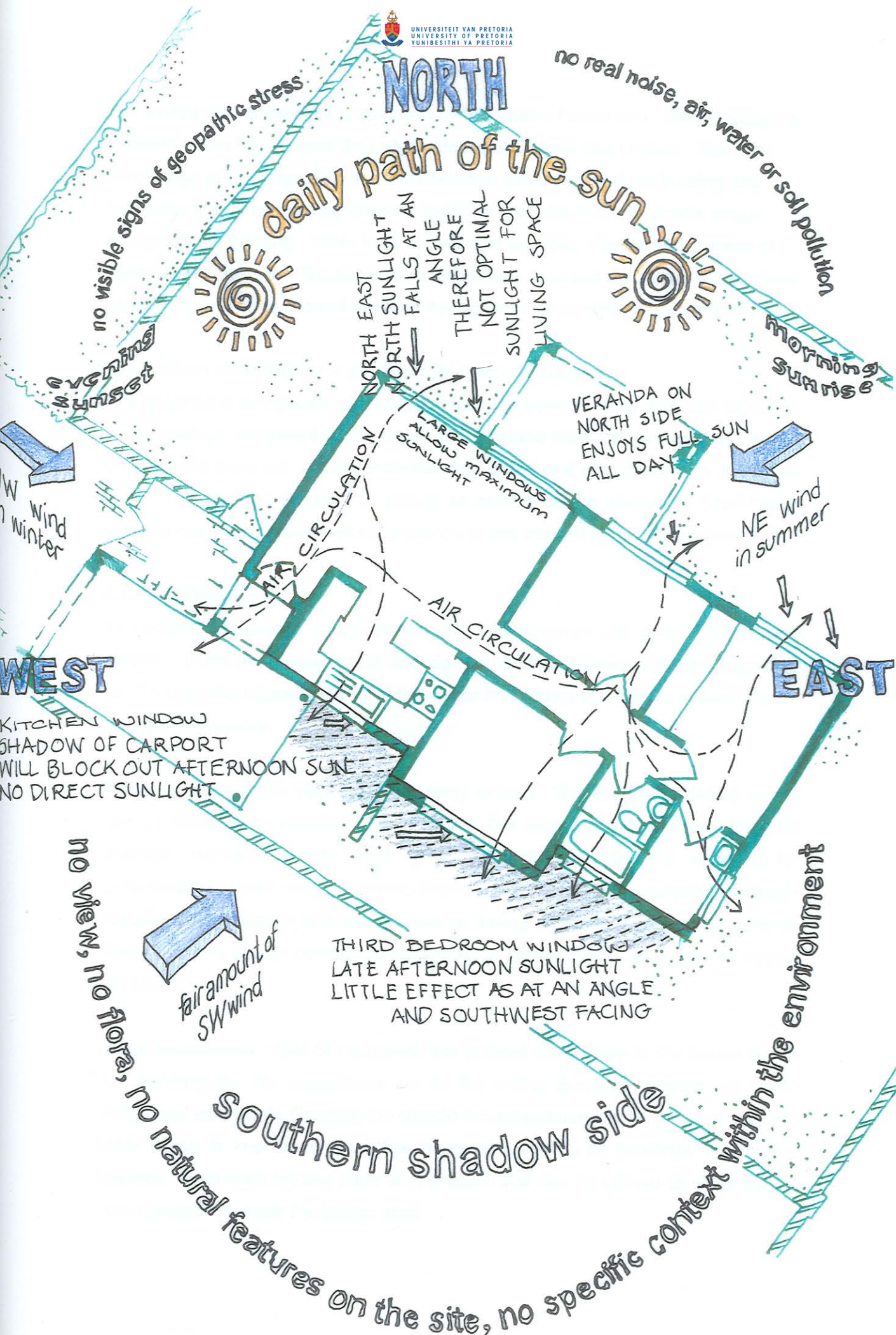


Figure 5.14 - Case study analysis 1b

All openings are rectangular with external and internal sills of plastered brickwork. A standard plastic d.p.c. has been used at the window opening. Windows frames and the front door are varnished timber except the sliding door which is aluminium. Internally the doors are hollow-core with metal frames, all painted finish. Clear 6mm glass has been used therefore there is no UV penetration. The sliding doors for safety reasons make use of shatterproof glass. The bathroom windows are textured to exclude the view through while still allowing light to penetrate. Brass and steel ironmongery is used.

Case study A is single story. Case study B has a loft room constructed of a pre-cast concrete and beam system floor. Case study B accesses the loft room via a timber staircase, which was pre-assembled off-site and installed once the internal construction was complete.

Services

The electrical cabling, plug points, switches, telephone wires and all other material pertaining to the electrical supply in the house are standard available materials from a building and electrical supplier.

Plumbing makes use of standard supply PVC and copper components, galvanised gutters and sanitary fixtures selected from the pre-selected range. An electric geyser is used to heat the water, which has been installed in the roof space in a position that minimises the distances between the outlets.

In the kitchen the units are melamine coated chipboard with formica tops and a stainless steel sink. The bedrooms have built-in-cupboards of melamine coated chipboard.

5.7 Life-cycle of the building

5.7.1 Life-cycle of building materials

The developer/builder aims to offer a good quality building at an affordable price. The developer has been in the market for twenty-five years and it is essential to their reputation to provide a quality building. The building materials used and finishes offered are all of SABS approved, good quality materials. Standard fixtures and sizes have been used that if a component is broken replacements should be available. The materials and building practices result in a building that should be around “for many years” and have a long life-span even though no target life time has been described.

5.7.2 Re-use of building materials

There were no previous buildings on site that needed consideration. No consideration was given to the re-use of building materials. When an old building is demolished the parts of the building are sorted and sold directly off site by the appointed demolishing company. It is however not a prerequisite of the developers to appoint a demolishing company that offers the opportunity to make building items available for re-use.

There was no use made of any natural materials found on site.

5.7.3 Re-cycling of building materials

The appointed demolishing company aims to collect maximum financial gain from the demolishing project. It is however once again not a prerequisite of the developers to appoint a demolishing company that offers the opportunity to make building items available for re-cycling. The developer does make use of rubble for fill on projects where necessary rather than dumping the material as landfill. This decision is economic, as the purchase of soil for landfill is more expensive. No consideration is given to items that might pollute the soil by becoming fill on site.

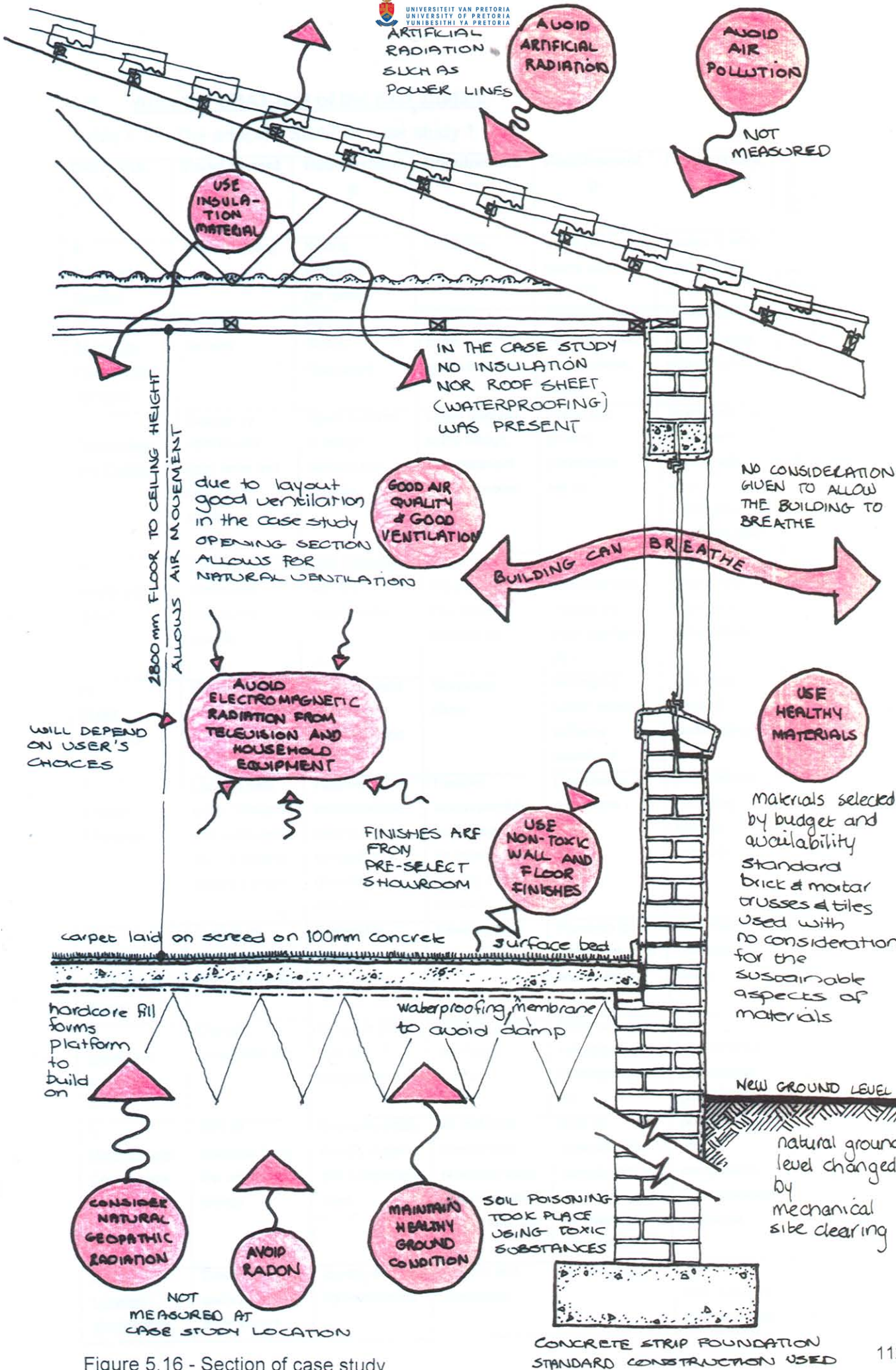


Figure 5.16 - Section of case study

5.8 Adapted SBAT test of the cast studies

Table 5.1 – The adapted SBAT of case study 1

CRITERIA (a –j)	Requirement A	Requirement B	Requirement C	Requirement D	Requirement E	SCORE
a) <u>Occupant Comfort</u>	Natural lighting yes	Natural ventilation (air quality) yes	Low noise yes	Views (all rooms external window) yes	Access to amenities, lay-out compact yes	5 — 5
b) <u>Access to Facilities and Services</u>	Crèche Schools yes	Banking, Shops, Restaurant yes	Proximity to parks and sports facilities	Communication Facilities (Post, Public phone, email)	Government / tax / licensing information	2 — 5
c) <u>Participation and Control</u>	Educate to control over light, temp and ventilation levels yes	Users involved in design / construction process yes	Users involved in the design, refurbishment of their spaces	Public and privacy parameters set-up	Space and / or equipment shared with local community e.g. Swim pool	1 — 5
d) <u>Health and Safety</u>	Community centre and community spaces	Fully compliant with fire requirements yes	Proximity to Police station, Fire station, hospital etc.	Access to nutritious food (restaurant, vege. gardens etc) yes	Free of air, electro, ground, noise, and water pollution	2 — 5
e) <u>Water Efficiency</u>	Rainwater harvesting	Water efficient devices: low flush WCs and urinals	Greywater reuse	Minimising runoff: external surfaces absorbent	Low water demand landscaping yes	0 — 5
f) <u>Energy Efficiency</u>	Located near public transport / all users within secure walking distance (4km)	Passive environmental control system for ventilation (thermal comfort)	Passive environmental control systems for heating and cooling (thermal comfort)	Low energy appliances / fittings	Solar control (including thermal comfort)	0 — 5
g) <u>Minimising or Recycling of Waste</u>	System for recycling (recycle depots)	System for reusing	Sewerage	Provision for dangerous toxic waste removal	Minimise construction waste yes	1 — 5
h) <u>Vegetation and Wildlife</u>	Use of a 'brownfield' site	Range of plants that are indigenous	diversity in flora and fauna habitats	Effect on neighbouring buildings: light etc yes	Low maintenance landscaping (e.g. fertilizers)	0 — 5
i) <u>Materials and Components</u>	80% of materials have low embodied energy	Environmentally friendly material and component used	All materials / components produced using only renewable energy sources	80% of materials and components for the buildings recycled / refurbished	80% materials and components from renewable resources	0 — 5
j) <u>Location identification</u>	Site features and natural environment	Identify existing flora and fauna	Climate and orientation yes	Natural water	Area Layout (incl. inclusive environments)	1 — 5

Table 5.2 – The adapted SBAT of case study 2

CRITERIA (a –j)	Requirement A	Requirement B	Requirement C	Requirement D	Requirement E	SCORE
a) <u>Occupant Comfort</u>	Natural lighting yes	Natural ventilation (air quality) yes	Low noise yes	Views (all rooms external window) yes	Access to amenities, lay-out compact yes	5 — 5
b) <u>Access to Facilities and Services</u>	Crèche Schools yes	Banking, Shops, Restaurant yes	Proximity to parks and sports facilities	Communication Facilities (Post, Public phone, email)	Government / tax / licensing information	2 — 5
c) <u>Participation and Control</u>	Educate to control over light, temp and ventilation levels yes	Users involved in design / construction process yes	Users involved in the design, refurbishment of their spaces	Public and privacy parameters set-up	Space and / or equipment shared with local community e.g. Swim pool	1 — 5
d) <u>Health and Safety</u>	Community centre and community spaces	Fully compliant with fire requirements yes	Proximity to Police station, Fire station, hospital etc.	Access to nutritious food (restaurant, vege. gardens etc) yes	Free of air, electro, ground, noise, and water pollution	2 — 5
e) <u>Water Efficiency</u>	Rainwater harvesting	Water efficient devices: low flush WCs and urinals	Greywater reuse	Minimising runoff: external surfaces absorbent	Low water demand landscaping yes	0 — 5
f) <u>Energy Efficiency</u>	Located near public transport / all users within secure walking distance (4km)	Passive environmental control system for ventilation (thermal comfort)	Passive environmental control systems for heating and cooling (thermal comfort)	Low energy appliances / fittings	Solar control (including thermal comfort)	0 — 5
g) <u>Minimising or Recycling of Waste</u>	System for recycling (recycle depots)	System for reusing	Sewerage	Provision for dangerous toxic waste removal	Minimise construction waste yes	1 — 5
h) <u>Vegetation and Wildlife</u>	Use of a 'brownfield' site	Range of plants that are indigenous	diversity in flora and fauna habitats	Effect on neighbouring buildings: light etc yes	Low maintenance landscaping (e.g. fertilizers)	0 — 5
i) <u>Materials and Components</u>	80% of materials have low embodied energy	Environmentally friendly material and component used	All materials / components produced using only renewable energy sources	80% of materials and components for the buildings recycled / refurbished	80% materials and components from renewable resources	0 — 5
j) <u>Location identification</u>	Site features and natural environment	Identify existing flora and fauna yes	Climate and orientation	Natural water	Area Layout (incl. inclusive environments)	1 — 5

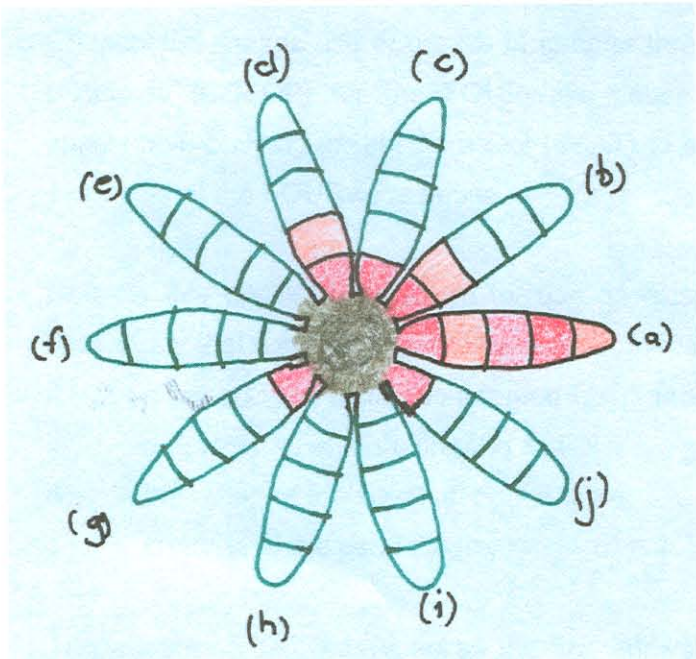


Figure 5.17 – The adapted SBAT diagram for case study 1

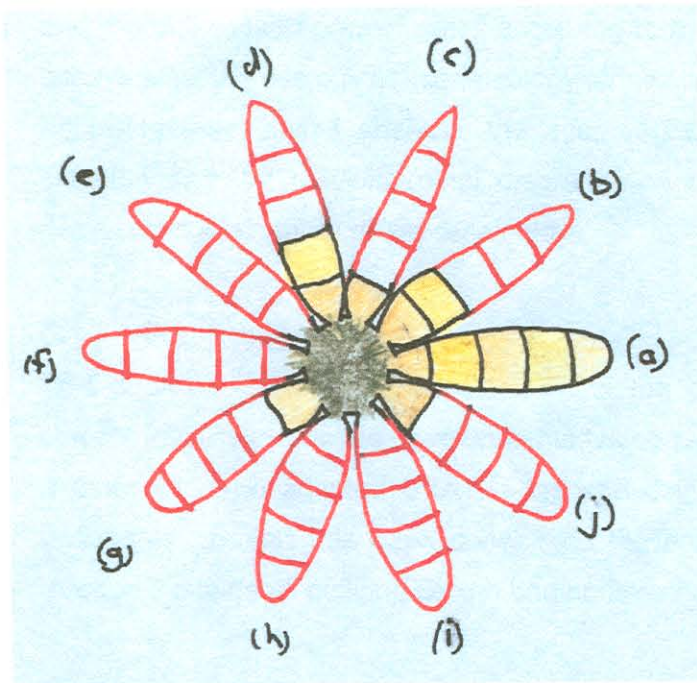


Figure 5.18 – The adapted SBAT diagram for case study 2

Both the SBDP and adapted SBAT analysis indicate that the case studies can not be considered sustainable. The only criterion that has been met fully is the occupant comfort. This criterion alone does not produce a healthy environment. Occupant comfort is not interchangeable with thermal comfort.

5.9 Summary

Chapter five makes use of results of chapter three, the sustainable building design principles (GSBDP) for the FOURways house and chapter four, the adapted sustainable building assessment tool (SBAT) to assess the sustainability of current examples of the FOURways house.

Chapter five applied the system for use on existing building (chapter four) to the case study that consists of the following four steps:

- i) a general test using the adapted SBAT table
- ii) a detailed analysis using the SBDP
- iii) the rating of the situation on the table
- iv) charting of the petal diagram

The adapted SBAT was used as the first analysis to gather information about the case study development. The SBDP was then used to analyse the development and the buildings in greater detail according to the same division of the interacting ecosystems, the ecology of user, ecology of the site and ecology of the building.

Following the detailed analysis, the adapted SBAT table was used to rate the situation and the resulting petal diagram was charted to graphically reveal the degree of sustainability of the case study.

5.10 Conclusion

This analysis leads to the conclusion that the case studies clearly indicate that current FOURways house developments taking place do not consider sustainability a criterion. The adapted SBAT, table and diagrams illustrate that although the occupants' comfort has been considered the provision of a healthy environment through sustainable building design and construction is not a priority.

Concluding from the research the current FOURways house is not a sustainable building environment to live in. It does not foster well-being nor act as a role model for lower LSM's to aspire to. Considering the scale and speed that the FOURways house is continued to be developed steps must be taken to ensure sustainability becomes an issue.

Local government, the developers and most of all the users should focus on this issue. The continued encroachment on the natural landscape linked with the building of an unsustainable building will certainly have disastrous consequences for both the environment and human beings.

Chapter VI

6 Conclusion

A dedicated search into the keywords appropriate to sustainable building design results in an apparent large range of available literature, however only a small number of books can be considered accessible or appropriate to the specific problem of domestic buildings and this research; medium density, middle-income houses in Gauteng. Available data are most often scientifically presented for a specific issue, such as Singh (1994) who focuses on the unhealthy organisms and diseases that develop in buildings. Data such as this, while valuable to experts, are not accessible or readily applicable to improve the sustainability of the domestic buildings being considered.

The local and international precedent gave leads contributing to the development of accessible information on sustainable building design principles for use in the FOURways house and was complemented by the SBAT which provides the basis to develop an appropriate tool for the target house type, namely the adapted SBAT.

This research focused on Gauteng, 'place of gold' in the Sesotho language, which covers an area of 18 810 square kilometres, accommodating industry and commerce. This province which produces nearly 40% of the GDP with 70% of the country's labour force, is not only an area with a great diversity of LSM groups, but also diverse cultural and societal needs as well. The research established that the 11,4% of the population composing LSM 7 is a relevant role model to work with, but also revealed that sustainability must be introduced at every level and in every sector of this province and its people.

Within this diversity the individual must be given the tools to achieve sustainability either through traditional means or technological advancements without sacrificing their individuality (Berström & Steinwell 1992:47). The sustainable building design principles (SBDP) is the background information (guidelines) to be used freely and uniquely by this diverse group to achieve the ultimate aim of a sustainable building environment. The adapted SBAT table may then be used to rate the building and its environment and the petal diagram visually presents the result so that irrelevant of one's expertise, the issue of sustainability in domestic building environments has been exposed to the architects, designers, developers, builders and user alike.

The analysis of current examples of the FOURways house using case studies indicated that sustainable building design is not currently a criterion for development.

The giving and taking pattern of earth and man is essential to sustainable architecture and habitation. Gauteng is characteristically economically driven and is more about taking than giving. This pattern will need to be adjusted in order to achieve a more sustainable living environment and a better guarantee of a bright future that includes fresh air and nature as well as economic sustenance.

This research only scratches on the surface of a much greater need to address sustainability in South Africa. A single set of guidelines will not suffice. The different aspects and parameters need to be addressed. Sustainability must be approached in a holistic way to cross the divides of diversity.

6.1 Further studies

The researcher intends to continue her study on the topic of sustainable building design. The lack of information regarding sustainable building design for the other income groups forming part of the population with respectively lower and higher income housing and regions beyond the borders of Gauteng may not be underestimated. Furthermore, analysis can go beyond medium density housing developments to include different densities. Sustainability in the rural areas is a whole separate subject outside of the study of development in the urban area and requires separate research in the future.

In this study the three-column definition of sustainability is acknowledged, however, the detailed study excludes the economic aspects of sustainability. The opportunity to include the economic aspects of sustainability into the adapted SBAT and SBDP is also relevant.

Another subject this research has revealed as worthy of further study is the effect of sustainable building design and the healthy environment on the psychological well-being of the occupants.

This research has opened the door to many other aspects of sustainability that all carry value in their own right and give the opportunity to work towards a more sustainable building environment.



Figure 6 - Final illustration from “*The Little Green Book*” by C. Denman (1990)

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Table 1.1 - Definitions of Sustainable Development

<p>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)</p>	<p>Sustainable development 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)</p>	<p>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)</p>
<p>Sustainability is a vision of the world that provides us with a framework and helps us to make decisions as a part of values that we hold dear and principles that we wish to live by. (The Brundtland Commission, 1987)</p>	<p>Sustainable development should be a process which allows for the satisfaction of human needs, but without compromising the needs of future generations. (The Brundtland Commission, 1987)</p>	<p>The world's development process of the 1980s and 1990s was a process of development that was not sustainable. (The Brundtland Commission, 1987)</p>

APPENDIX 1

Range of definitions of sustainable development (Du Plessis 1989:21-22)

Table 3.1 - Definitions of Sustainable Development

<p>Sustainable development means improving the quality of human life while living within the carrying capacity of supporting ecosystems (IUCN/UNEP/WWF, 1991b, p.221)</p>	<p>Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs. (WCED, 1987, p.8)</p>	<p>Sustainable development means that we should leave future generations a stock of capital no smaller than we have now. (Pearce, D <i>et al</i>, 1994)</p>
<p>Sustainability is a vision of the future that provides us with a road map and helps us to focus our attention on a set of values and ethical and moral principles by which to guide our actions" (Viederman, S, 1995, p.37)</p>	<p>Sustainable development should be a process which allows for the satisfaction of human necessities without compromising the basis of that development, which is to say, the environment(Winogard, M,1995, P.203)</p>	<p>Sustainable development is a process of change with the intention of achieving harmony between social, economic and ecological objectives and system requirements in the short and long run. (Hediger, W, 1997, p.101)</p>

<p>“Sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the concentration of technological development and institutional change are made consistent with future as well as present needs” (WCED, 1987, p.9)</p>	<p>Sustainable development embodies a belief that people should be able to alter and improve their lives in accordance with criteria which take account of the needs of others and which protect the planet and future generations. Thus people's rights and responsibilities form the crux of any discussion of sustainability” (Sharp, R. 1996, p.309)</p>	<p>Sustainability is the general requirement that a vector of development characteristics be non-decreasing over time, where the elements to be included in the vector are open to ethical debate and where the relevant time horizon for practical decision-making is similarly indeterminate outside of agreement on intergenerational objectives (Pearce, <i>et al</i>, 1990, p.3)</p>
<p>Sustainable development is a development strategy that manages all assets, natural resources and human resources, as well as financial and physical assets, for increasing long-term wealth and well-being. (Repetto, R, 1986, p.15)</p>	<p>Sustainable development is the complex of activities that can be expected to improve the human condition in such a manner that the improvement can be maintained. (Munro, DA. 1995. p 29)</p>	<p>Sustainable development is development that delivers basic environmental, social and economic services to all residences of a community without threatening the viability of the natural, built and social systems upon which the delivery of those systems depends. (ICLEI, 1996, p.4)</p>
<p>Sustainability is the doctrine that economic growth and development must take place, and be maintained over time, within the limits set by ecology in the broadest sense - by the interrelations of human beings and their works, the biosphere and the physical and chemical laws that govern it. (Ruckelshaus, WD, 1989)</p>	<p>Sustainability refers to the ability of a society, ecosystem, or any such ongoing system to continue functioning into the indefinite future without being forced into decline through the exhaustion of key resources. (Robert Gilman, President of Context Institute, online in CESD)</p>	<p>Sustainability is an economic state where the demands placed upon the environment by people and commerce can be met without reducing the capacity of the environment to provide for future generations. (Hawken, P, 1993, p.139)</p>

APPENDIX 2

Extract from the *Manual for Energy Conscious Design – “The Highveld climatic zone”* (Holm 1996:64-73)

5.12 Climatic zone – Highveld

5.12.1 Geography



Fig. 5.12.1 Climatic zone – Highveld

Location
The Highveld climatic zone is situated in the central highlands of South Africa.

Climate type
The climate is mainly subtropical, transitional temperate.

Description of local climate
The climate is mainly temperate with a large daily temperature variation and strong solar radiation. Humidity is low to moderate.

5.12.2 Climate

Temperature

The maximum summer temperature is about 30°C. The average monthly temperature is 17°C.

Humidity

The average monthly relative humidity is 65%.

Wind

Summer winds are moderate, but winter winds are strong and predominantly north-westerly. There is also a strong wind from the south-east.

5.12.3 Comfort zone

Temperature

The comfort zone temperature is 18°C to 24°C. The average monthly temperature is 17°C. The average monthly relative humidity is 65%.

Humidity

Humidity is low to moderate.

5.12.4 Planning

Green

Compliant with protection for production of green and solar radiation and summer sun.

Table 5.2.1 – Climatic data for Johannesburg (intermediate)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Maximum monthly mean temperature (°C)	21.8	25.1	28.2	31.3	34.3	36.8	38.2	37.8	35.2	31.8	28.2	25.1	21.8	18.5
Minimum monthly mean temperature (°C)	-4.2	-0.8	2.5	5.8	9.2	12.5	15.2	17.1	18.1	16.8	14.2	11.5	8.2	4.8
Average monthly rainfall (mm)	138	109	78	58	42	32	28	32	48	78	109	138	178	218
Average monthly relative humidity (%)	64.5	62.0	60.0	58.5	57.5	57.0	57.5	58.0	58.5	59.0	59.5	60.0	60.5	61.0
Average monthly wind speed (km/h)	12	15	18	22	25	28	30	32	30	28	25	22	18	15
Wind	71	85	98	112	125	138	148	152	148	138	125	112	98	85
Wind	35	40	45	50	55	60	62	65	68	70	72	75	78	80

6.12 Climatic zone – Highveld

6.12.1 Background

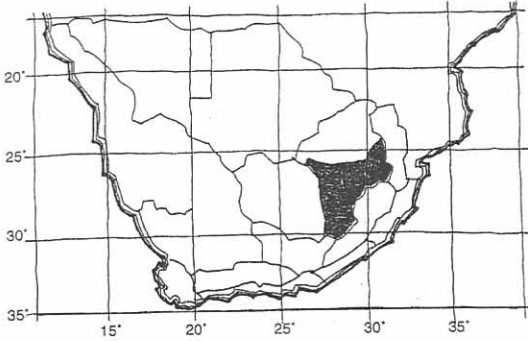


Fig. 6.12.1 – Climatic zone – Highveld.

Location

26,1° to 31,2° East and 24,5° to 30,8° South.

Towns in region

Lydenburg, Ficksburg, Johannesburg International Airport

Description of zone climate

Distinct rainy and dry seasons exist with a large daily temperature variation and strong solar radiation. Humidity levels are moderate.

6.12.2 Climate

Temperature

The maximum diurnal variation occurs in September. The average monthly diurnal variation is 11K.

Humidity

The average monthly relative humidity is 56%.

Wind

Summer winds are predominantly north-easterly, and winter winds are predominantly north-westerly, but there is also a fair amount of south-westerly wind.

6.12.3 Comfort zone

Temperature

The summer temperatures which exceed the comfort zone are insignificant. Winter temperatures are approximately 15K below the comfort zone.

Humidity

Humidity levels are low in the winter.

6.12.4 Planning

Urban

Compact with protection for pedestrians against high ultra violet radiation and summer rains.

Table 6.12.1 – Climatic data for Johannesburg International

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
Maximum average monthly temperature (°c)	25,6	25,1	14,7	21,2	18,9	16	16,6	19,3	22,8	23,7	24,1	25,2	21,10
Minimum average monthly temperature (°c)	14,7	14,2	13,2	10,4	7,3	4,2	4,3	6,3	9,5	11,3	12,7	13,9	10,17
Average monthly amplitude (K)	10,9	10,9	1,5	10,8	11,6	11,8	12,3	13,0	13,3	12,4	11,4	11,3	10,93
Average monthly relative humidity (%)	64,0	65,0	64,0	61,5	53,5	51,5	48,5	46,0	46,0	52,5	59,5	60,5	56,04
Average monthly rainfall (mm)	126	90	91	52	13	8	4	6	28	73	118	105	59,50
Rham	78	80	80	78	71	70	67	64	63	67	73	74	72,1
Rhpm	50	50	48	45	36	33	30	28	29	38	46	47	57,60

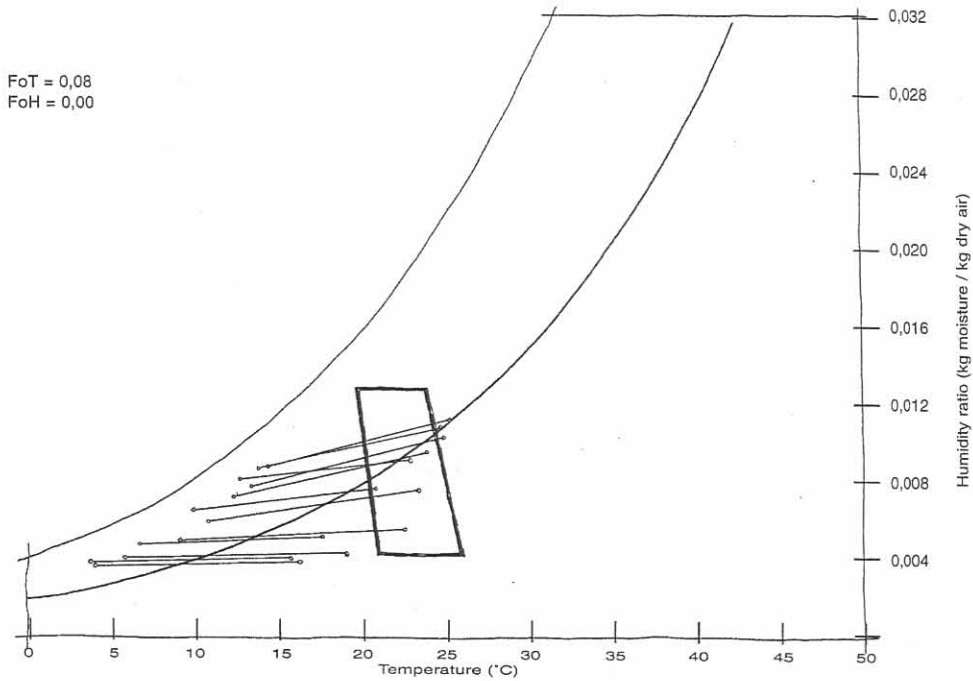


Fig 6.12.2 – Psychrometric chart showing the comfort zone's position relative to the climatic lines.

Plan form

Winter and summer requirements differ. The winter demands include a compact plan form, a well-insulated envelope, and solar gain is desirable.

Position of functions

External spaces should provide shade in summer for outdoor activities.

Rain protection

Building entrances can be shielded from sporadic thunderstorms.

6.12.5 Building envelope

Mass

Thermal mass is also advisable especially in inland areas when the daily temperature swing is larger than 13K. It can be provided by massive floors and internal partitions. It is effective for approximately half of the under heated period and for the entire overheated period.

Insulation

Lightweight insulated roofs are feasible in this region.

Properties of materials

All external surfaces should be light coloured or reflective (but not shiny metal) to minimize solar heat gain in the overheated period.

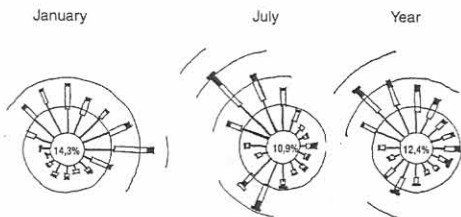


Fig. 6.12.3 – Wind rose for Johannesburg International airport

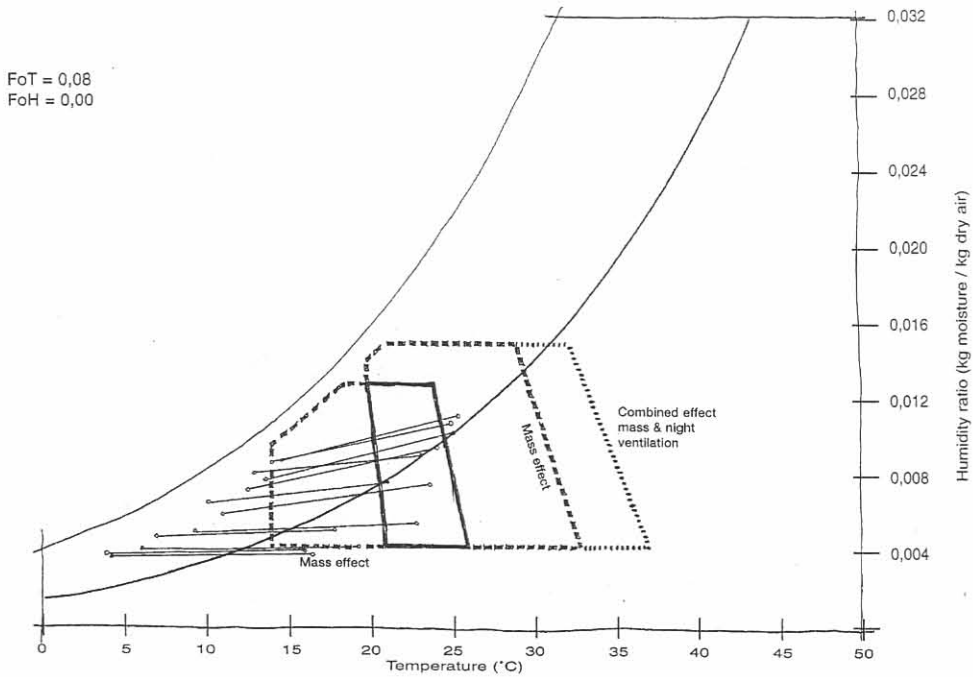


Fig. 6.12.4 – Psychrometric chart showing the enlarged comfort zone obtained by supplying thermal mass to the structure. The combined effect of ventilation and thermal mass on the comfort zone is also shown. 22,2 % of the mass effect is sufficient in summer.

6.12.6 Solar control

Sun angles

It is recommended that summer sun be screened and winter sun be allowed to penetrate.

Equatorial window

An equatorial window with an area equal to 19,2 % of the floor area is effective for the entire overheated period. Openings for solar gain should be orientated towards the winter sun and screened in summer when solar control is necessary to prevent overheating.

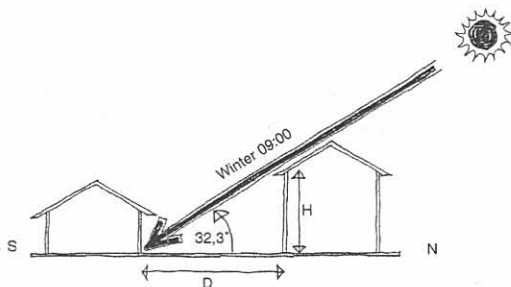


Fig. 6.12.5 – Solar access for building spacing in Johannesburg International. $D=1,6 H$

6.12.7 Ventilation

Ventilation is effective for alleviating overheating, but may be unnecessary if thermal mass is exploited. Night ventilation can be implemented to compensate for insufficient mass.

6.12.8 Management

Opening of windows if night ventilation is feasible.

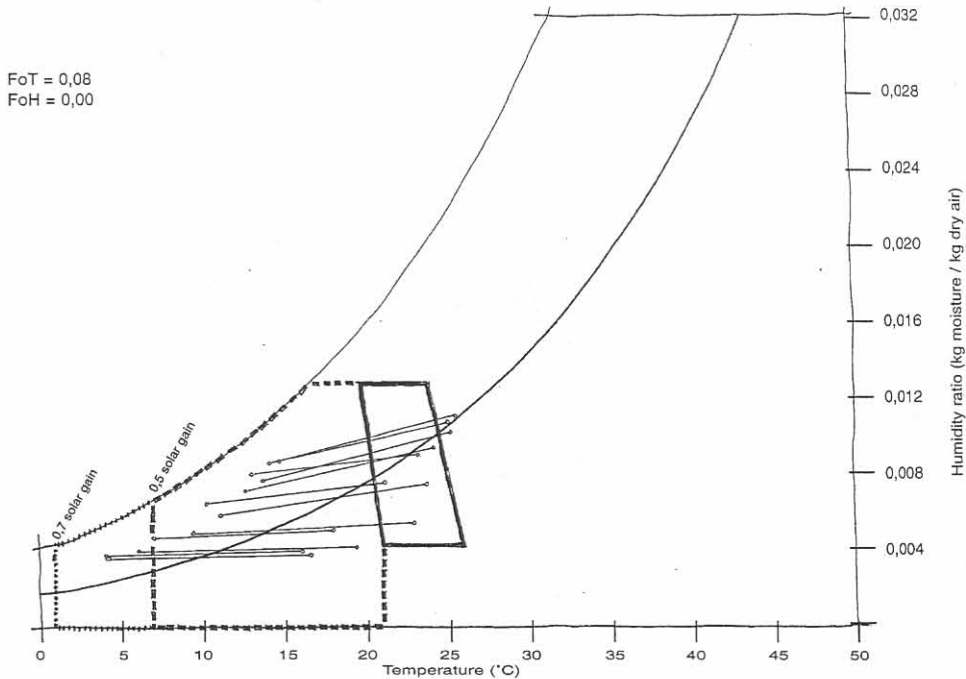


Fig. 6.12.6 – Psychrometric chart with equatorial window with efficiencies of 0,5 and 0,7 sized 24,3% and 16,4% respectively of floor area.

6.12.9 Systems

Evaporative cooling

Direct evaporative cooling is effective for controlling the entire overheated period, but is unnecessary if thermal mass is exploited.

Active

Airconditioning is not necessary unless the building function demands it.

Table 6.12.2 – 12:00 sun angles for Lydenburg, Johannesburg and Ficksburg

Vertical sun angle at 12:00 solar time			
	Latitude (South)	Solstice (21 Mar/23 Sept)	Winter (22 June)
Lydenburg	25,10°	64,9°	41,4°
Jhb International	26,13°	63,87°	40,37°
Ficksburg	28,86°	61,14°	37,64°

Mechanical

Mechanical ventilation is not necessary unless the building function requires higher ventilation rates.

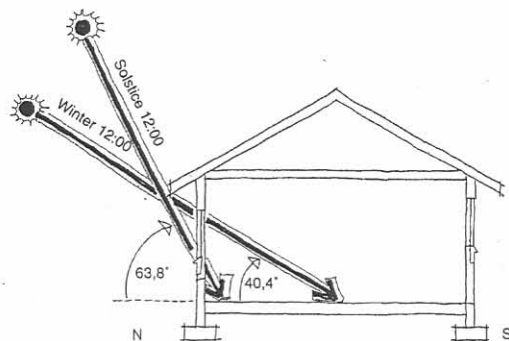


Fig. 6.12.7 – Roof overhang, window height and positioning for Johannesburg International Airport.

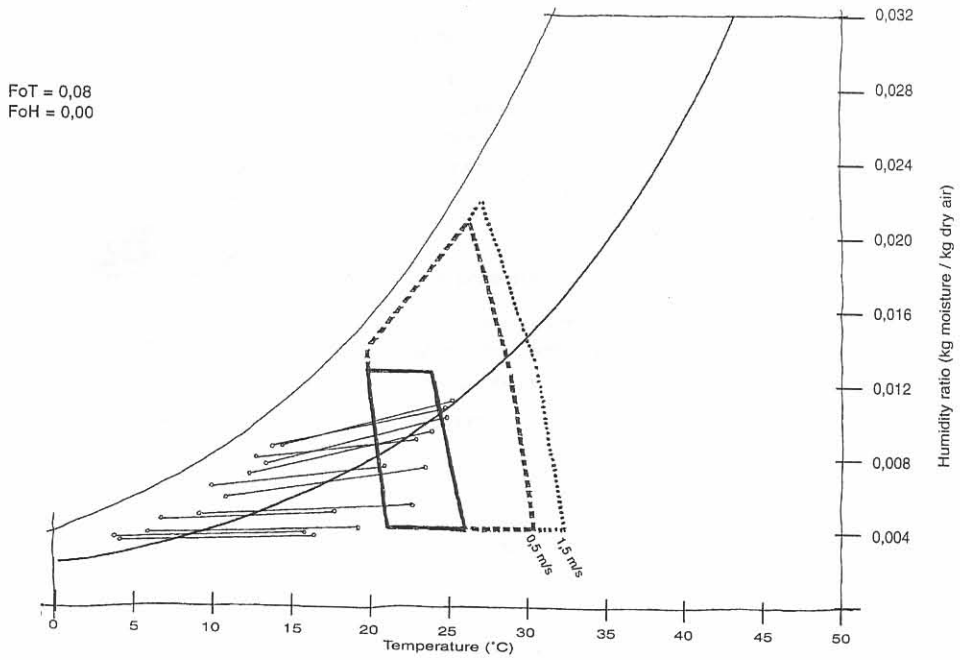


Fig.6.12.8 – Psychrometric chart with ventilation. A minimum requirement is 28,6 % of the effect of 1m/s required to deal with the worst case summer condition.

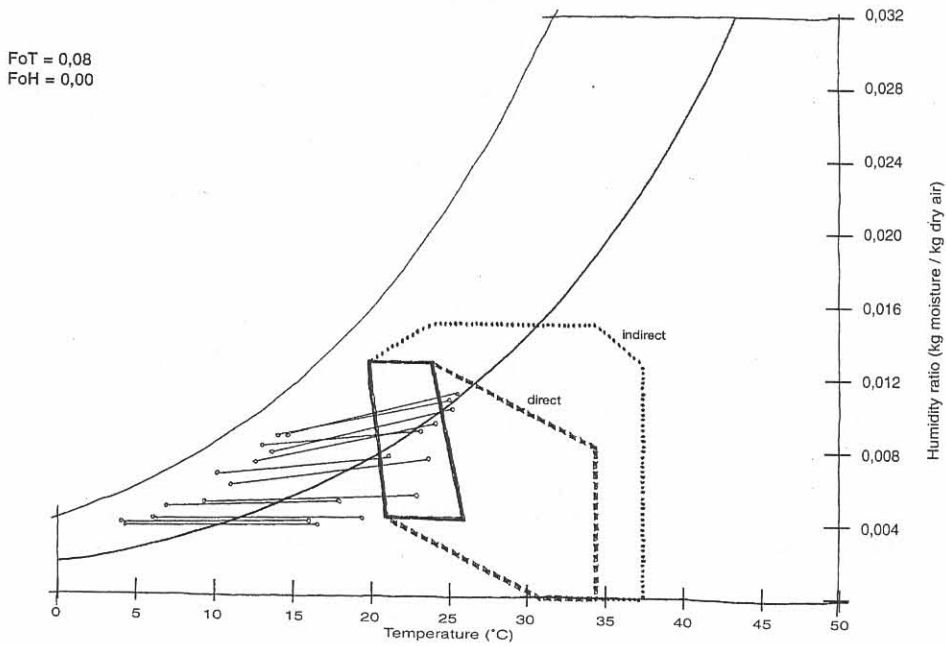


Fig. 6.12.9 – Psychrometric chart with evaporative cooling. 12,0 % of direct evaporative cooling is effective.

6.13 Climatic zone – Northern Transvaal

6.13.1 Background

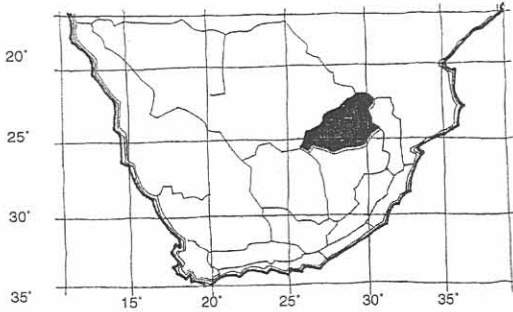


Fig. 6.13.1 – Climatic zone – Northern Steppe.

Location

25,8° to 30,7° East and 22,0° to 25,9° South.

Towns in region

Louis Trichard, Pietersburg, Pretoria

Description of zone climate

Distinct rainy and dry seasons exist with a large daily temperature variation and strong solar radiation. Humidity levels are moderate.

6.13.2 Climate

Temperature

The maximum diurnal variation occurs in July. The average monthly diurnal variation is 13K.

Table 6.13.1 – Climatic data for Pretoria

Jan	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
Maximum average monthly temperature (°c)	28,6	28	27	24,1	21,9	19,1	19,6	22,2	25,5	26,6	27,1	28	24,81
Minimum average monthly temperature (°c)	17,4	17,2	16	12,2	7,8	4,5	4,5	7,6	11,7	14,2	15,7	16,8	12,13
Average monthly amplitude (K)	11,2	10,8	11	11,9	14,1	14,6	15,1	14,6	13,8	12,4	11,4	11,2	12,68
Average monthly relative humidity (%)	58,0	59,5	60,0	59,5	55,0	53,0	50,0	46,0	45,0	49,5	54,0	56,5	53,83
Average monthly rainfall (mm)	136	75	82	51	13	7	3	6	22	71	98	110	56,17
Rham 72	74	76	78	76	75	71	64	61	64	68	70	75	70,75
Rhpm 44	45	44	41	34	31	29	28	29	35	40	43	44	36,92

Humidity

The average monthly relative humidity level is 59%.

Wind

Summer winds are predominantly east-north-easterly to east-south-easterly. Winter winds are predominantly south-westerly with a fair amount originating from the north-east.

6.13.3 Comfort zone

Temperature

Summer temperatures extend approximately 3K above the comfort zone. Winter temperatures extend to approximately 15K below the comfort zone.

Humidity

Humidity levels are moderate and are not considered problematic.

6.13.4 Planning

Urban

Protection of pedestrians by trees, arcades or canopies. South facades of street receive high radiation during summer and should be tree lined.

Plan form

Winter and summer requirements differ. The winter demands include a compact plan form, a well-insulated envelope, and solar gain is desirable.

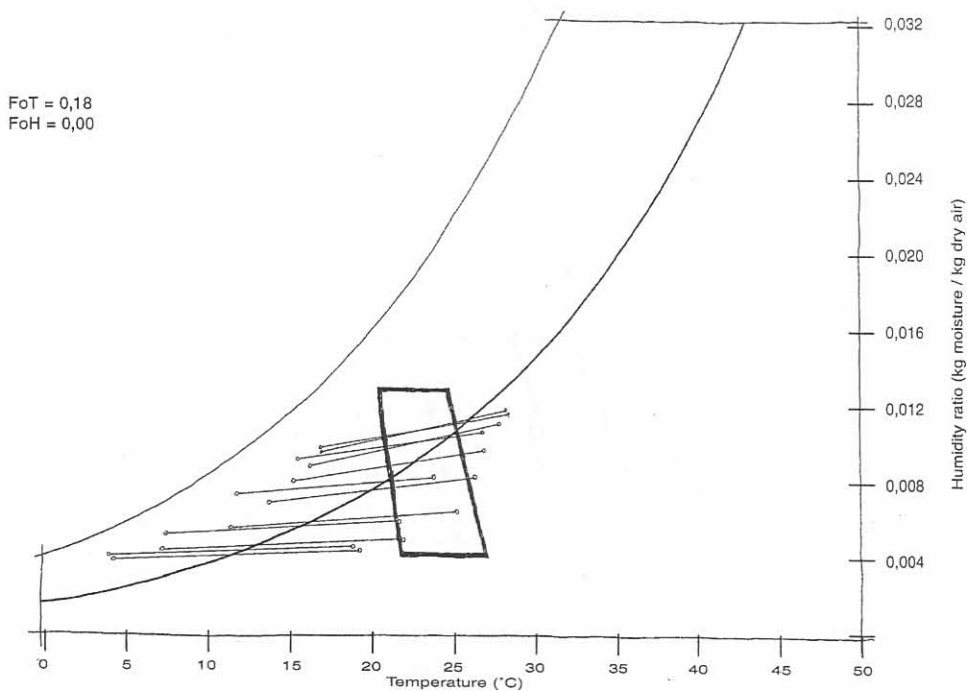


Fig. 6.13.2 – Psychrometric chart showing the comfort zone's position relative to the climate lines – Pretoria.

Position of functions

External spaces should provide shade in summer for outdoor activities. Place buffer zones west and south.

Rain protection

It will be convenient to shield entrances from sporadic thunderstorms.

6.13.5 Building envelope

Mass

Thermal mass is effective for approximately half of the under heated period and the entire overheated period. Thermal mass is also advisable especially in inland areas where the daily temperature swing is larger than 13K. It can be provided by massive floors, roofs and internal partitions. It is effective for approximately half of the under heated period and for the entire overheated period.

Insulation

Lightweight insulated roofs are feasible in this region provided that walls and floors give thermal mass.

Properties of materials

External surfaces should be light coloured or reflective to minimize solar heat gain in the overheated period.

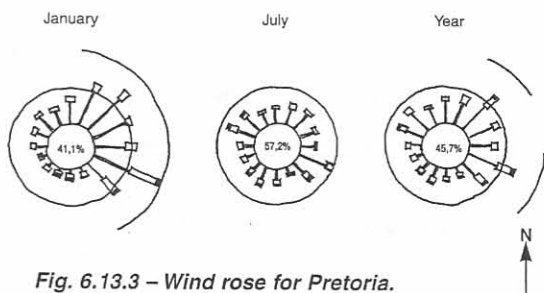


Fig. 6.13.3 – Wind rose for Pretoria.

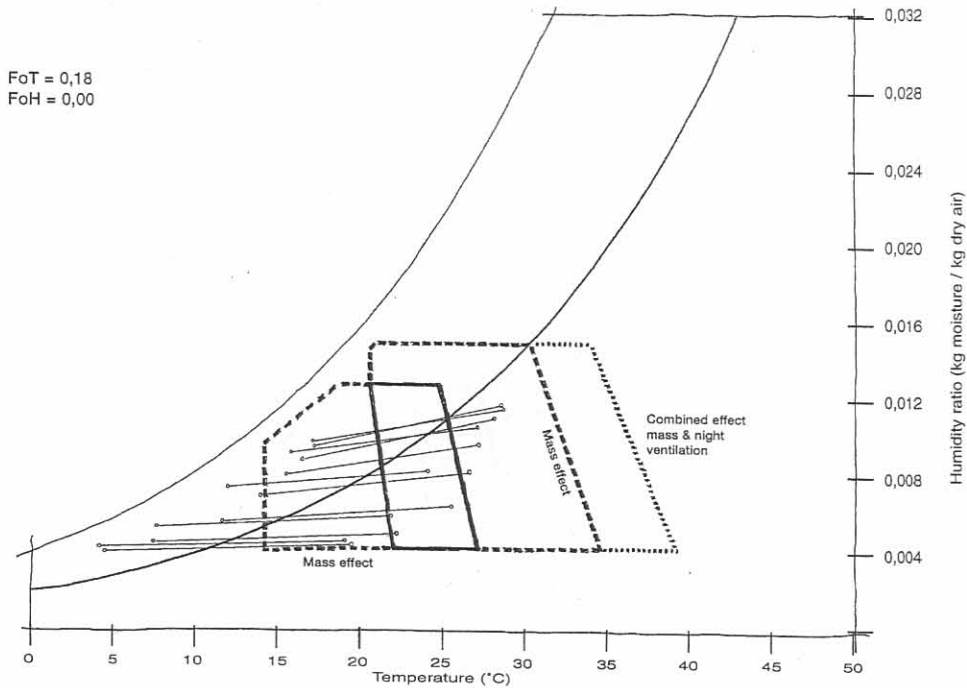


Fig. 6.13.4 – Psychrometric chart showing the enlarged comfort zone obtained by supplying thermal mass to the structure. The combined effect of ventilation and thermal mass is also shown. Night structural cooling is optional.

6.13.6 Solar control

Sun angles

It is recommended that summer sun be screened and winter sun be allowed to penetrate.

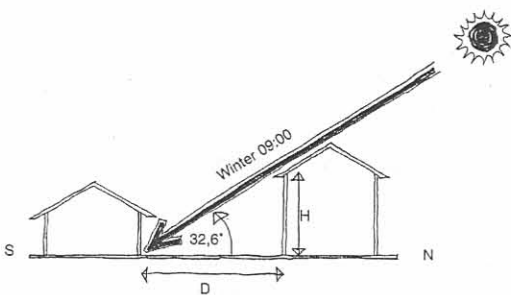


Fig. 6.13.5 – Solar access for building spacing in Pretoria. $D=1,5 H$

Equatorial window

An equatorial window equal to 21,2 % of the floor area is effective for the entire winter period.

6.13.7 Ventilation

Ventilation is effective for the overheated period. Night ventilation can be used to compensate insufficient mass.

6.13.8 Management

Opening of windows if night ventilation is feasible.

6.13.9 Systems

Evaporative cooling

Direct evaporative cooling is effective for most of the overheated period.

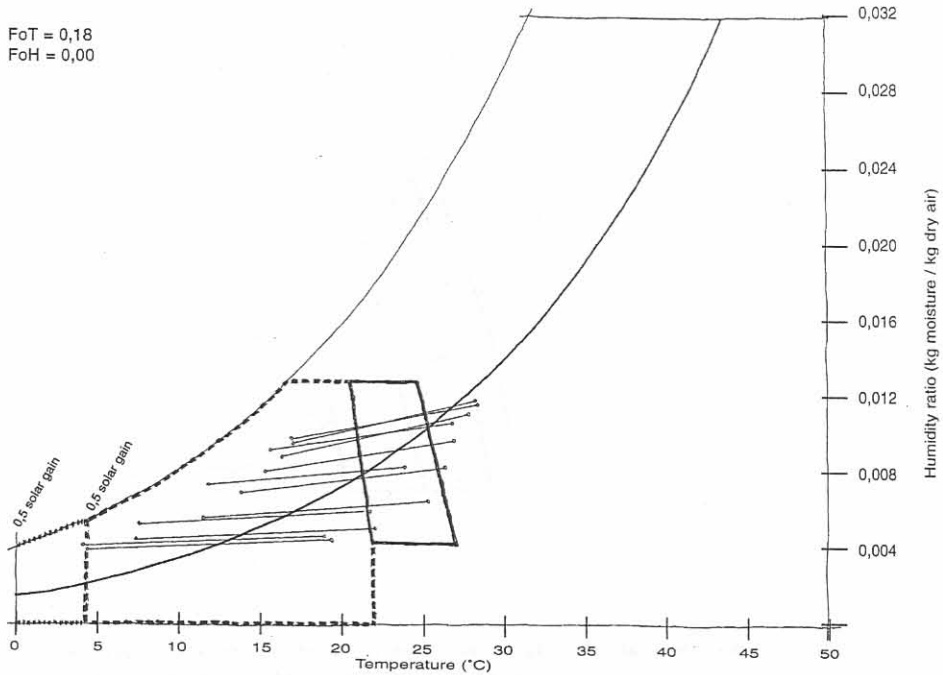


Fig. 6.13.6 – Psychrometric chart with equatorial window with efficiencies of 0,5 and 0,6 sized 21,2% and 18,9% respectively of floor area.

Active

Airconditioning is not a necessity, but the building function may require it.

Mechanical

Mechanical ventilation may be necessary to achieve the required ventilation rates.

Table 6.13.2 – 12:00 sun angles for Pietersburg, Louis Trichard and Pretoria

Vertical sun angle at 12:00 solar time			
	Latitude (South)	Solstice (21 Mar/23 Sept)	Winter (22 June)
Louis Trichard	23,86°	66,14°	42,64°
Pietersburg	23,64°	66,36°	42,86°
Pretoria	25,77°	64,23°	40,73°

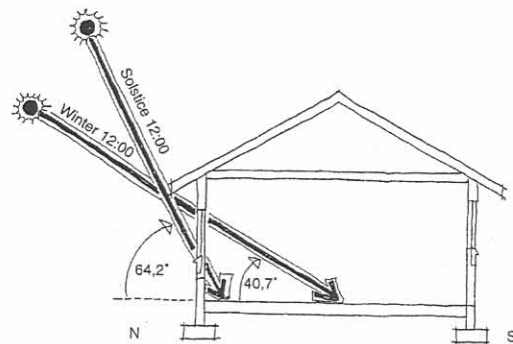


Fig. 6.13.7 – Roof overhang, window height and positioning for Pretoria.

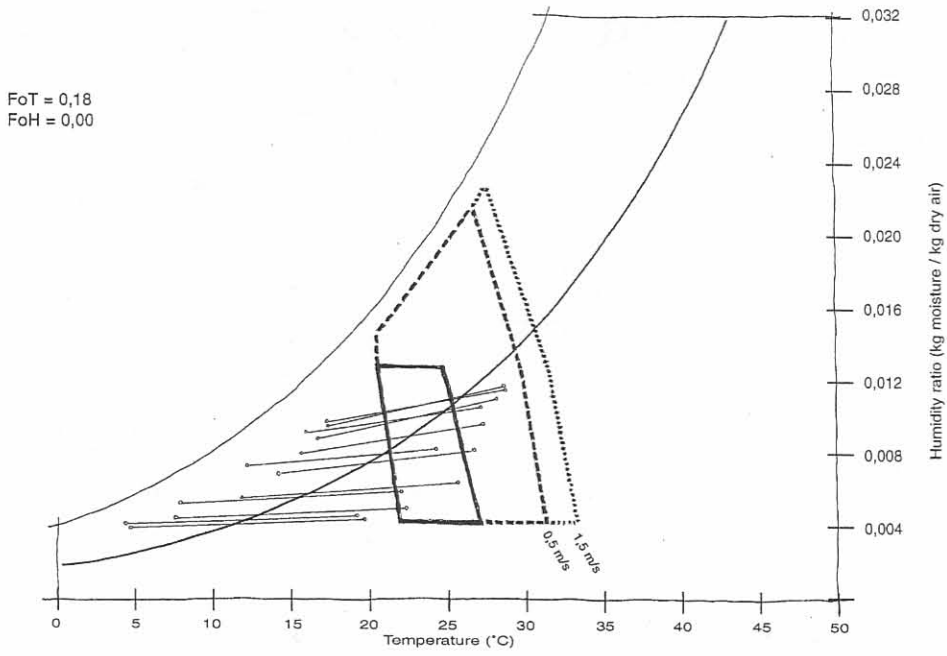


Fig. 6.13.8 – Psychrometric chart with ventilation. A minimum requirement is 67,9 % of the effect of 1 m/s required to deal with the worst case summer condition.

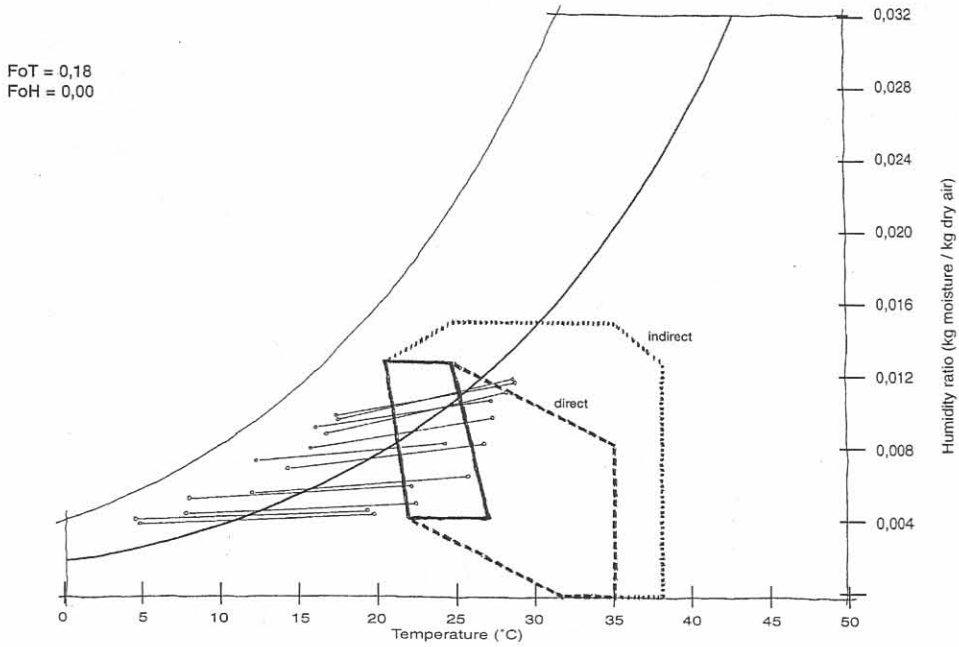


Fig. 6.13.9 – Psychrometric chart with evaporative cooling. Direct evaporative cooling is not quite sufficient.

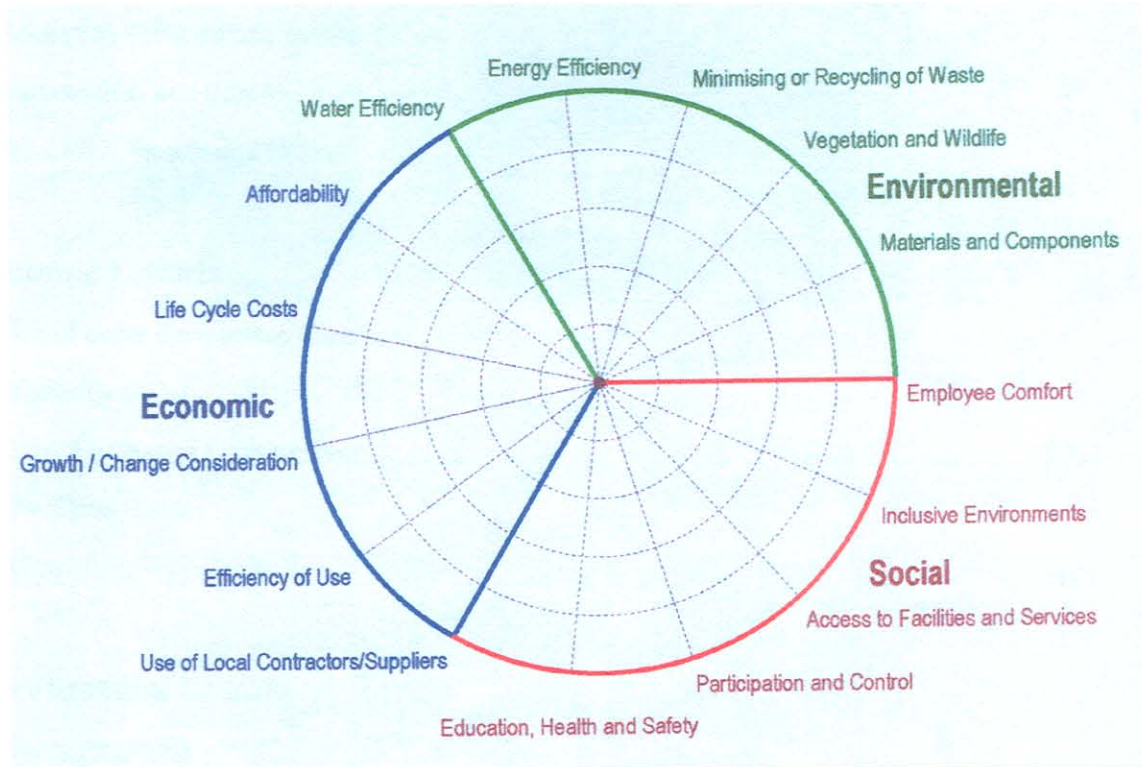
APPENDIX 3

A comparison of on-site waste disposal methods (City of Austin 1998:website)

<u>ISSUE</u>	<u>COMPOSTING TOILET</u>	<u>SEPTIC TANK TREATMENT</u>	<u>AERATION PLUS CHLORINATION</u>
<u>Destroys viruses</u>	<u>yes</u>	<u>no</u>	<u>uncertain</u>
<u>Destroys beneficial bacteria</u>	<u>no</u>	<u>no</u>	<u>Uncertain but regrow later</u>
<u>Destroys harmful bacteria</u>	<u>yes</u>	<u>no</u>	<u>Will regrow later</u>
<u>Destroys parasitic worms, except nematodes (roundworms)</u>	<u>yes</u>	<u>no</u>	<u>no</u>
<u>Destroys nematodes (roundworms) only</u>	<u>unsure</u>	<u>no</u>	<u>no</u>
<u>Destroys protozoan cysts (including Giardia and Entamoeba)</u>	<u>yes</u>	<u>no</u>	<u>unlikely</u>
<u>Reduces phosphorus pollution</u>	<u>yes</u>	<u>no</u>	<u>no</u>
<u>Reduces nitrogen compound pollution</u>	<u>yes</u>	<u>To some degree</u>	<u>yes</u>
<u>Creates carcinogenic trihalomethanes</u>	<u>no</u>	<u>no</u>	<u>yes</u>
<u>Creates residual sludge</u>	<u>yes</u>	<u>no</u>	<u>no</u>
<u>Requires chemicals to be added</u>	<u>no</u>	<u>no</u>	<u>yes</u>
<u>Maintenance-free period</u>	<u>3 months</u>	<u>3 months</u>	<u>Constant supervision</u>
<u>Requires de-sludging</u>	<u>15-20 years</u>	<u>1-4 years</u>	<u>6 months - 4 years</u>
<u>Health risk if mechanical failure occurs</u>	<u>low</u>	<u>high</u>	<u>medium</u>
<u>Degree of water conservation</u>	<u>high</u>	<u>low</u>	<u>low</u>

APPENDIX 4
The prototype SBAT (CSIR 2001)

Sustainable Building Assessment Tool
Detailed Evaluation Results – SBAT Diagram



Sustainable Building Assessment Tool

Target Criteria Descriptors

Social Criteria

- Employee Comfort
- Inclusive Environments
- Access to Facilities and Services
- Participation and Control
- Education, Health and Safety

Economic Criteria

- Use of Local Contractors/Suppliers
- Efficiency of Use
- Growth / Change Consideration
- Life Cycle Costs
- Affordability

Environmental Criteria

- Water Efficiency
- Energy Efficiency
- Minimising or Recycling of Waste
- Vegetation and Wildlife
- Materials and Components

Detailed Evaluation Results - Social

Employee Comfort

- Natural lighting
- Natural ventilation
- Low noise
- Views (all work positions min 6m from external window)
- Access to amenities: WC, refreshments (tea making point)

Inclusive Environments

- Easy access to disabled friendly public transport
- All routes in and between buildings smooth and even (ie wheelchair accessible)
- All changes in levels routes in and between buildings include ramps with 1:12 fall, hand rails and/or lifts
- Required number of disabled accessible WC(s) available
- Edges (ie between walls and floors) and stair nosing clearly distinguished with contrasting colours

Access to Facilities and Services

- Creche
- Banking
- Shops
- Communication Facilities (Post, Public Telephone, email)
- Government / tax / licensing information

Participation and Control

- Personal control over light, temp and ventilation levels
- Users involved in design / construction process
- Users involved in the design, refurbishment of their spaces
- Users able to adapt their spaces to suit themselves (ie furniture / privacy)
- Space and / or equipment shared with local community

Education, Health and Safety

- Space available for group training sessions/access to learning packages
 - Fully compliant with fire escape requirements
 - Access to Sports facilities
 - Access to nutritious food (restaurant, vegetable gardens etc)
 - Materials used, screened for hazardous compounds (ie VOCs)
-

Sustainable Building Assessment Tool

Detailed Evaluation Results - Economic

Use of Local Contractors/Suppliers

- 80% of construction carried out by contractors within 20km of site
- 80% of construction materials obtained from within 40 km of site
- 80% of components (windows, doors, etc) and furniture made within country
- Space / outsource opportunities provided for small businesses
- All repairs/maintenance/cleaning of building can be carried out by contractors within 40km of building

Efficiency of Use

- Space Management System ie charged to cost centres
- Proportion of useable space to non usable space (Circulation, WCs storage) min 80%
- Patterns of occupance
- Efficient space use measures: shared workspaces (ie hotdesking)
- Use of ICT to reduce space requirements (email, video conferencing etc)

Growth / Change Consideration

- Floor to ceiling / underside of slab height min 3000mm
- Non structural internal partition walls
- Modular, loose furniture
- Services strategy
- Structural strategy

Life Cycle Costs

- Maintenance costs
- Cleaning
- Security / caretaking
- Insurance / water / energy / sewerage
- Plant / component replacement

Affordability

- Design: highly 'buildable', simple shapes
 - Procurement: costs reduced through donations, community involvement, partnerships
 - Construction: phased or built as shell with finishes to follow
 - Operation: costs shared with other users
 - Use neighbouring space / facilities rather than duplicate
-

Sustainable Building Assessment Tool

Detailed Evaluation Results - Environmental

Water Efficiency

- Rainwater harvesting
- Water efficient devices: low flush WCs and urinals
- Greywater reuse
- Minimising runoff: absorbant external surfaces
- Low water demand landscaping

Energy Efficiency

- Located near public transport / all users within walking distance (4km)
- Passive environmental control system for ventilation
- Passive environmental control systems for heating and cooling
- Low energy appliances / fittings
- Solar control

Minimising or Recycling of Waste

- System for recycling
- System for reusing
- Sewerage
- Provision for dangerous toxic waste
- Systems set up to minimise/reuse waste produced during construction process

Vegetation and Wildlife

- Use of a 'brownfield' site
- Range of plants
- Range of habitats provided
- Effect on neighbouring buildings: light etc (buildings kept apart minimum 10m for 1 s, 15m for 2s+)
- Minimal ext inputs required for maintenance of landscaping (ie ferlizers/ pesticides)

Materials and Components

- 80% of materials have low embodied energy
 - No material / component used manufactured through process which harms the environment
 - All materials / components produced using only renewable energy sources
 - 80% of materials and components for the buildings recycled / refurbished
 - 80% materials and components from renewable resources
-