DEFINING THE 'SUSTAINABLE HOME'

IN THE MOZAMBICAN URBAN CONTEXT

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Masters Thesis in Design for Sustainable Development, 2015
Department of Architecture
Chalmers University of Technology

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IN THE MOZAMBICAN URBAN CONTEXT

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KEYWORDS
Maputo, Mozambique, Urban context, Residential building, Construction material, Construction technology, Design guidelines

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ABSTRACT

AIM
The aim of this thesis is to gather and synthesize the necessary resources to assist designers in single-family house design specifically in the Maputo urban context.

These resources will consist of relevant design guidelines and principles for the Mozambican socio-economic and cultural context.

The thesis will also emphasize principles that aid in higher end-user engagement with sustainable processes and principles, as a means to advance the layman's understanding and acceptance of sustainability thought in their daily lives.

PURPOSE
The purpose of this is to assist designers in Mozambique to understand relevant sustainability concepts, techniques and technologies that they may employ in home projects, through the collection of the most relevant information into a single pedagogic document.

END RESULT
The thesis concludes with a project proposal in which modular designs are tested, focusing on sustainability aspects related to appropriate material selection, thermal building performance and increased overall building resilience in the Mozambican context.

STRATEGY
The compilation of these resources is achieved through:

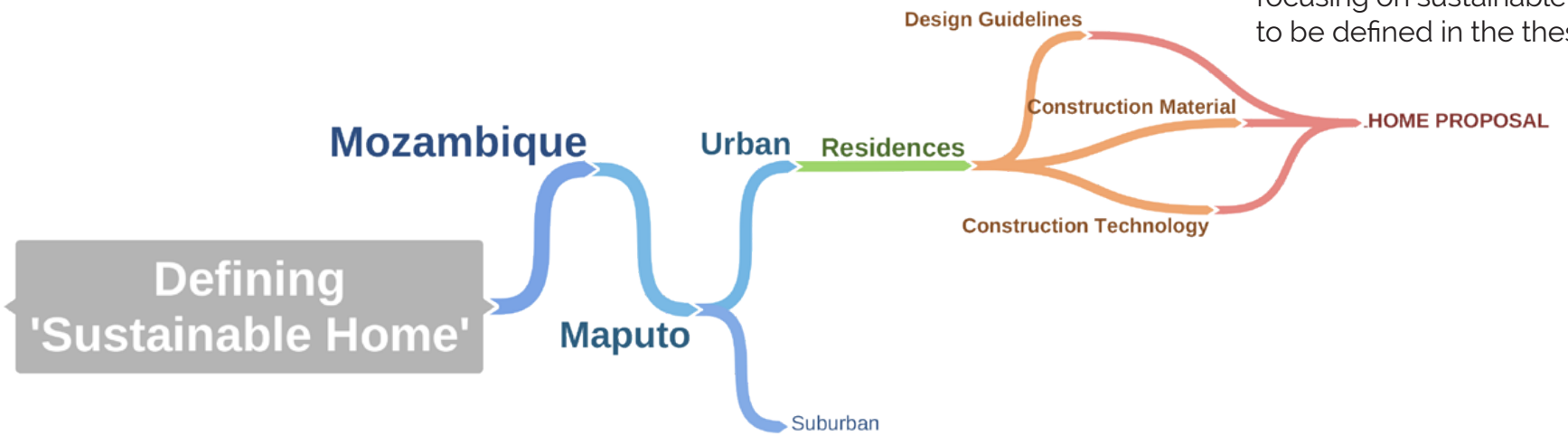
1) an analysis of Maputo's urban context that focuses on its climate, social, historic and economic context;

2) discussions and interviews with the current Headmasters and professors of the Architecture Faculties in Maputo, pertaining to the current state of sustainability discourse and its practical application in the context;

3) an exploration of the Home of today as it exists, regarding the different typologies, their guiding principles, construction materials and techniques;

4) finalized with a proposal for the Home of tomorrow with the point of departure being the critical revision of the analysed material and it's reformulation when focusing on sustainable design principles, to be defined in the thesis.

KEYWORDS



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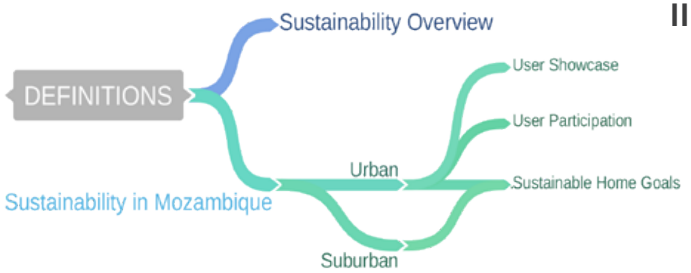

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Fig. 1 BATIK depicting traditional lifestyle in Maputo by Nato Manjene, 2014

I. INTRODUCTION

INTRODUCTION

This chapter presents a comprehensive Project Plan for the Master Thesis.

It can be used as a 'reading guide' to understand the structure of the document.

It details various aspects that are important to understand the contextual background and relevance of the topic.

The various components of the project are explained, as well as the working strategy employed.

My background — *How past experiences both personal and professional have culminated in this Master Thesis project*

Previous work experience — *Project descriptions and images of previous work that may be relevant in terms of skill and ability to the this project*

Sustainability in Mozambique — *Introduction to the concept of 'sustainability' as it exists in the Mozambican context, particularly in the built environment*

State of the Art — *Examples of literature and projects that define the State-of-the-art of sustainability thought in Mozambique, that were used as a starting point for this Master Thesis project*

Mozambique — *Brief introduction into the contextual reality presented in Mozambique, with an emphasis to the role of Maputo and economy in the built environment*

What & Why — *Outline of the Master Thesis objectives, what it seeks to achieve and why these objectives are important to pursue*

Urban vs. Suburban — *Introducing the distinction between these two contexts*

Expanding urban — *The contextual focus of this Master Thesis proposal*

Condominiums & developments — *The project typology of this Master Thesis*

Topics to explore — *List of chapters and the topics explored in each, highlighting what should be achieved*

Guiding questions — *Overview of the questions the Master Thesis attempts to answer*

Delimitations — *Overview of the scope of the Master Thesis, by highlighting which fields of design it will focus on*

Intended outcomes — *Detail what the final result of the Master Thesis will entail and how the project may proceed from there*

Work strategy — *Explain by chapter heading how each part of the Master Thesis was developed and information gathered and compiled*

ABOUT MAURO PAUL

MY BACKGROUND

Mauro, born in Mozambique, has a BSc. In Architecture from the University of Pretoria.

My architectural education in South Africa had a somewhat strong focus on developing a broad knowledge base that might otherwise lie in the realm of other specialists.

This enables the architect to function as a project manager, capable of bringing together the different professions that participate in putting together a building.

As a consequence, my interest was broadened past the physical design of spaces into the choice of materials and the potential performance of buildings.

After working in the position of Junior Architect in a medium-size firm in Maputo that focused on commercial and residential projects, applying for studies in the Masters Program Design for Sustainable Development at Chalmers presented the opportunity to develop my interest in this field of building performance, which is still in its infancy in the African educational arena.

In the MPDSD programme the studio *'Planning and Design for Sustainable Development in a Local Context'* was invaluable in its introduction to thinking about processes that may occur at a neighbourhood planning scale and the kind of relationships that buildings with different functions can develop to result in a better functioning whole.

Taking part of the course *'Design Systems'* provided a valuable insight into the intricate relationships that seemingly unrelated subjects can experience and the way tweaking small details/inputs can have great consequences over the whole system .

The studios *'Sustainable Building'* and *'Sustainable Building Competition'* served to advance my own understanding of individual building-scale processes, with a great emphasis placed on state-of-the-art materials, construction methods and techniques that present new and exciting opportunities for sustainable design.

As a consequence of personal experiences and observation of the Mozambican context where it comes to the sustainability of materials employed and even the actual performance of the finished product, coupled with the wealth of knowledge made available throughout the studies, the idea for this thesis took shape.

I have developed a personal interest in addressing the subject of sustainability in Mozambican architecture, specifically where it comes to the Maputo context.

THESIS BACKGROUND

SUSTAINABILITY IN MOZAMBIQUE

The population of Mozambique has been growing at a fast pace. In the last 25 years it has gone from 14 million people in 1989 to 24 million people in 2013.

This growth is reflected in the increased need for residential infrastructure, but severely handicapped by the current practice of architectural design and construction techniques that are employed in informal self-built projects.

These self-built projects are, generally done by inexperienced designers, following suit of traditional and vernacular construction and design principles, coupled with a limited understanding of modern construction knowledge.

This limited understanding of modern construction knowledge stems from the fact that the majority of the built environment workforce in Mozambique acquired their knowledge through informal training and apprenticeships in previous construction sites. Mozambique is lacking in formal schools that train builders and masons to the existing standard of building knowledge.

STATE-OF-THE-ART

There exists a knowledge void of what can be considered state-of-the-art techniques, methods and technologies in regards to the built environment as a whole, but specifically towards sustainable design as it exists today, particularly when compared to contexts where it is most advanced, admittedly also in its relative infancy.

This is further exacerbated by the fact that sustainable design ideas and principles that may reach Mozambique have not been studied and adapted to the context, when it comes to its particular climate, existing building materials and construction technology or even the economic conditions of the majority of the population and their specific social needs.

There have been, in recent years joint ventures to develop and tailor these universal principles of sustainable design to be better adapted to their individual contexts, between some European and African universities, through the project **SURE-Africa** (*Sustainable Urban Renewal: Energy Efficient Buildings for Africa*)., between 2007 and 2009.

This project seeked specifically to 'deepen and disseminate the existing knowledge in four Portuguese speaking African countries, in the area of sustainable architecture, and particularly as it refers to the bioclimatic project and the energetic efficiency of buildings.'

Regarding the Mozambican context, this joint venture culminated in the handbook '**Arquitectura Sustentável em Moçambique: manual de boas práticas**' (*Sustainable Architecture in Mozambique: Good practices Handbook*).

This handbook is a noble starting point for the adaptation of international sustainable principles for Mozambique,

Taking that information background as a starting point, It is my hope that this research document is a worthy stepping stone towards a much needed revaluation of the priorities and considerations in sustainable design discourse and its implementation in my home country.

THESIS BACKGROUND

MOZAMBIQUE

The Mozambican context presents itself as a complex system, with a predominantly poor population, specially in the rural areas and a new and rapidly growing mineral industry that has resulted in the rush for infrastructure development.

This growth is greatly experienced nearer to the centres of the industrial investments in the centre and north of the country, but predominantly in the capital, Maputo.

This is a result of a society structure where seemingly most of the government and investment entities are concentrated in Maputo.

There are distinct differences between what can be understood as sustainability in the developed world versus what is applied in Mozambique.

The country is still one of the poorest and most underdeveloped in the world, resulting in the type of sustainable practice that focuses on economic aspects such as material affordability and availability of construction methods.

However, due to the recent growth resulting from investments into the mineral industry, there have been a number of residential developments in Maputo and other urban centres that seek to provide affordable housing for the Mozambican middle class..

These developments conform to the reality of Maputo only in relation to what has been common practice in the country for the past 40 years when it comes to building objectives:

A dependency on fossil fuels and air conditioning for mechanical ventilation without which the building might be inhabitable and a focus on building aesthetics that mimic those of high-profile international style architecture with expansive glass and steel façades poorly translated to the social and climatic reality of the context; minimal thought

Fig.5 Mozal in Maputo accounts for 2% of world Aluminium output

Fig.6 Maputo suburb with typical constructions

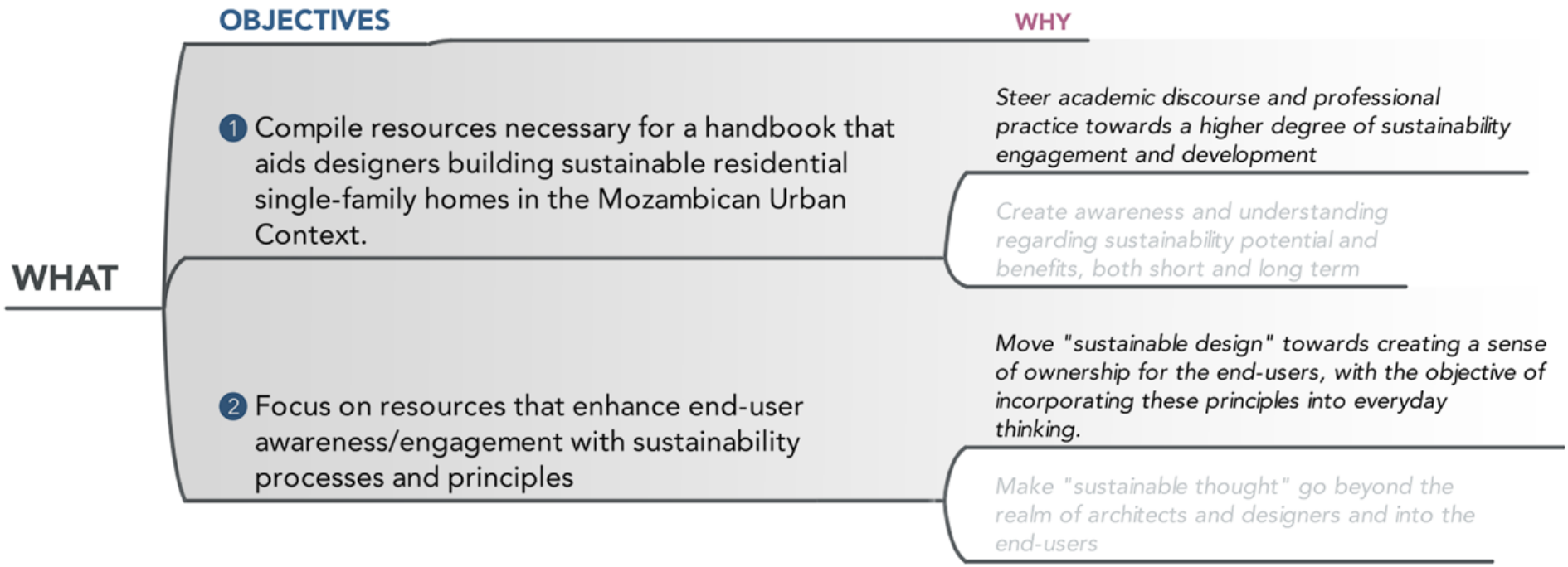
THESIS OBJECTIVES the what & why

WHAT?

The thesis collects the existing relevant information and knowledge regarding traditional, vernacular and modern construction materials, techniques and design guidelines for home design and development and reinterprets these in a way that may uplift the discussion regarding what can be achieved with the current contextual, social and economic conditions.,

It also seeks to address the gap between economic, social and environmental aspects in the Mozambican context, using these recent residential development projects as a basis for analysis and discussion.

This kind of investigatory work can contribute to the development of sustainable thought in Mozambique because there have been few recent projects that have been done with the aim of challenging the current design methodology in Mozambique when it comes to the feasibility of implementation of sustainable design principles, besides those that address the economic aspect of construction and maintenance.



THESIS OBJECTIVES the what & why

WHY?

> *'The problems of environmental sustainability and energy economy are universal and common to all countries and regions of the world.' (Tessema, 2009)*

Like in every other context in the world, the built environment in Mozambique must do its part in changing towards practices that are harmonious with and enhance natural ecological systems.

Low economic reasons are often cited as the main factor for harmful practices that stem from the building and design industry such as high-embodied energy construction materials, poor building performance, low quality in construction methodology and poor maintainability.

These reasons however may be invalid if we consider that around the world, in contexts with similar characteristics it is possible to identify examples of projects that accomplish sustainable design goals through the use of relevant and well-thought out design principles.

This thesis thus seeks to bring this approach to the Mozambican context, of working with the social and economic conditions that exist to deliver a project proposal that may serve as inspiration and example of what can be accomplished, if one takes into consideration broader goals than the common economic reasons that the existing market uses as a guiding force.

The thesis identifies these potentials so that sustainable design discourse in Mozambique can be advanced, both from the designers perspective but also for the end-user, that they may incorporate these principles into everyday thinking

Fig.7 House to office conversion, central Maputo

Fig.8 Typical one-room habitation, Maputo suburb

THESIS OBJECTIVES the what & why

URBAN VS SUBURBAN

Maputo presents two distinct realities: the urban and the suburban, with big discrepancies between them.

The resources that exist in one do not exist in the other and consequently there isn't one solution or design proposal that would effectively address both contexts.

In the suburban, for example, one might not have access to amenities such as water, electricity, etc. unlike the urban and city centre.

EXPANDING URBAN

The focus of this thesis lies on the expanding urban context - not the city centre that may present already a high density, but the suburban areas in the periphery that are quickly being taken over by the built-up city in expansion.

In the city centre there are several new high rise apartment and office buildings coming up. Further away from the centre there are many more condominium-type projects, where you have the same house plan repeated throughout the site.

This presents and interesting and relevant area to intervene in terms of sustainable design, because as house prices in the city centre rise and city densification reaches it's limit due to existing infrastructure and prohibitive costs, more and more people are going to move into these condominiums.

A project that deals with this area of design would be dealing with the future problems that arise from unplanned urban sprawl resulting from such project typology.

Fig.9 Two-storey house to six-storey apartment building conversion, central Maputo

Fig.10 'Casa Jovem' houses, a typical Condominium development in the expanding Urban Context in Maputos periphery

THESIS OBJECTIVES the what & why

CONDOMINIUMS & DEVELOPMENTS

These condominiums can include as few as a handful of detached single-family homes or be as extensive as hundreds of houses, including a mix between residential and commercial activities, social spaces and other collective infrastructure services.

There are generally few high-rises in these planned condominium areas, with the majority of the space being low-density residential homes, or apartment buildings going up to three or four storeys.

The most common house typologies are single-family detached homes and semi-detached homes, or "*casas geminadas*".

As standard procedure, the developer for the condominiums presents one or several 'typical house' plans, and among these prospective home-owners chooses, purchases and finances the construction of the building, often with regular site inspections and possible changes to the final design of the home.

Because of the added involvement of the end-user in the actual design and building stages of the home, this kind of project presents an opportunity to explore the relationship between sustainable development in the realm of user participation.

The thesis addresses this typology, as a prediction that this is where the biggest impact can be made in the residential development of Maputo for the years to come.

Fig.11 Typical semi-dettached house at Casa Jovem Complex, Maputo

Fig.12 Typical high-rise apartment block at Casa Jovem Complex, Maputo

THESIS STRUCTURE AND READING INSTRUCTIONS topics to explore

I. THE PARTICULARITIES OF THE CONTEXT

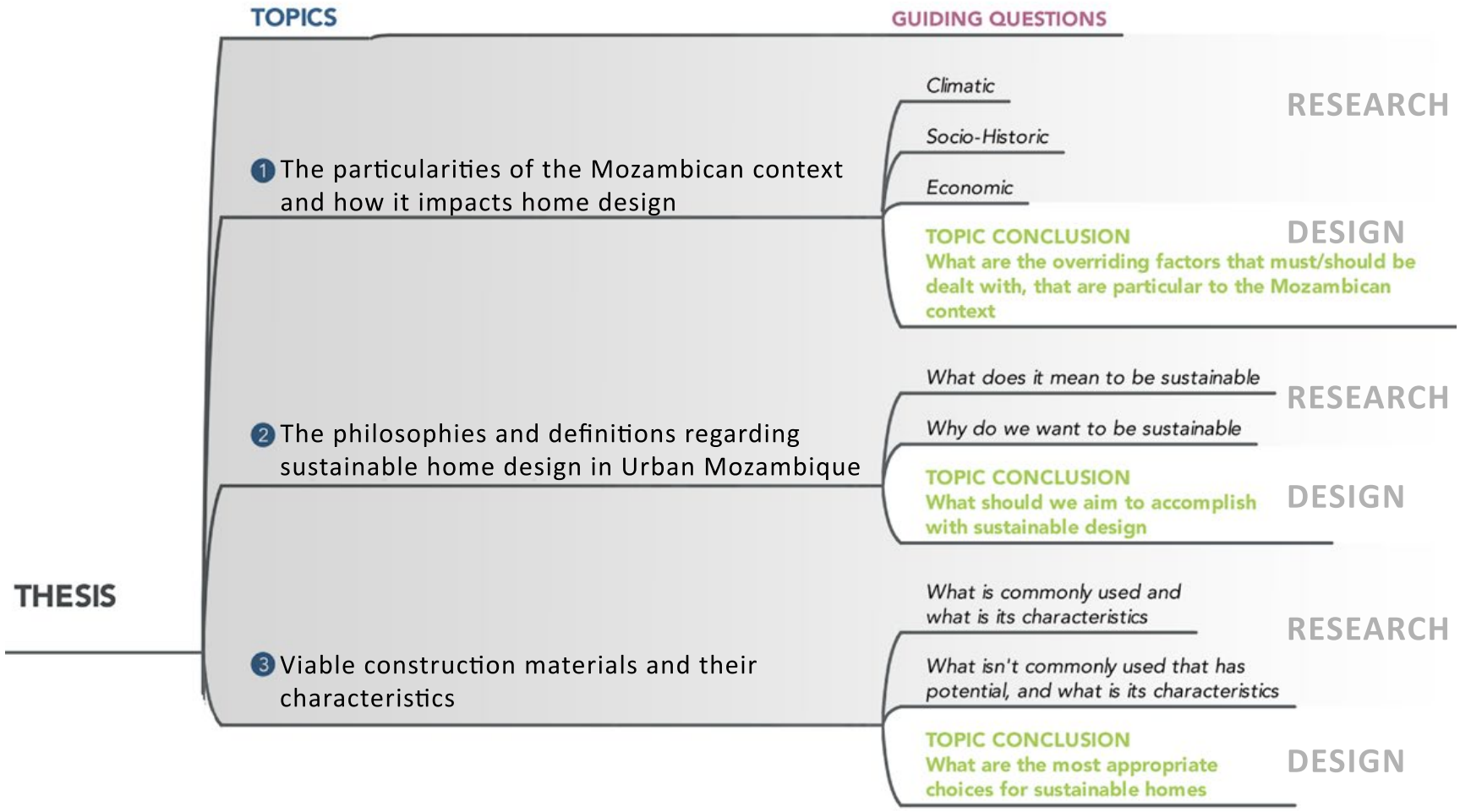
The first part of the thesis develops a common understanding of the Mozambican context, particularly Maputo, with a focus on residential buildings. It positions the discussion within the climatic, socio-historic and economic strata.

The aim of this analysis is to be able to summarize the overriding factors that should and must be dealt with that are particular to the Mozambican context.

II. PHILOSOPHIES AND DEFINITIONS REGARDING URBAN HOME DESIGN

The second part of the thesis analyses sustainability concepts as they are understood and practiced in Mozambique, both from an academic and a practical point of view.

The aim of this analysis is to understand what are appropriate and reasonable goals to be accomplished through sustainable design.



THESIS STRUCTURE AND READING INSTRUCTIONS topics to explore

III. & IV. CONSTRUCTION MATERIALS & RELEVANT TECHNOLOGIES

Parts 3 and 4 deal with practical aspects of home design, such as guidelines to have in mind, available and appropriate construction materials that may be employed and common construction techniques and technologies that are important to be aware of.

This analysis will enable conclusions regarding what devices may or may not be used for designing residential buildings, both from a historical perspective but also from a contemporary understanding of building processes.

V. DESIGN EXAMPLE

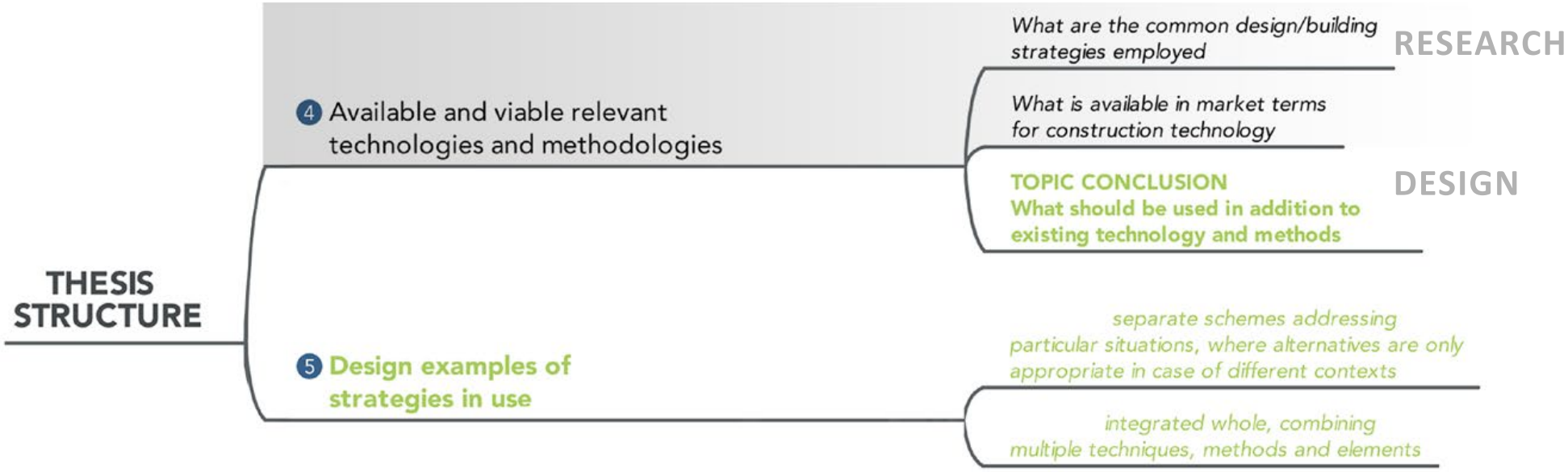
The last part of the thesis includes a design proposal for a single-family detached house set in a condominium development, which employs or attempts to summarize all the topical conclusions from the previous chapters.

This proposal will include a site analysis, client brief and design guidelines and objectives to be achieved for residential development in the expanding Urban fabric of Maputo.

It will be as extensive as detailing employed guidelines, materials and techniques for construction., as well as an estimated building performance analysis.

VI. APPENDIX

Additional material can be found here, including sketches, figures and interview transcripts.



THESIS RESULTS guiding questions and delimitations

QUESTIONS

What does sustainability mean in the Mozambican context

What are case studies of sustainable homes n Mozambique

What are the principles, technologies and techniques used in these references

How can these systems and processes be exposed to create awareness in the end-user

How can this new awareness in the users be transformed into acceptance of sustainability as a way of life

The guiding questions chosen for the thesis range from an academic approach of trying to understand the existing discourse in the country regarding the meaning of sustainability, to a practical approach, of pinpointing existing technologies and techniques that are commonly employed to achieve certain sustainability goals.

An underlying focus is also given to improving building performance through user-participation of the end-user in sustainable goals.

DELIMITATIONS

Emphasis on technological, social and economic limitations and potentials in Mozambique

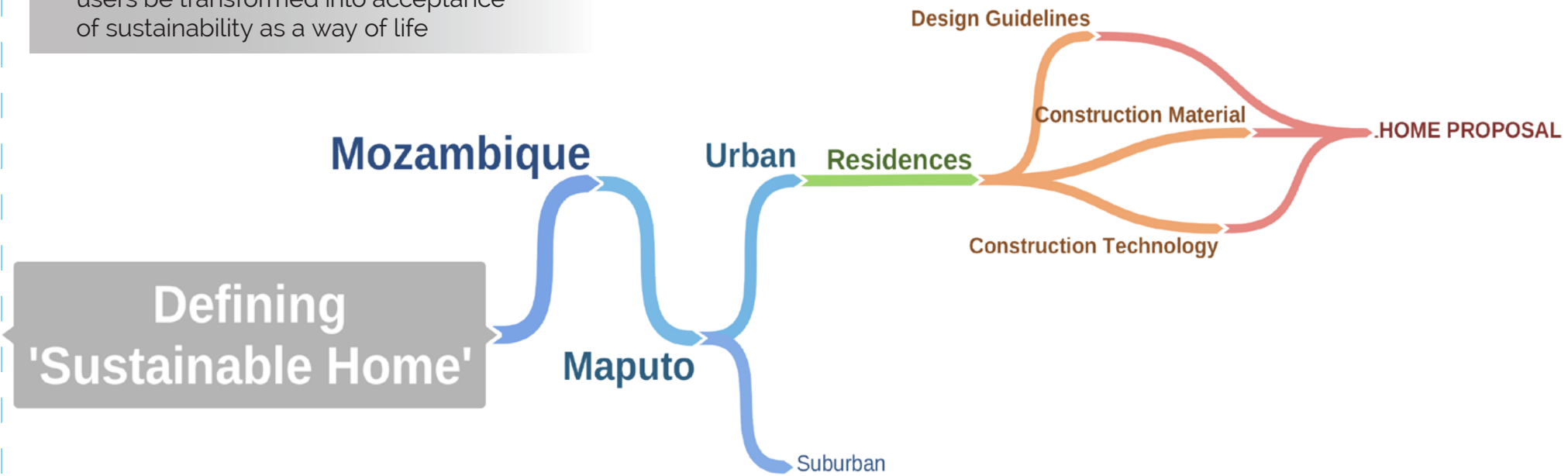
Focus on the urban environment

Focus on residential field

Emphasis on single family homes

Focus on structure and material choices

Focus on socio-environmental aspects of design.



THESIS RESULTS intended outcomes

INTENDED OUTCOMES

The thesis is compiled in a didactic and pedagogical manner, so that the analysis and conclusion from each individual chapter may be used by designers in the Mozambican context to develop their own residential projects in a sustainable manner.

These conclusions represent a refined understanding of the context and its effects on sustainable home design through guidelines and principles expressed in either concepts or diagrams.

The thesis chapters progress from a larger scale zooming in, from the climate and historic perspective, to the philosophies and concepts employed by current practicing architects and professors, to practical examples of materials and construction technologies, to culminating in a project proposal that seeks to bring all of these conclusions together into a complete vision of what the Home of the Future may look like.

Ultimately this thesis can be used to progress towards a coherent understanding of sustainability in the residential context as it exists and future potentials in Mozambique, as well as design testing, where these principles are applied in a specific design scheme.

This thesis is the first step towards a handbook that can be used by architects and designers who are interested in implementing sustainable practices in their homes.

Fig.13 View of thesis proposal module

THESIS RESULTS work strategies

OVERALL STRATEGY

A variety of different methods and strategies were employed to gather and compile the information in each chapter.

Apart from general knowledge concerning the history and climate of Mozambique which is wide-spread on the internet and literature, many of the resources and conclusions gathered in this document are a result of on-site observation, face-to-face interviews with Mozambican designers and extrapolations from software calculations.

I had the opportunity to personally travel to Mozambique for three weeks during March 2015 and have a first-hand account of the topic under discussion.

I. MOZAMBICAN CONTEXT

Information regarding the Mozambican and Maputo contexts is available in *UN HABITAT 2010 - Mozambique Cities Profile* and *Master Thesis by Bonito,J. 2011 - Arquitectura moderna na Africa Lusofona*

Information on the Mozambican climate, as well as strategies on designing for the particular climate included books such as *UN HABITAT 2014 - Sustainable building design for tropical climates* and *Guedes, C 2009 - Arquitectura sustentavel em Moçambique*

The psychrometric charts were created through the software Climate Consultant 6.0 using available weather data.

II. PHILOSOPHIES AND DEFINITIONS REGARDING SUSTAINABILITY

The discourse stems primarily from interviews with Luis Lage, the Director of the Architecture Faculty of Eduardo Mondlane University; Miguel Cesar, Course coordinator for Architecture and Urban Planning in ISCTEM; Jessica Lage, Architecture PhD student at Porto University researching the 'Formalities of informal habitation in Suburban Maputo.'

III. & IV. CONSTRUCTION MATERIALS AND RELEVANT TECHNOLOGIES

Conclusions for this chapter are primarily a result of observation of the built environment in Maputo, photographs and visits to construction-sites throughout Maputo, as well as through references obtained during the interviews.

V. DESIGN PROPOSAL

Parallel to developing the previous chapters that define the design guidelines for the thesis project, the final design proposal is developed to respond to the different aspects raised regarding possible and realistic social, environmental and economic sustainability goals, achievable in the Maputo context.

This thesis proposal is done while in contact with the architect ultimately responsible for the real-world proposal and implementation on site.

Fig.14 Interviews with Architecture professors and a PhD student. Transcripts in the Appendix

Fig.15 Photos from on-site visits in the Appendix

Fig.16 Reference literature, as detailed in the References

THESIS RESULTS work strategies

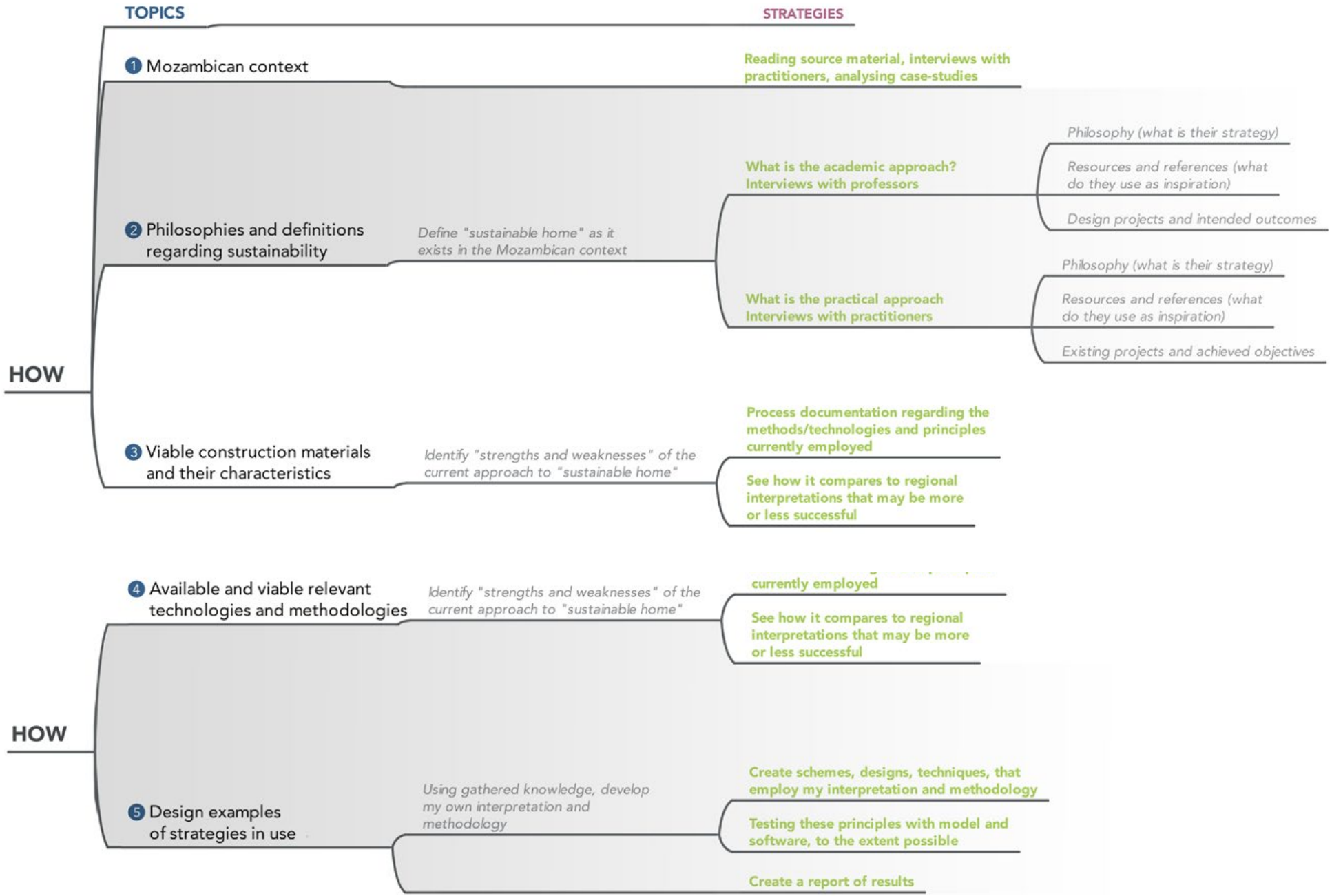


Fig. 17 View over built-up Maputo, 2015

II. CONTEXT ANALYSIS - URBAN MOZAMBIQUE

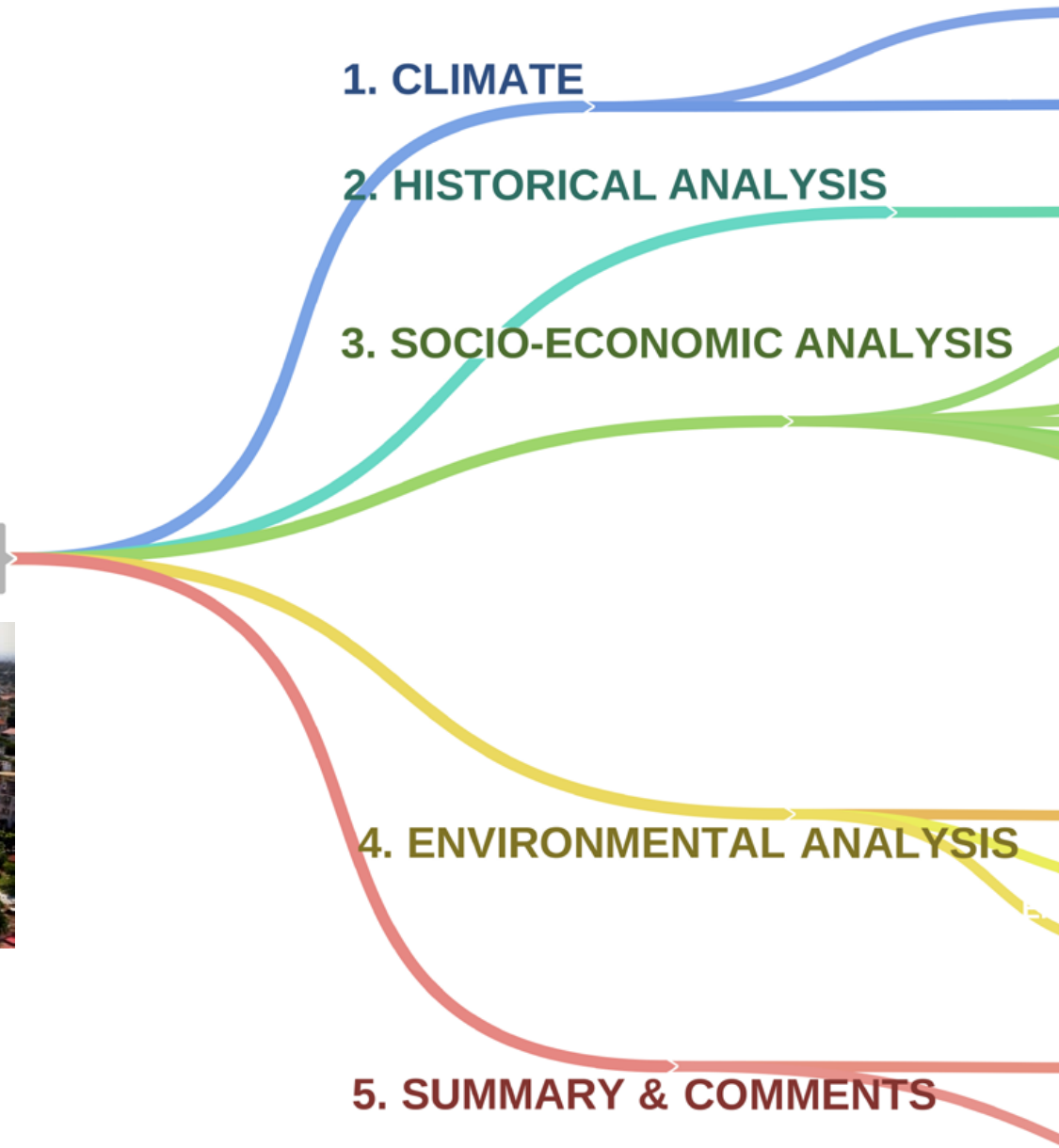
CONTEXT ANALYSIS urban mozambique

The aim of this chapter is to summarize the elements that should be held in mind when designing for the built environment Mozambican context, with particular focus on Maputo.

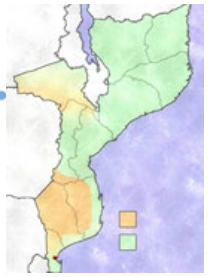
The climate is identified, as well as general understanding of its impact on everyday life.

A brief historical description of Maputo is developed, to highlight the elements that shaped residential building design.

Social, economic and environmental aspects that may have a strong impact on the built environment are also detailed.



- **Mozambique & Maputo** — *General overview of relevant climatic conditions*
- **Daylight, Temperature, Precipitation, Humidity** — *Climatic characteristics present in Maputo, and their impact on the built environment*
- **19th Century - 1992** — *Brief overview of Maputo's history, with a focus on the built environment and its impact on Mozambican society*
- **1993 - Present** — *Description of factors that shaped the present socio-economic state of Maputo*
  - **Urban context - 'Cement City'** — *Description of the conditions in the urban context*
  - **Suburban context - 'Bamboo City'** — *Description of the conditions in the suburban context*
    - **HDI** — *Breakdown of the Human Development Index of the country*
    - **Education** — *Account of the state and level of education in the context*
    - **Social classes** — *List of the social classes that comprise the Mozambican population*
    - **Lack of housing** — *The state of housing availability and provision to the population of Maputo*
- **Water & Sanitation** — *Detail of the quality and availability of water to both urban and suburban areas, as well as the type of sanitation used by the majority of the population*
- **Energy sources** — *Quick overview of available energy sources*
- **Environment** — *A breakdown of the impact that human activity has had on the environment in Maputo*
- **Key principles** — *Relevant terms and expressions to keep in mind for future chapters*
- **Choice of target market** — *More comprehensive explanation on which target market the Master Thesis project addresses, and the reasoning behind the choice.*



CLIMATIC ANALYSIS

MOZAMBIQUE

The climate of the greater part of Mozambique is mega thermic, characteristic of tropical and subtropical latitudes, classified as a Tropical Climate.

It is characterized by an average temperature of air higher than 18° C in the coldest month and by a high value of annual precipitation with a dry season in winter.

The dry season monthly rainfall is on average less than 60 mm.

Despite the variety of weather phenomena present in the Mozambican territory, the type of climate that prevails is the tropical rainy climate of Savannah.

Because this was the predominant climate type, most classifications have taken to describing the climate of virtually the entire Mozambican territory as the monsoon climate: hot, dry Winter and hot and humid Summer.

It is referred as monsoon for it's link with the monsoon winds, that seasonally blow over the Indian Ocean.

DAYLIGHT

The insolation period is quite extensive throughout the year, with days that last between 14:00 hours (the longest day) and the 10:00 hours (shortest day).

MAPUTO

As a result of the characteristic hot and wet season that is felt in Maputo for a large part of the year, this climate can be briefly characterized by:

"a burning sun that alternates with torrential rains, bringing to life an endless cycle of massive vegetation, surpassing the man with the force of its growth.
This is accompanied by a life of insects and parasites deadlier than the enormous jungle animals." (Bonito, 2011)

fig. 18 Mozambique in Africa

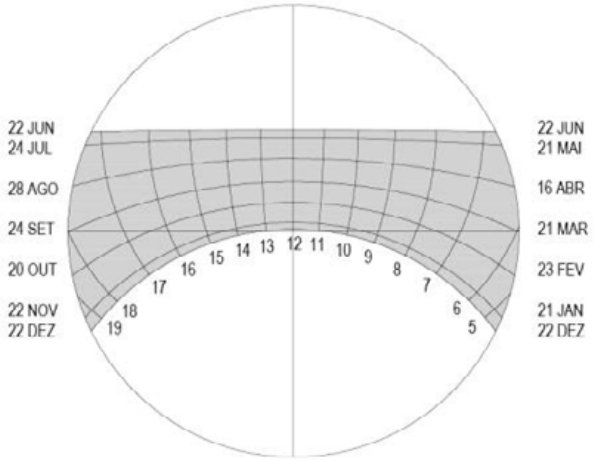


fig. 19 Maputo Solar Chart

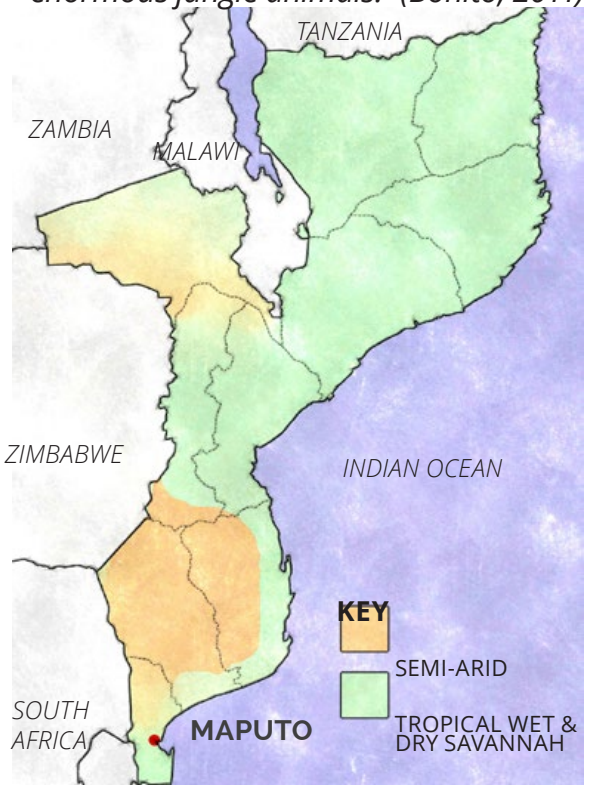


fig.20 Mozambique Climate

CLIMATIC ANALYSIS

TEMPERATURE

The air temperature in Mozambique is generally high, with an average value that surpasses the 20°C and reaches 29°C.

Average temperatures are in the hottest month between 22° and 30°C. The hottest month is between October and February.

The coldest month is usually July, with average temperatures that alternate between 14° and 25°C.

Annual variations are large, as the diurnal variations can reach a magnitude such that on certain days the experience is characteristic of the four seasons.

PRECIPITATION AND HUMIDITY

Mozambique's climate can be characterized by two yearly seasons: the rainy season or warm season and the dry season or cool season, and their transition months.

What truly differentiates them is the presence or absence of dew on the ground.

The amount of rainfall varies between 400 and 2000 mm of annual average.

The Mozambican climate is therefore considered moderately rainy (average between 500 and 1000 mm) and rainy (average between 1000 and 2000 mm).

It should be noted that the rainy season coincides with the months of higher temperatures,

The reduced temperature variation during the wet season indicates the predominant sea air masses.

During the dry season, the progressively larger amplitude indicates the predominance of air masses with continental characteristics.

		J	F	M	A	M	J	J	A	S	O	N	D	ANUAL
Average air Temperature	°C	25,4	25,5	24,6	23,0	20,8	18,4	18,1	19,1	20,4	22,1	23,4	24,7	**22,1**
Average max. air Temperature	°C	35,4	35,0	34,0	32,8	32,0	29,5	29,7	31,9	34,7	35,3	35,1	35,9	33,4
Average min. air Temperature	°C	19,0	19,0	18,1	15,8	12,3	10,6	10,3	11,5	12,9	14,7	16,1	17,9	14,9
Variation amplitude	°C	16,4	16	15,9	17	19,7	18,9	19,4	20,4	17,1	20,6	19	18	18,2

Average value for Precipitation in Maputo

	J	F	M	A	M	J	J	A	S	O	N	D	ANUAL
mm	131	124	127	53	29	23	15	13	28	48	85	99	776

Average value for Humidity in Maputo

	J	F	M	A	M	J	J	A	S	O	N	D	ANUAL
%	75,8	76,0	77,4	76,3	74,6	72,2	73,2	73,0	72,9	73,9	74,5	74,9	74,6

HISTORIC ANALYSIS

It has been shown that the pioneer-ism of the Modern Movement in the Lusophone Africa lies in how the modern ideology, inspired by the Brazilian experience, was locally interpreted.

From this viewpoint the excellence of this heritage lies, in part, in its responsiveness to the environment in which it operates, through a design with climate based on concerns today associated with the concept of environmental sustainability, rooted in the awareness of the functional needs and the available resources. (*Fernandes, 2008)*

19TH CENTURY

The Modern Movement architecture history in Mozambique goes hand in hand with that of Portugal.

The Portuguese nation plays the historical role of owning and colonizing the overseas dominions, civilizing the indigenous peoples who live in them and exercising the moral influence afforded to them by the patronage of the East.

Settled in 1830 as a small village. In 1878 Maputo at the time called Lourenço Marques has a small size with about 2,400 inhabitants, surrounded by water. The first buildings were made of wood until a fire destroyed everything. The buildings were rebuilt in brick, adobe, mud, zinc and tile.

It's official expansion plan from 1887 shows two distinct meshes. The main with generous dimensions was the formal city, with all the fundamental infrastructure for a developing city including electric trams. The smaller mesh with a distinct orientation situated north-west of the city was the intended "Indigenous neighbourhood", built in a precarious fashion.

This division is of particular relevance in so far as it would form a peripheral avenue which marks the separation of today's urban fabric uniformity of the formal 'Cement city' and the peripheral 'Bamboo city' slums, which define the urban fabric of the city.

Fig.21 Map of Maputo in 1878, then known as Lourenço Marques

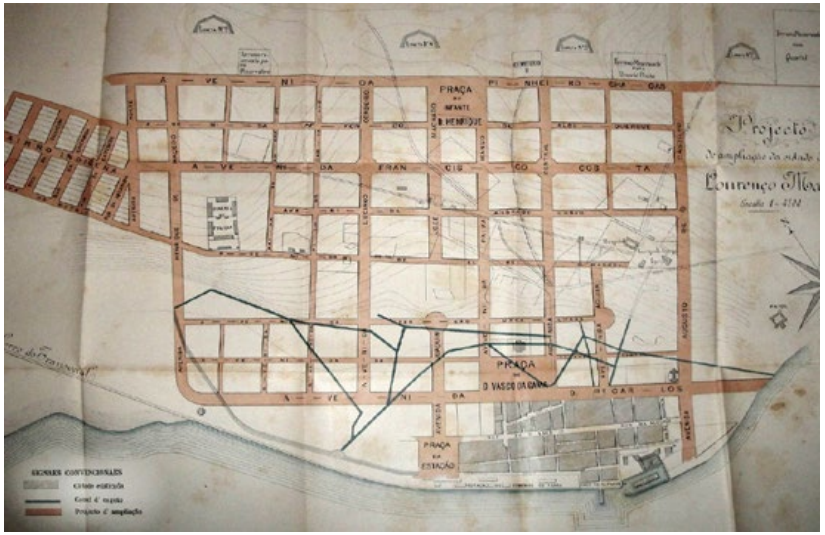


Fig.22 Expansion plan for Lourenço Marques, 1887

Fig.23 Downtown street, 1890s

HISTORIC ANALYSIS

EARLY 20TH CENTURY
Earlier in this period the current architectural production in Lourenço Marques was still characterized by small pavilion constructions in wood, zinc and iron.

In 1912 the City Council approved a proposal to stop this kind of buildings, which enhances the change that was taking place gradually to the use of cement.

In a 1915 city plan a new rotary axis is visible and even partial occupation of blocks designed to be highways.

It's the inevitable population growth of the city that sees its density grow substantially, concentrated in the central area,

1920 FIRST CONCRETE CONSTRUCTIONS
The employment of reinforced concrete is widespread in most of the buildings from the 1920s, which helps dictate the change in the construction paradigm and resulting in considerable expansion of the city.

At this time Lourenço Marques is the capital of the Portuguese colony of Mozambique with 37,000 inhabitants in 1928.

The urban development happens very quickly between the early twentieth century to the 1930s, accompanied by the evolution of technology employed in architecture.

Fig.26 Indigenous neighbourhood, 1910

Fig.27 Railway station, built 1916

Fig.28 Downtown avenue, 1920s

Fig.24 Indigenous street, early 1900s

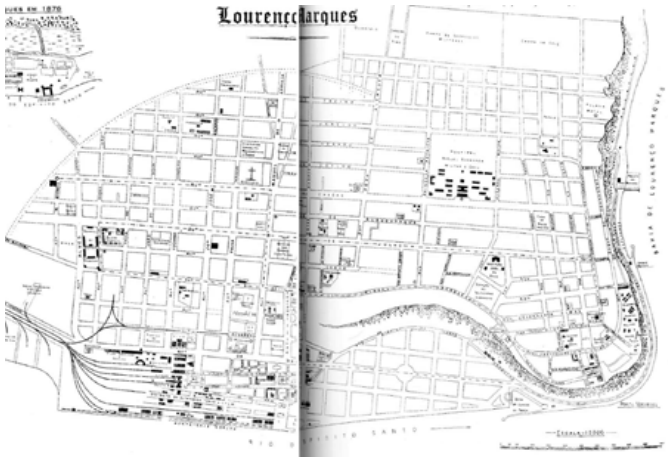


Fig.25 Lourenço Marques plan, 1929

HISTORIC ANALYSIS

1930-49 MODERN STYLE

In the late 1930 the current architecture is one of transition to modernist architecture, which was being implemented with the gradual application of modern materials in the construction and the growing popularization of reinforced concrete.

These works reflected this trend in forms of geometric expression of art deco type and "Portuguese streamline moderne", which is be developed in the decades of 1940-50,

A new expansion plan in 1955 sees the Cement city expanding towards the north-east. Still the Bamboo city plan does not allow for any formal permanent buildings, so the indigenous population must still live in temporary accommodation.

Fig.29 Streamline modern style, 1930-40s Lourenço Marques

1950-63 EXPANSION

The course of the 1950s is marked by a growing economic investment, accompanied by the city's urban growth and in 1960 Lourenço Marques has a population of around 180,000 inhabitants.

The Bamboo city has expanded to such a degree in the 1960s that it impeeds the expansion of the Cement city.

The segregation was by race, where europeans could live in the formal housing, the mixed-race could live in the immediate periphery and africans in the precarious suburbs

Fig.30 Modern style building, 1950s Lourenço Marques

Fig.31 Aerial of Lourenço Marques, 1960s

Fig.32 Gil Vicente cinema, 1940s

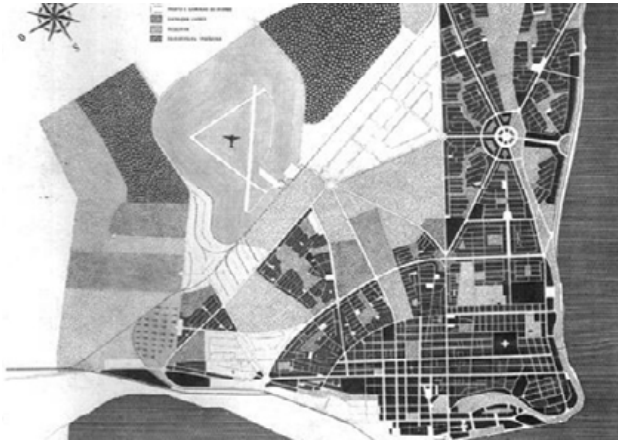


Fig.33 Urban plan for Lourenço Marques, 1955

HISTORIC ANALYSIS

1964-74 INDEPENDENCE WAR
Calls for self determination arose, specially in light of the great wave of decolonisation, resulting in the war for independence which started in 1964.

In 1970 more than 350,000 people live in the capital of the colony. During this period the majority of buildings constructed are high-rise apartments.

After increased fighting, Portugal and Mozambique negotiate a peace treaty in 1974 and independence declared in 1975.

1975-76 FROM LM TO MAPUTO
Lourenço Marques is changed to Maputo.

The nationalization of rental housing in 1976 gave the state the responsibility of managing a huge number of buildings, to the detriment of constructing new housing and infrastructure.

The central question of housing policy focused on creating and improving infrastructure and reorganizing peripheral neighbourhoods.

The municipal policy stressed the provision of urban land for people to build their own houses, giving priority to recently educated and newly-wed young people.

The municipality encouraged partnerships with the private sector to gradually solve social housing issues.

1977-92 CIVIL WAR
The civil war caused an unprecedented migration to urban areas. The end of the civil war only increased urban pressures, as Mozambicans were desperately seeking employment opportunities, access to health, and education in the cities.

A complicated urban organizational structure inherited from the Portuguese did not adequately deal with this influx, and the majority of migrants established themselves in informal settlements.

Fig.34 City plan, 1965

Fig.35 Aerial of lourenço Marques, late 1960s

Fig.36 Construction of a 33 storey apartment building, 1974

SOCIO-ECONOMIC ANALYSIS

1993 - PRESENT

Emerging from a devastating civil war and near bankruptcy in 1992, the country has grown at an annual rate of nearly 10 percent.

The post war recovery has been described as an international success story; having improved on nearly all indicators it has been measured.

Even so, it is still one of the poorest countries in the world. Maputo's budget is USD 6.4 million, which translates to about USD 5 per inhabitant. Being the largest port in the country, Maputo's economy is centred around the harbour.

Today Maputo has 1.3 million inhabitants, with the majority (70%) living in the slums.

There is a greater than ever fragmentation between the formal Cement city and the informal Bamboo city, with a steady influx of people from the rural areas wanting to live in the city.

URBAN CONTEXT - CEMENT CITY

The Cement city consists of conventional permanent buildings made of reinforced concrete and cement block supplied with road, water, electricity, telephone, and drainage systems.

Major challenges include garbage collection, poor roads, and poor drainage.

The challenges are exacerbated by the continued explosive growth of Maputo's population.

Over the last 20 years, migration from the countryside to the city has led to a population growth rate in the city of about 3.5 percent.

Despite being completely surrounded by the Bamboo city, it constantly pushes out, looking to expand.

This sometimes results in mass relocation of people in the suburbs, to give way to condominiums and warehouses.

SUBURBAN CONTEXT - BAMBOO CITY

> *(...) the housing stock is characterised by much more variable quality in the larger surrounding peri-urban areas, most of which have few public services. There is evidence of improvements at an individual level – especially in permanent wall construction material (mostly cement blocks) – there is continued poor access to infrastructure of all types and high levels of overcrowding*
> (UN Habitat 2012)

The growth of the housing stock has not been accompanied by the provision of the necessary infrastructure.

Many are located near or in floodplains. A majority are thus at risk of natural hazards like floods and landslides.

Lack of solid waste management, proper drainage and poor sanitation makes the communities vulnerable to flooding and water borne diseases.

Fig.37 Cement city aerial, 2015

Fig.38 Bamboo city aerial, 2015

Fig.39 Suburban homes in floodplain, 2015

SOCIO-ECONOMIC ANALYSIS

HDI (HUMAN DEVELOPMENT INDEX)

Mozambique has one of the lowest HDI, at 0.32 ranking 178th out of 187 countries in the world.

The country had one of the highest growth rates in the world in 1997-1998, and experiences consistent economic growth.

> *"The perception of economic prosperity is, however, stimulating an unsustainable rural exodus, leading to the proliferation of slum areas and contributing to an environmentally unsustainable situation."*
>
> (UN Habitat 2012)

High growth has resulted from increased rural migration to urban areas, with people looking for improved housing and basic services such as water and electricity supply and sanitation facilities.

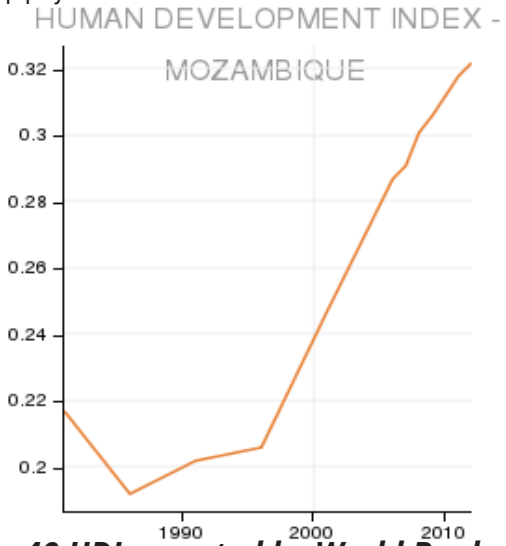


Fig.40 HDI reported by World Bank, 2010

EDUCATION

> *"In 1975, on independence of Mozambique, the country had a world highest illiteracy rate of about 93% and had no experience in adult education"* (UN Habitat 2012)

Literacy rate was at 48% in 2013. On average, each year around 500 new schools have been constructed and 3,500 new teachers recruited. In 2004, school fees were suspended and have now been abolished for primary education.

> *"This rapid increase in enrolment has not been matched by increases in investment in the quality of education provided or by adaptive strategies for such massive increases in student numbers"*
>
> (UN Habitat 2012)

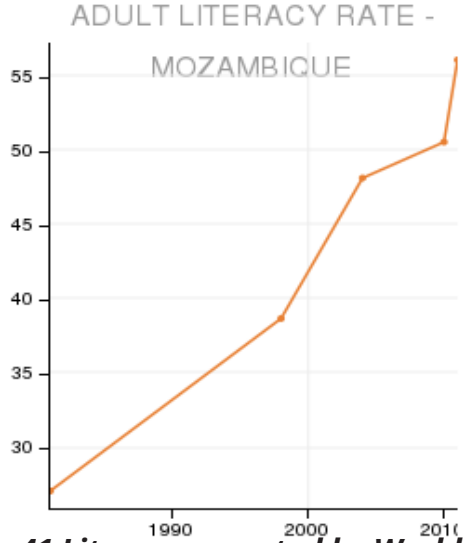


Fig.41 Literacy reported by World Bank, 2010

SOCIAL CLASSES

There has been a reduction in absolute poverty at the national level: from 69% in 1997 to 54% in 2003.

Although the country presents a large disparity between the different income brackets, there is a general trend towards improved life conditions.

LACK OF HOUSING

Mozambique currently faces difficulties in finding adequate solutions to human settlements and addressing housing needs in urban areas.

The UN-HABITAT reports that only 56% of the population has access to durable housing.

> *"(...) people living in the cement city are often tenants.(...) In contrast, the majority of the people in the periphery are the owners of their small houses or barracks."*
>
> (UN Habitat 2012)

ENVIRONMENT ANALYSIS

WATER

The consortium responsible for rehabilitation and extension of water networks in urban settings (Aguas de Moçambique) reports urban access to water in Mozambique at 78% and rural areas at 24%. In Maputo, piped water and sewer systems are only accessible to 25 percent of the city's population.

Water supply is closely connected to housing development. After independence, the number of home connections in the suburban areas increased, causing supply capacity problems.

New private water supply systems have appeared, including wells, elevated water tanks and simple home connections.

ENERGY SOURCES

Most of the electricity produced in the country by the Cabora Bassa hydro-electric dam and is exported to South Africa and Zimbabwe. Electricity supply is generally unreliable. Eighty per cent of energy consumed in Mozambique is still from woody biomass.

Fig.42 Typical charcoal stoves

SANITATION

Safe sanitation in Mozambique is done by septic tanks or drainage systems in urban settings. In Maputo, four-fifths of households are not connected to a central sewerage system. As a result, only 10% of Maputo sewerage is treated, while the bulk (90%) end up in the sea as raw sewerage. Most public places in slums and suburban areas don't have adequate sanitation facilities, sometimes not even a latrine.

In most of the suburban areas, solid waste is collected through community based teams from the household to the secondary disposal point. Due to the mushrooming of constructions, particularly in slum areas where planning is not obeyed, refuse vehicles and ambulances find it impossible to meander the narrow streets.

The majority use pit latrines or other options. Recent studies show that the use of pit latrines has led to the contamination of ground water, with severe health consequences.

Fig.43 Public water pump from borehole

ENVIRONMENT

Maputo experiences great land pressure, exceeding by far its carrying capacity and leading to land degradation on a scale never recorded before, soil erosion, and increased vulnerability to disasters.

Given the technical and financial weaknesses within most of Mozambique's recently created municipalities, environmental problems are, as a rule, beyond the current institutional capacity. Most municipalities have proven unable to solve or even mitigate causes and effects of urban environmental issues – Maputo in particular.

Problems range from localized issues, such as domestic pollution caused by the use of wood fuel, atmospheric pollution caused by increased numbers of urban vehicles (many of them in a deplorable mechanical condition), and industrial pollution caused by the continual use of obsolete technologies – to questions linked to defective sanitation and drainage of the river basins.

Fig.44 Clogged run-off drainage

SUMMARY & COMMENTS

KEY PRINCIPLES
Tropical Climate: hot & dry Winter; hot & humid Summer.
Hottest month between 22° and 30°C.
Coldest month between 14° and 25°C.

Portuguese colony until 1975. Maputo architecture is a mixture of modern architecture in the city centre and vernacular architecture in the suburbs.

Poor infrastructure and services, including water, sanitation and energy.

Lack of housing.

Environmental damage as a result of poor planning and excessive land pressure.

TARGET MARKET FOR PROPOSAL
The average conditions and income of the population is increasing, resulting in a growing middle class. This is the segment that is expected to drive the biggest change in the coming years and presents the greatest potential for impacting future development in terms of sustainability.

The urban population growth since 1975 has been high due to a rural exodus of people looking for better work opportunities.

These were some of the primary factors in choosing Maputo's expanding urban context as the location for this Master Thesis project proposal, focusing on the new middle class segment of the population who is driving this expansion.

The majority of growth may occur in the expanding urban context, so this presents the area of greatest potential for impacting future developments in terms of sustainable development.

VERNACULAR VS. COLONIAL
Due to the history of the country, vernacular architecture is socially associated with inferior quality and standards when compared to western introduced materials and designs.

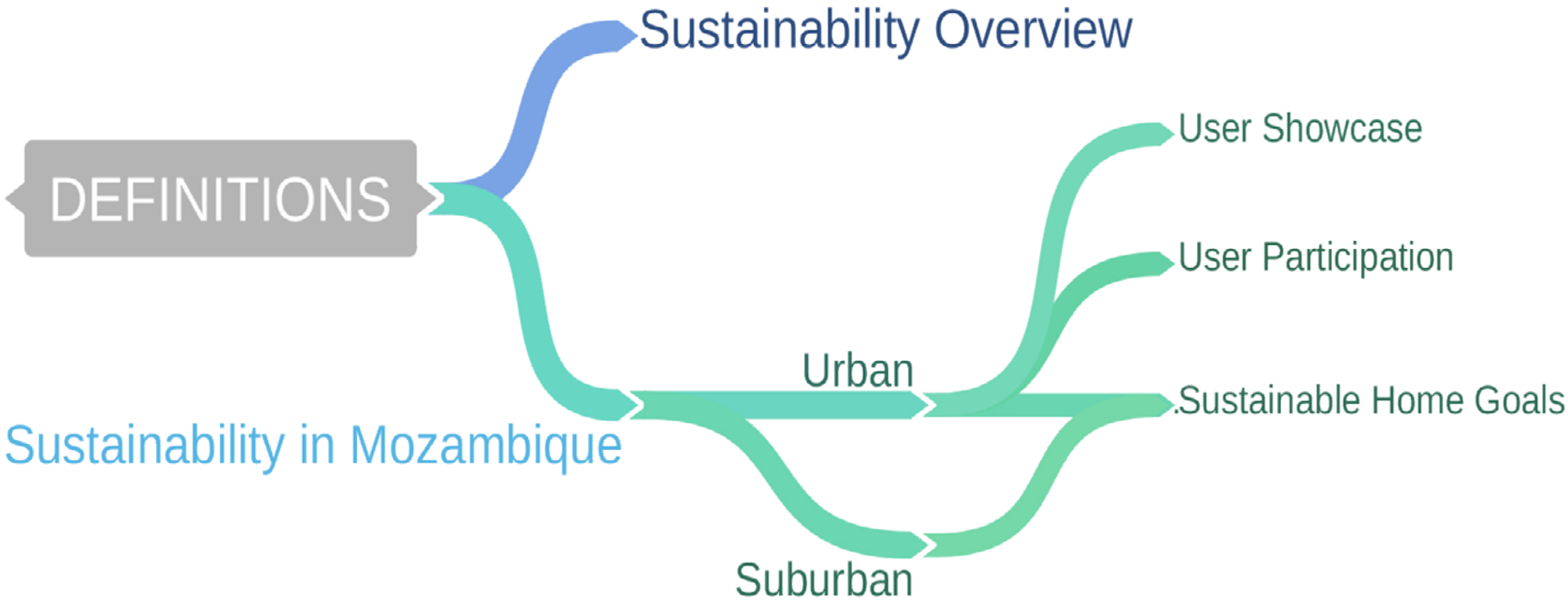
Although the majority of the population may live in homes constructed of natural building materials, with a growing income and means, the tendency is to rebuild their homes with cement and concrete buildings.

DESIGN FOR CLIMATE
Thermally comfortable buildings should give priority to natural ventilation strategies and well shaded openings to reduce solar gains.

West and east facade openings should be avoided.

MUNICIPAL SERVICES
Infrastructure upgrade is not keeping up with this expanding urban context. This means that municipal services such as water, electricity and sewerage are not always guaranteed.

This is why the Thesis proposal deals with these elements, by showing how they can be handled at a single building scale.



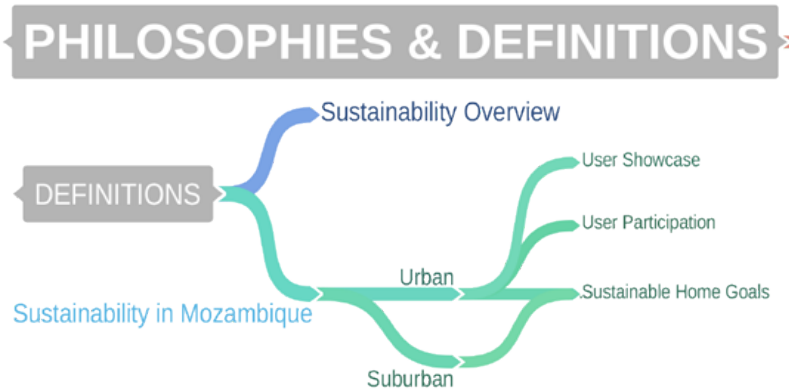
III. PHILOSOPHIES & DEFINITIONS

THE MOZAMBICAN APPROACH

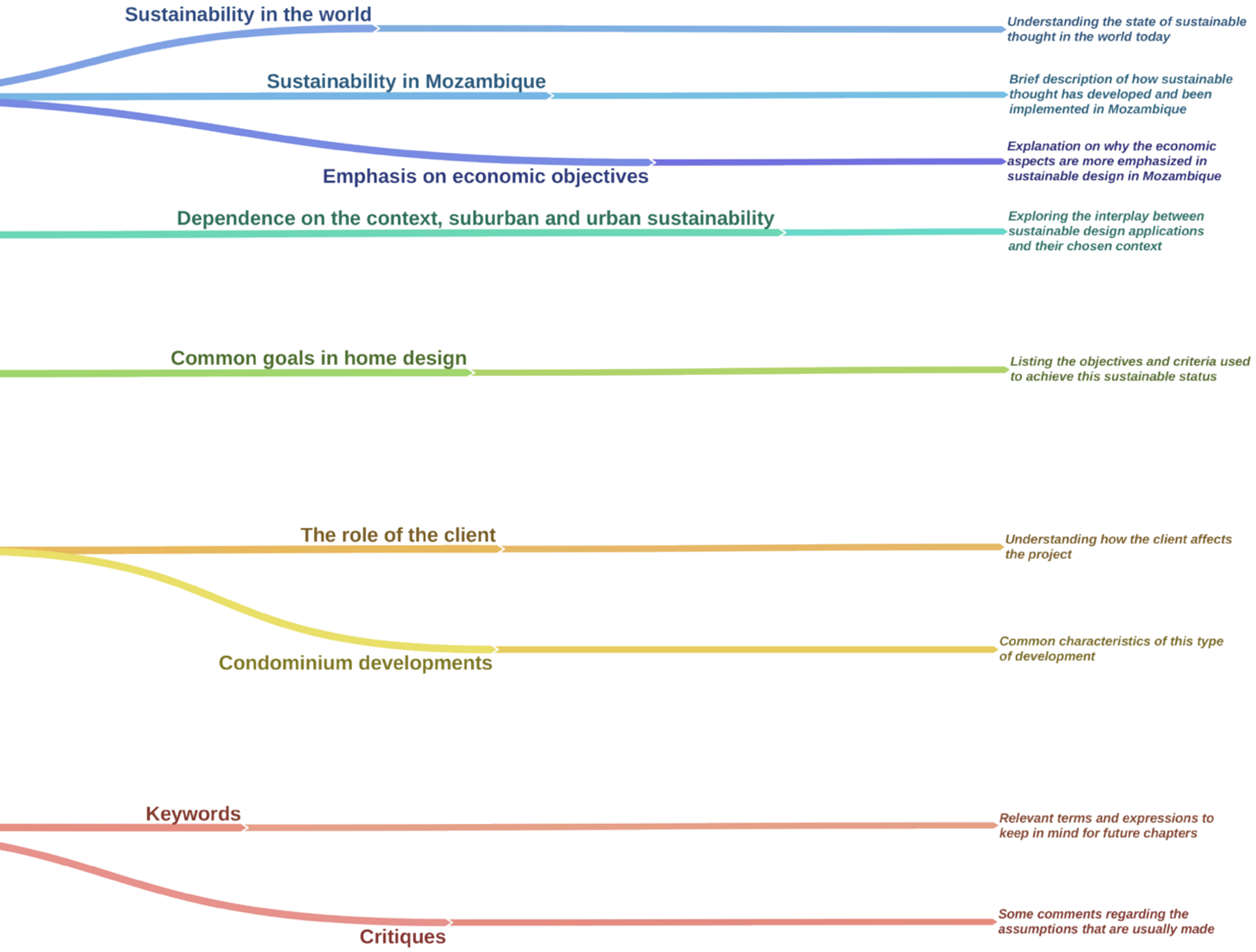
PHILOSOPHIES & DEFINITIONS the mozambican approach

The aim of this chapter is to analyse the approach to sustainable design as it is employed in Mozambican built environment, particularly in regards to residential buildings.

Both academic and practical approaches are explored, to arrive at a comprehensive understanding of what are appropriate and reasonable goals to accomplish with sustainable design in Mozambique.



1. DEFINING SUSTAINABILITY
2. DEFINING THE CONTEXT
3. DEFINING SUSTAINABLE HOME
4. CLIENT PARTICIPATION AND IMPACT
5. SUMMARY & COMMENTS


Sustainability in the world
Understanding the state of sustainable thought in the world today
Sustainability in Mozambique
Brief description of how sustainable thought has developed and been implemented in Mozambique
Emphasis on economic objectives
Explanation on why the economic aspects are more emphasized in sustainable design in Mozambique
Dependence on the context, suburban and urban sustainability
Exploring the interplay between sustainable design applications and their chosen context
Common goals in home design
Listing the objectives and criteria used to achieve this sustainable status
The role of the client
Understanding how the client affects the project
Condominium developments
Common characteristics of this type of development
Keywords
Relevant terms and expressions to keep in mind for future chapters
Critiques
Some comments regarding the assumptions that are usually made

DEFINING SUSTAINABILITY IN MOZAMBIQUE

SUSTAINABILITY IN THE WORLD

The concept of sustainability is closely linked with the discovery that to assure the survival of humanity, it is of everyone's responsibility to adopt strategies which do not threaten to destroy the environment through the overuse of natural resources and destruction of ecosystems around the world.

The activities of building and infrastructure construction and upkeep are some that most strongly impact the global environmental balance due to high energy demands in the production of materials and in the provision of reasonable comfort conditions.

However, none of the strategies employed today by the majority of countries has resulted in any real or absolute decrease in their resource consumption, and in many cases the trend has shown just the opposite to be true.

SUSTAINABILITY IN MOZAMBIQUE

Mozambique is no exception to this scenario. It is a country with big technological and technical limitations, because it does not produce a big part of their standard construction materials and equipment, it has a poor distribution of the few producing units of basic construction material and it has no formal commercialization network for these same products.

Due to socio-historic reasons brought about by their national independence, the country has practically restarted their construction industry in respect to their technical capacity which are mainly located in the big urban centres.

Outside of these big urban centres these are almost non-existent, at least to the extent of being able to respond to contracts of any modest dimensions.

EMPHASIS ON ECONOMIC OBJECTIVES

This situation results in an even higher cost for construction, shifting the primary focus in virtually all projects to minimizing construction cost whilst ensuring minimum quality in building.

> "Discussions about economic development and poverty reduction rarely include environmental issues as part of the equation."
> (UN Habitat 2012)

Sustainability thus is elevated to a principal status, but only where it has to do with the economic principles, specifically the affordability of the project for the client.

A common dilemma is to attempt to reduce the operational and maintenance costs of buildings which invariable results in higher initial construction costs. This puts a strain on the client, who often times has a very limited budget to begin with.

fig. 45 Virtually all residential projects are done by informally trained local builders Photo by Mauro Paul

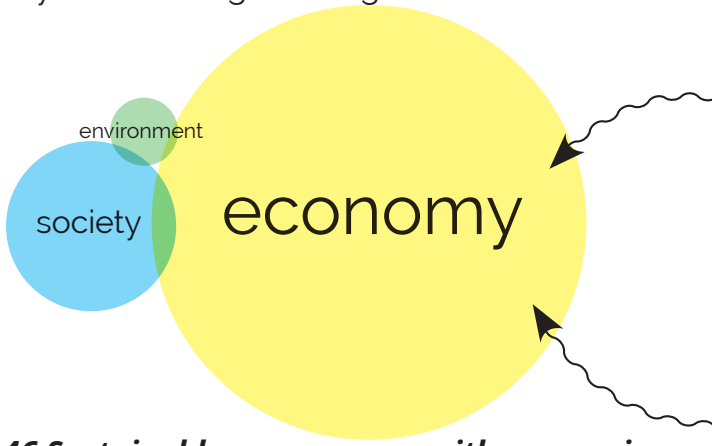


fig. 46 Sustainable synonymous with economic

DEFINING THE CONTEXT IN MOZAMBIQUE

DEPENDENCE ON THE CONTEXT

In all cases however, the main defining factor for the level of sustainable design principles and strategies that can be successfully implemented is linked to the context of the project, whether it is in the urban or suburban.

URBAN SUSTAINABILITY

In Mozambican urban areas there are guidelines that focus on the good use of space, well ventilated rooms to ensure thermal comfort, proper positioning of all wet-areas (such as bathrooms and kitchens), a separation between social and private areas for social comfort.

Although there is a formal requirement for state buildings to have water recovery cisterns, this requires big investments for a small perceived return, since such water is only available during a small period of the year; The amount that is captured can be used for flushing toilets, but in order to do this it would require a reorganization of the plumbing system.

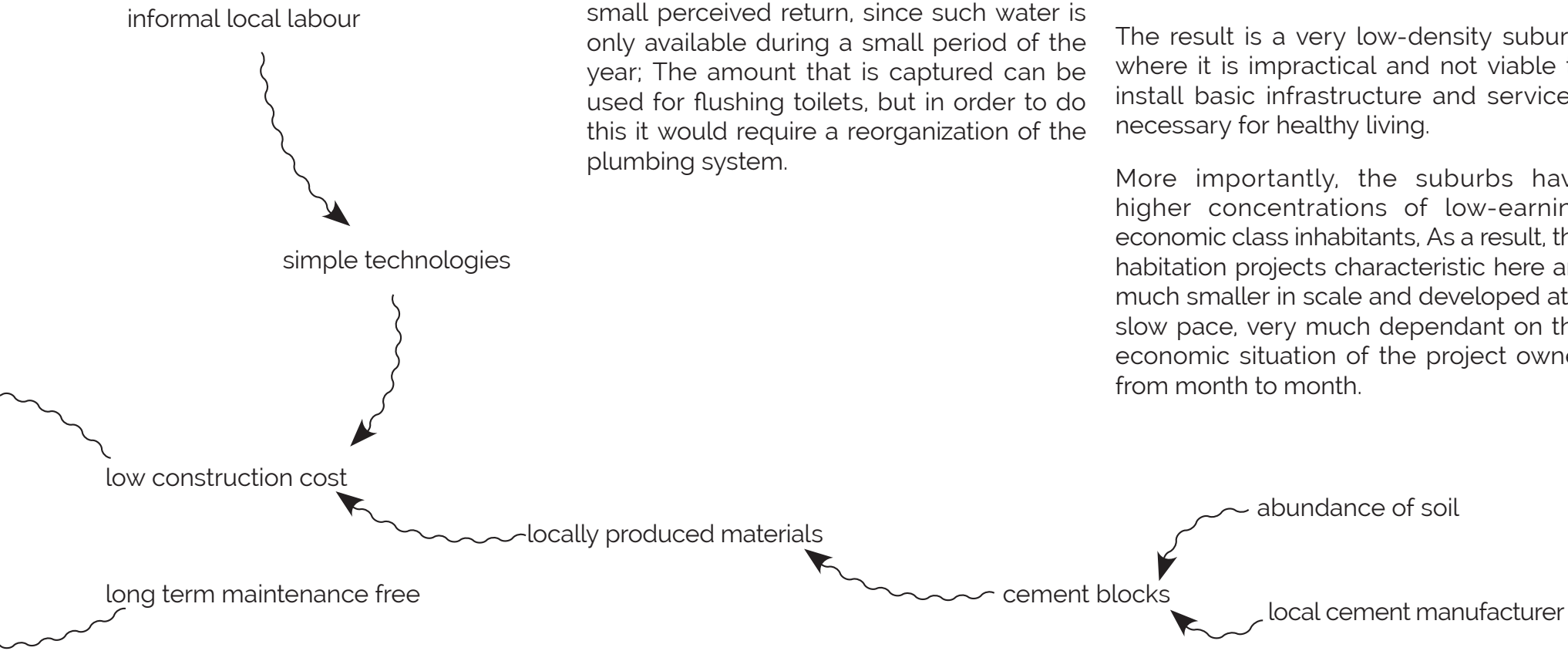
SUBURBAN SUSTAINABILITY

The principal focus of suburban sustainability becomes the proper use of local materials and workforce, the use of recyclable materials, an improved latrine and sometimes rainwater collection,

The majority of family habitation projects are still built by the families themselves. This means that they utilize simple technologies, which do not permit their grouping in multi family buildings.

The result is a very low-density suburb, where it is impractical and not viable to install basic infrastructure and services, necessary for healthy living.

More importantly, the suburbs have higher concentrations of low-earning economic class inhabitants, As a result, the habitation projects characteristic here are much smaller in scale and developed at a slow pace, very much dependant on the economic situation of the project owner from month to month.



DEFINING SUSTAINABLE HOME IN MOZAMBIQUE

COMMON GOALS IN HOME DESIGN

"(...) to attain social sustainability a construction must also improve life conditions, provide safety and comfort, reflect local cultural aspects, protect and promote health for its occupants and facilitate intergenerational equity."
Jessica Lage

There are some common elements which are considered the base of good design, both in the urban and suburban contexts.

The project must allow for evolution and predict future extensions because as a result of personal economy, often times the house is built room by room, with the users already living in the house.

The houses tend to grow to accommodate future generations because living close to your family is an important concept. The families are generally big and the rooms can always be rented out.

"Sustainability means a process that is maintained over time." Miguel Cesar

The house must satisfy thermal and social objectives that deal with the comfort of the user, such as proper cross ventilation, good room orientation and solar building orientation with proper disposition of windows that provide adequate illumination and security.

The principal areas become the proper use of local materials and workforce, the use of recyclable materials, an improved latrine and rainwater collection

An improvement in the distribution of space. It is essential to make the best use of the available space because it is a limited commodity.

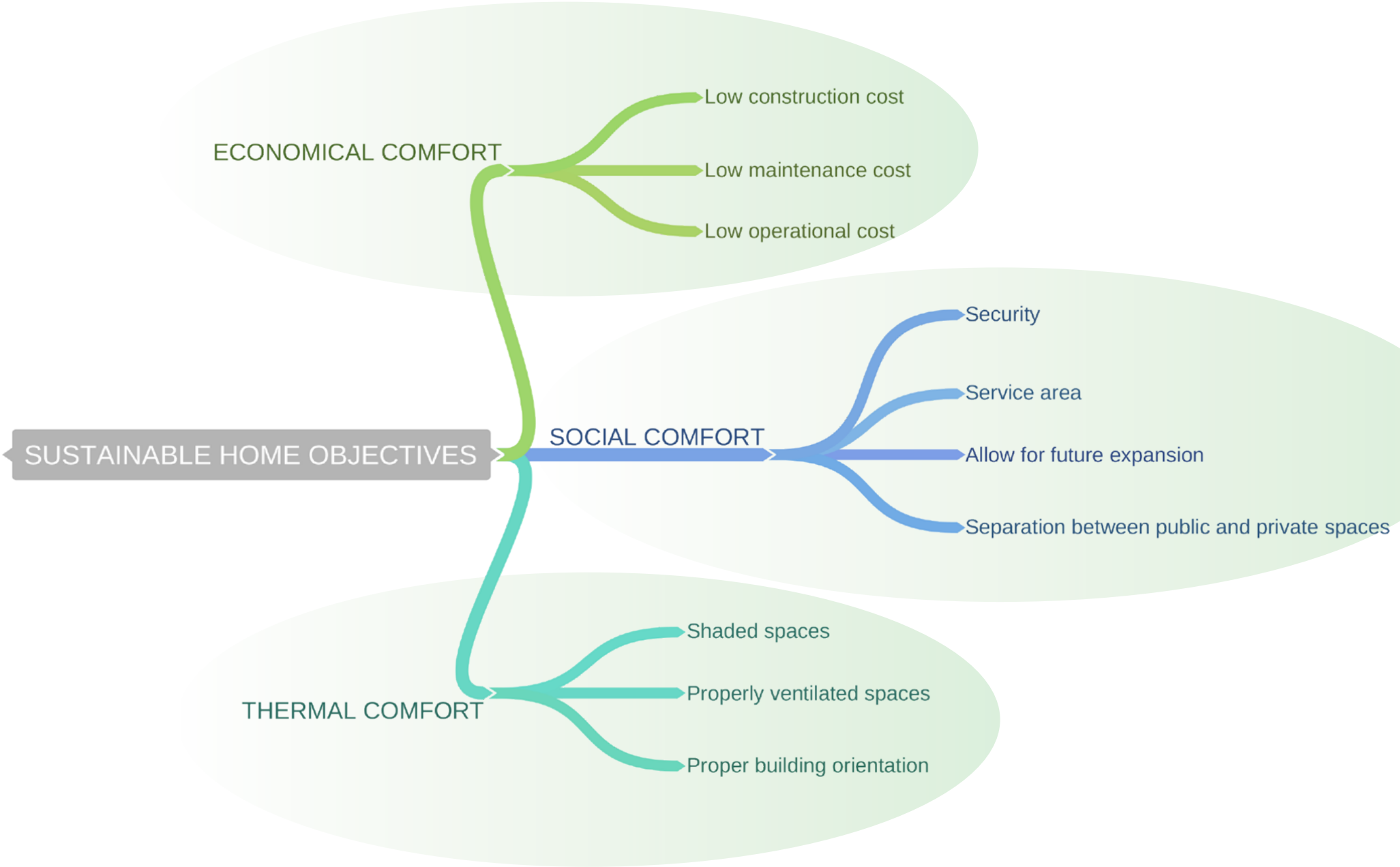
"Alternative housing presents precarious conditions and does not comply with construction regulations and municipalities seldom enforce building by-laws against such inadequate buildings." Luis Lage

The majority of new constructions in the urban context, which is growing the fastest, is done with cement blocks and concrete structures.

In a global perspective this is not sustainable due to the high embodied energy associated with the production of these materials. But in a local perspective it is considered the ideal material because of the long lifetime of these materials and the low costs associated with maintenance and operation.

Natural materials carry a certain association with them, which makes the majority of the population to see them as less durable and a sign of lower social standing.

DEFINING SUSTAINABLE HOME IN MOZAMBIQUE



CLIENT PARTICIPATION AND IMPACT ON CONSTRUCTION PROJECTS

THE ROLE OF THE CLIENT

Since 1991 the government has alienated all houses that had been nationalized and liberalized property ownership, thereby creating the opportunity for Mozambicans to buy previously nationalized houses.

The majority of residential projects being realized are client-initiated activities - this means that the individual prospective home owner obtains the lease for a piece of land and funds the project themselves.

The prospective client most often seeks the expertise of a local or known master builder who has participated in other home projects and sets about designing the home, often times simultaneously to the building process.

This style of construction often times results in 'open house' designs mixed with a 'evolutive home' approach, where several rooms and areas are developed at a time, with some thought for how the project may develop over the next years.

CONDOMINIUM DEVELOPMENTS

There is however a growing trend for developers and contractors to acquire municipal permission to develop a condominium with several homes.

After developing a design proposal with the different typologies in a catalogue format, it is down to the client to choose among the available plots and the desired typologies for the homes.

These can be single-family detached homes, semi-attached homes or less frequently multi-storey apartment buildings.

An important aspect of condominium developments is that the developer is tasked with providing for the required infrastructure on site such as access roads, adequate water, electricity and sewerage management services.

SUMMARY & COMMENTS

KEY PRINCIPLES
Technological and technical limitations.

Does not produce many of the materials used in construction industry.

Greatest weight given to economic considerations of building a home.

Important to keep the operational and maintenance costs to a minimum.

Urban and suburban present distinctly different challenges and characteristics.

CRITIQUE ON ECONOMIC SUSTAINABILITY
The typical residential development tends to focus on thermal and social comfort.

This is an inward approach where the designer is preoccupied with the impact of the building in relation to their client comfort.

There are guidelines that deal with other essential systems such as water and sewerage management on-site but due to the general lack of training by local builders these are not often properly implemented.

This is coupled with the fact that residential projects are often developed over large periods, one room at a time, with the client living on-site.

NATURAL VS. CONVENTIONAL MATERIALS
The lack of focus on environmental factors means that cement and concrete buildings are seen as ideal because they require less maintenance. The population with buildings made of natural materials see their buildings as temporary and precarious and inferior quality. There is a dissociation between the precariousness of these buildings and poor construction technology.

There has developed a type of social stigma towards buildings made of natural materials and the only new constructions made in this style tend to be those focused towards tourist applications such as restaurants and hotels.

CRITIQUE ON DURABLE ARCHITECTURE
Although the current thought focuses heavily on maintenance-free buildings, this design strategy does not consider the impact of a national building stock that is long lasting but does not consider its own future impact.

As such, this 'durable architecture' approach may result in buildings that are poorly adapted to future needs, that present a lack of flexibility in their usage and that are resistant to being adapted and updated.

MAINTENANCE OF BUILDINGS
Indigenous and natural materials require more maintenance and to be replaced over time.

This is a labour intensive activity that can provide job opportunities as well as contribute to the economy.

These are generally environmentally friendly when compared to conventional materials, with smaller footprints.

ARCHITECTURE EDUCATION
The emphasis is in forming architects that are capable of developing a project from the technical stand point in construction detail. There is less emphasis on innovation and more on repeating tried and tested methods. This leaves a lot of room for improvement, specifically when it comes to the sustainability ideas.

Fig. 47 Semi-dettached home under construction at Casa Jovem, Maputo, 2015

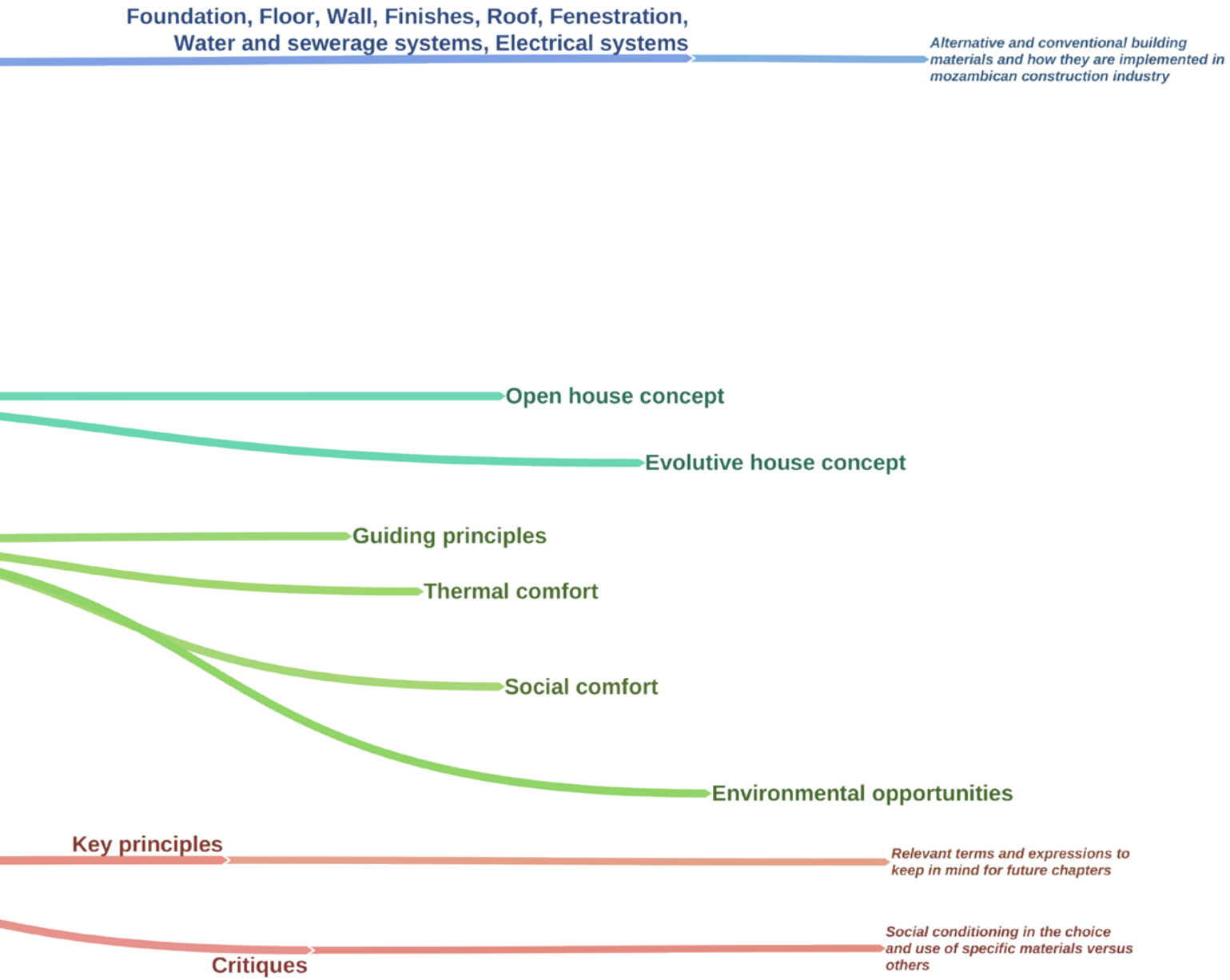
IV. HOME OF TODAY

HOME OF TODAY

Deals with practical aspects of home design, such as guidelines to have in mind, available and appropriate construction materials that may be employed and common construction techniques and technologies that are important to be aware of.

This analysis leads to conclusions regarding what devices may be used for designing residential buildings from a contemporary understanding of building processes.

HOME OF TODAY



MATERIALS AND TECHNOLOGIES

OVERVIEW

> *"Although there are local alternatives and local people have easy access to these options, little has been done to improve the use of local building materials." Luis Lage*

The materials and builders are always local. This is a matter of availability and cost of transport. To reduce construction costs there is also a lot of material upcycling.

A lot of building work is done with manual labour because it is cheap. Attaining a high level of quality and durability in finishes is difficult in Mozambique as a result of the lack of skilled labour.

All elements are standardised: doors, windows, room sizes. Sometimes these are only acquired after a time, so it is important that they are of standard sizes and shapes.

ALTERNATIVE BUILDING MATERIALS

The majority of Mozambican houses are considered to be precarious constructions: some 94% in rural areas and about 62% in urban or suburban areas. The insecurity of precarious houses imposes the need for cyclic maintenance due to their poor durability and high vulnerability to natural stresses.

Most houses in the suburban landscapes and rural areas are made of alternative materials such as adobe, bamboo, sticks, wood, grass or palm leaves. Adobe, bamboo, wood and sticks are principally used as wall materials, while grass and palm leaves are used as roofing materials

EARTH

Earth is a resource that is used by the majority of the population across the country and is normally used to produce bricks, to plaster adobe brick walls and even in stake or bamboo-framed walls. Areas along the coast are prone to floods during the rainy season making the use of unfired adobe brick inappropriate.

fig. 48 Red sand delivery

BAMBOO

Bamboo is an abundant building material, widely used for purposes such as making framed walls, roof frames,

fig. 50 Woven bamboo screen

STONE

Stone occurs in abundance in the mountainous areas but it is used infrequently as an alternative construction material. It is difficult to extract and shape and its processing requires much energy (either human or mechanical).

Small stones are used in the mixing of concrete and obtaining the correct sand to stone ratio is essential to acquiring the appropriate strength.

fig. 49 Construction gravel

PALM LEAVES

For roofing material, palm leaves and grass are the most common choices. Palm leaves are normally used in coastal areas where coconut palms grow abundantly. Inland, grass is the favoured material for making roofs.

fig. 51 Palm leaf roof

MATERIALS AND TECHNOLOGIES

CONVENTIONAL BUILDING MATERIALS

Most houses in the central part of urban areas are constructed with conventional materials like cement, steel, glass, galvanized metallic sheet and fibre cement.

These materials are regarded as being the most recommended for the construction of safe and durable houses.

CEMENT BLOCKS

The cement block is seen as the ideal construction material throughout the country for its high durability when compared to natural alternatives such as adobe bricks and bamboo walls.

It is commonly used as a self supporting element in one storey buildings or in conjunction with reinforced concrete structures in multi-storey buildings.

fig. 52 Cement blocks

REINFORCED CONCRETE

Reinforced concrete is the standard material choice for buildings that have multiple storeys.

It is common to see it employed in single storey buildings as well as a framing element with ground floor ringbeams, corner pillars and window and door lintels.

Although precast elements are available, the cheapest alternative is often to cast it in-situ.

fig. 53 Reinforced concrete mixture

METAL SHEETS

Corrugated sheets are a common sight in Maputo, because they are light and allow for shallower slopes than the traditional ceramic roof tiles which are heavier and require a stronger bearing structure.

fig. 54 Metal sheet roofing

STEEL, ALUMINIUM & GLASS

There has been an increase in the usage of steel and aluminium windows in recent years. These are considered cheaper alternatives to traditional timber frames, though they do not incorporate net screens efficiently which is an important consideration because of the protection from the mosquito.

Commercial buildings such as offices and banks often adopt large unshaded glass façades,

fig. 55 Glass facade office, Maputo

MATERIALS AND TECHNOLOGIES

CONVENTIONAL CONSTRUCTION

Brief example of the elements in the typical residential project construction process in the urban context, following the conventional choice of materials and technologies.

FOUNDATIONS

Concrete blocks

Reinforced concrete

Concrete piles

fig. 56 Pouring concrete foundation

fig. 57 Concrete block foundation

GROUND FLOORS

Stabilized soil

Concrete

fig. 58 Concrete ground floor slab

fig. 59 Compacted soil

WALLS

Cement blocks

Ceramic brick

Reinforced concrete, Glass

fig. 60 Cement block and ceramic brick walls

ROOF

Metal sheet

Ceramic tile

Reinforced concrete

fig. 61 Concrete beam and block roof

MATERIALS AND TECHNOLOGIES

ALTERNATIVE CONSTRUCTION

Brief example of the elements in the typical residential project construction process in the suburban context, following the alternative choice of materials and technologies.

FOUNDATIONS

Stabilized stone

Earth blocks

Wooden stakes

fig. 62 Compressed earth brick

GROUND FLOORS

Stone

Stabilized soil

fig. 63 Stabilized soil floor

WALLS

Bamboo

Cement blocks

Stabilized soil blocks or mud

fig. 64 Bamboo wall home

ROOF

Metal sheet

Palm leaves

Thatch

fig. 65 Thatch roof

TYPOLOGIES 'open house' concept

CONCEPT

> *"An Open House is a succession of open and closed spaces, that is a yard where the family expands its daily life activities" (Andersen, 2010)*

The open house design typology can be described as a grouping of stand-alone buildings or rooms that serve specific purposes such as bedrooms, food preparation or latrine, with the greatest emphasis given to the yard of the plot.

The majority of the time is spent in the yard and the family only goes inside during bad weather or sleep.

All the social activity happens outdoors, often times in the shade of a building or trees.

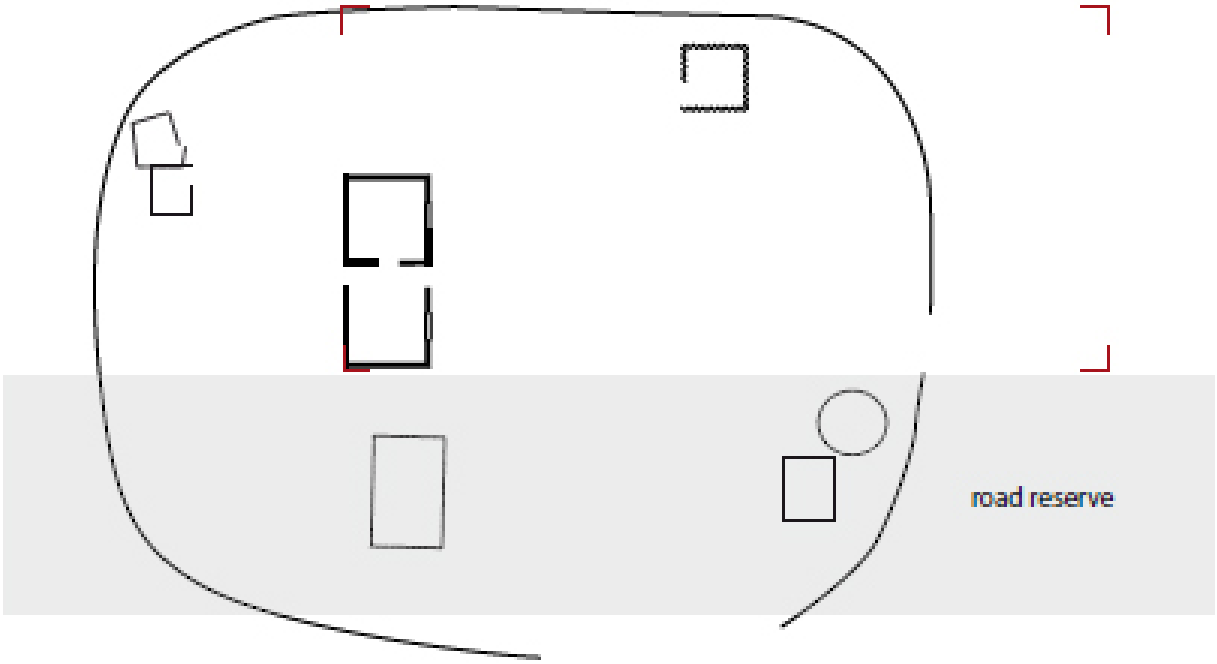


fig. 66 Case study from HomeSpace-House Change (2010)
This figure showcases an example of the Open House design typology. Several individual one-room buildings that serve singular purposes in the same plot, with the greatest importance given to the yard where most of the activities take place.

TYPOLOGIES 'open house' concept

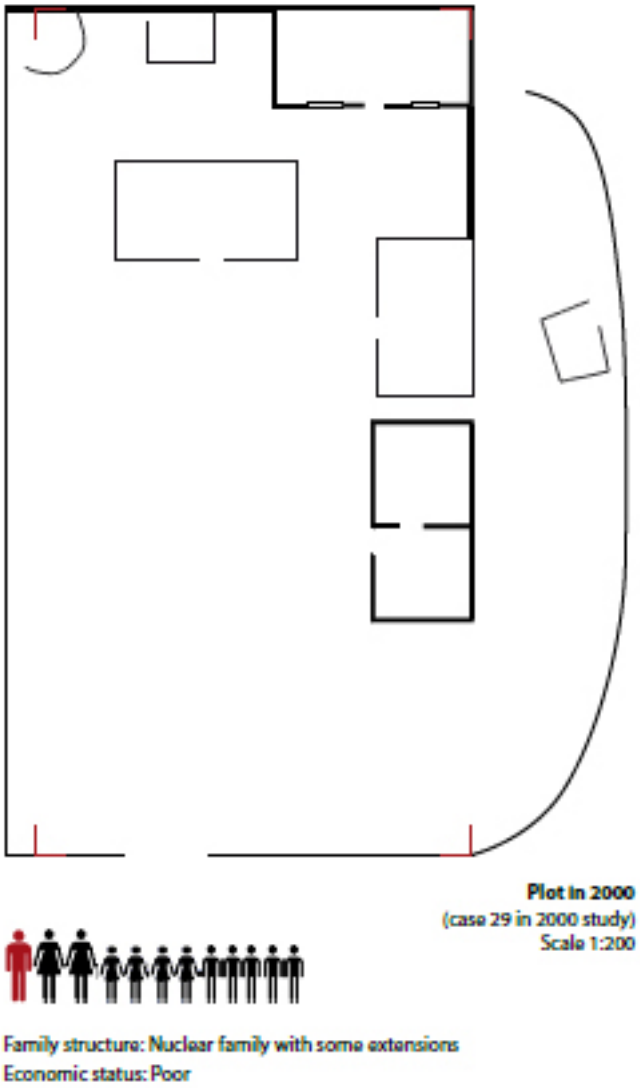


fig. 67 Case study from HomeSpace-House Change (2010)

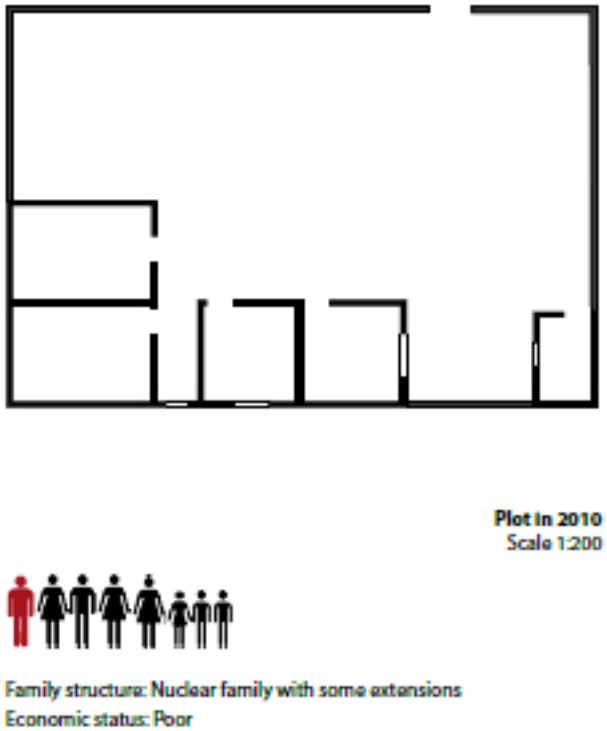


fig. 68 Case study from HomeSpace-House Change (2010)

TYPOLOGIES 'evolutive house' concept

CONCEPT

This typology has many possible interpretations. The core idea is to start by building the minimum amount of rooms that will allow the home owner and family to live on site.

This usually translates to a living room and bedroom, with an exterior latrine and exterior food preparation area.

Once these spaces are complete, slower expansion occurs, usually one room at a time.

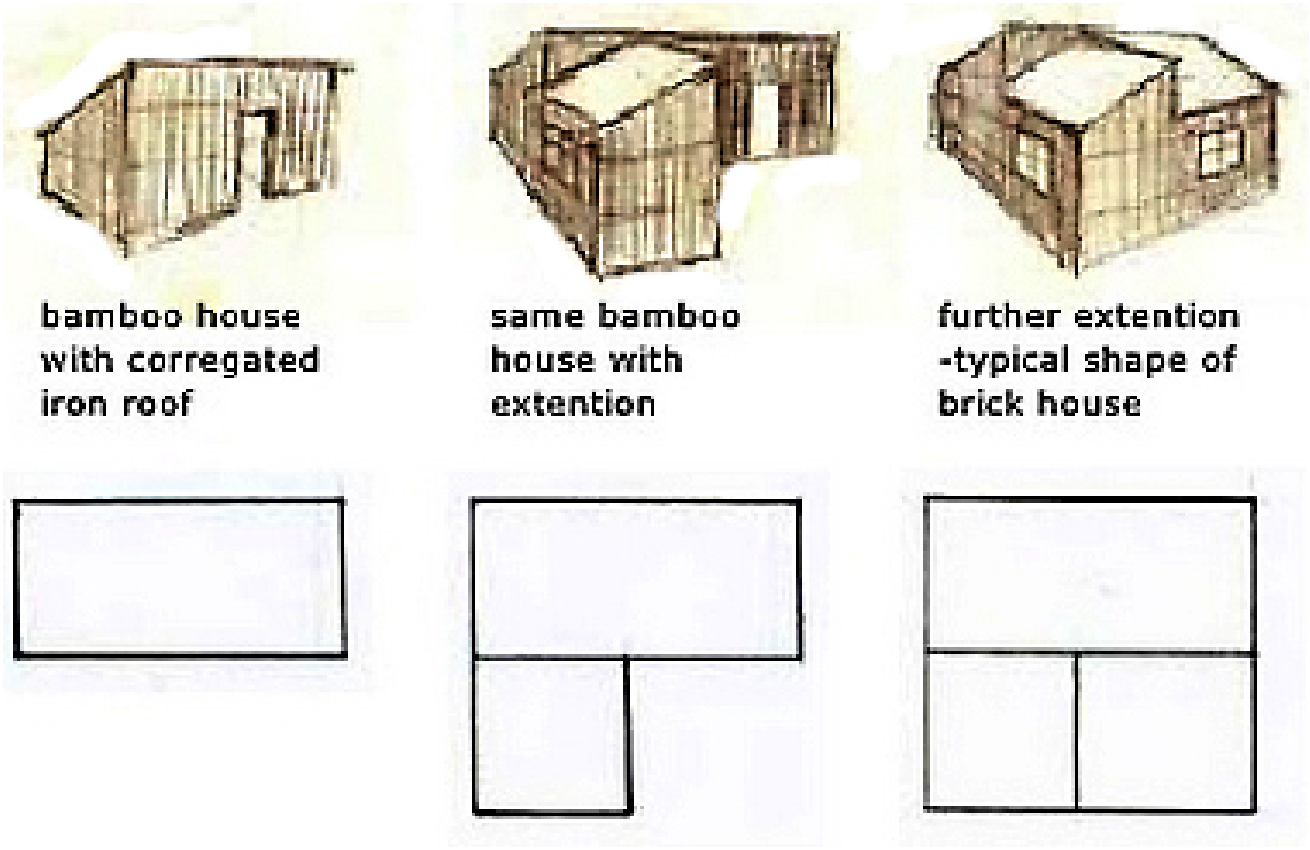


fig. 69 Case study from Five Weeks in Africa - Bergen School of Architecture (2009)
This figure showcases a typical evolutive house done with bamboo.
The home begins as a singular room and as materials become available or the family grows, additional rooms are added.
This solution simplifies the matter of roof waterproofing, because each additional roof does not require the disassembly of the old structure.

TYPOLOGIES 'evolutive house' concept

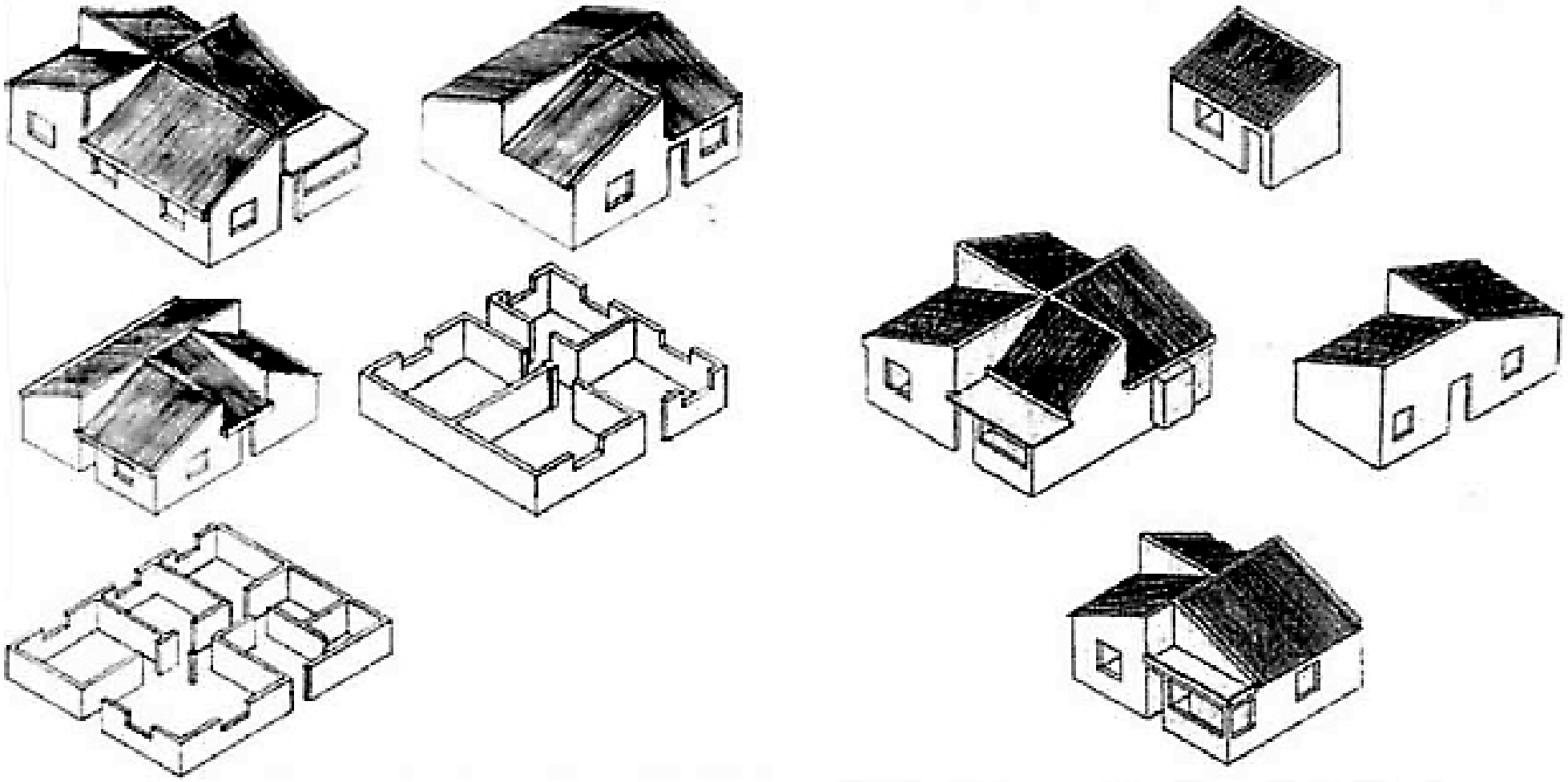


fig. 70 Evolutive home, as presented by Luís Lage (2005). Similar principle to the previous figure, but accomplished with cement blocks and ceramic tile roofing.

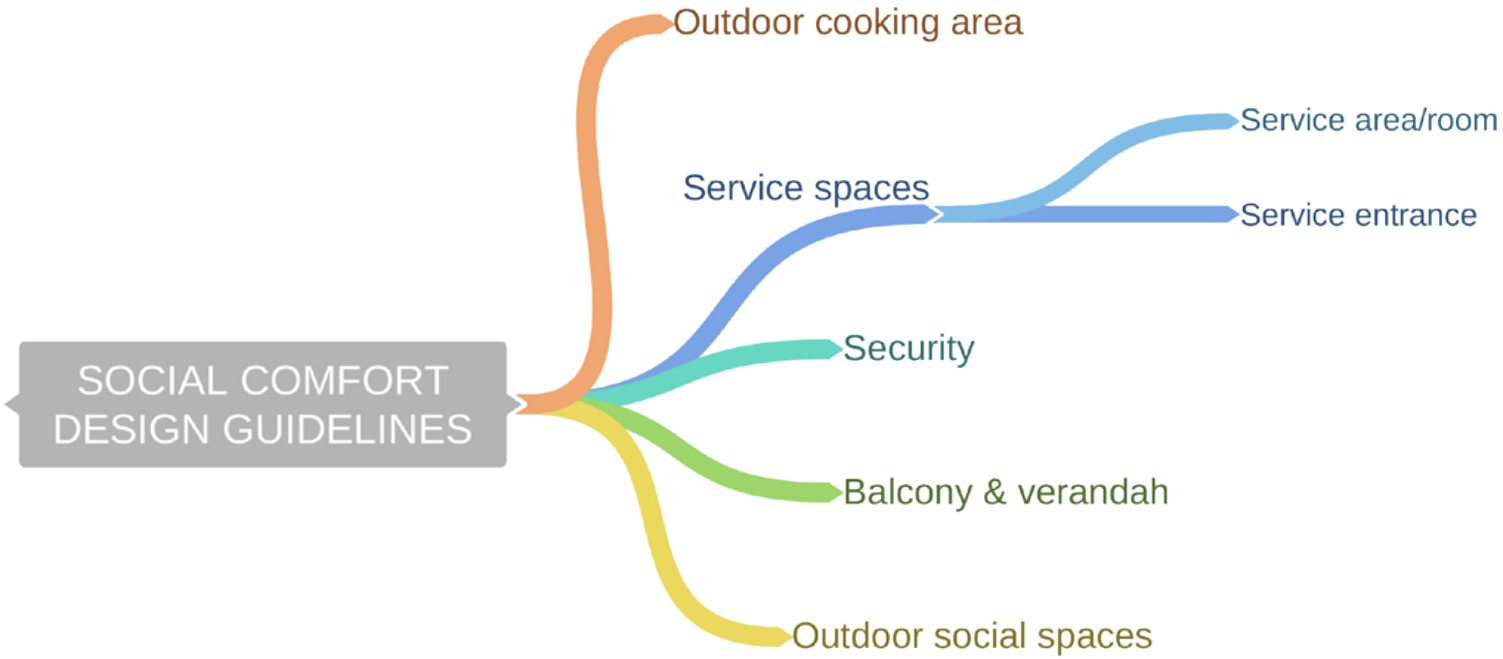
DESIGN GUIDELINES overview

CONCEPT

Most practiced guidelines for good design in the residential home of today focus on achieving thermal and social comforts.

This portion elaborates on what these guidelines are and in specific cases gives examples of how to achieve these.

See appendix for more design examples.



DESIGN GUIDELINES thermal comfort

CLIMATE CONSIDERATIONS

The climatic conditions reported mean in short that the inhabitants of this territory are in need of protection from the Sun and rain, but that because of the high moisture content, the movement of air is essential.

In order to quantify these conclusions, I input Maputo's climate data into a psychrometric chart.

This chart plots 8760 hours of the year in accordance to measured temperature and relative humidity.

Typical to the hot and humid tropical climate, high temperatures linked with high humidity causes discomfort.

Nights can often be still and sultry, specially during summer time. This brings little to no relief to the heat brought about during the day.

This may even cause the indoor temperature to be higher than outdoors at night, because of ineffective thermal shedding on low-wind days.

COMFORT ZONE

Using Givoni's Bioclimatic Charts as a reference, I made some general assumptions regarding what is comfortable in this climate,

In this case, a variation from 18 to 24 degrees Celsius, ranging from 20 to 80% relative humidity. In these conditions, it is assumed that people are in thermal comfort conditions in the indoor space.

With this range of comfort, 21% of the year (or 1823 hours) is comfortable. The strategies employed in the design must work towards bringing the points outside of the comfort zone into the comfort zone.

The majority of the rest of the year is warmer and/or more humid than the established comfort zone.(58% of the year).

Only 21% of the year presents cooler temperatures than the desired comfort conditions.

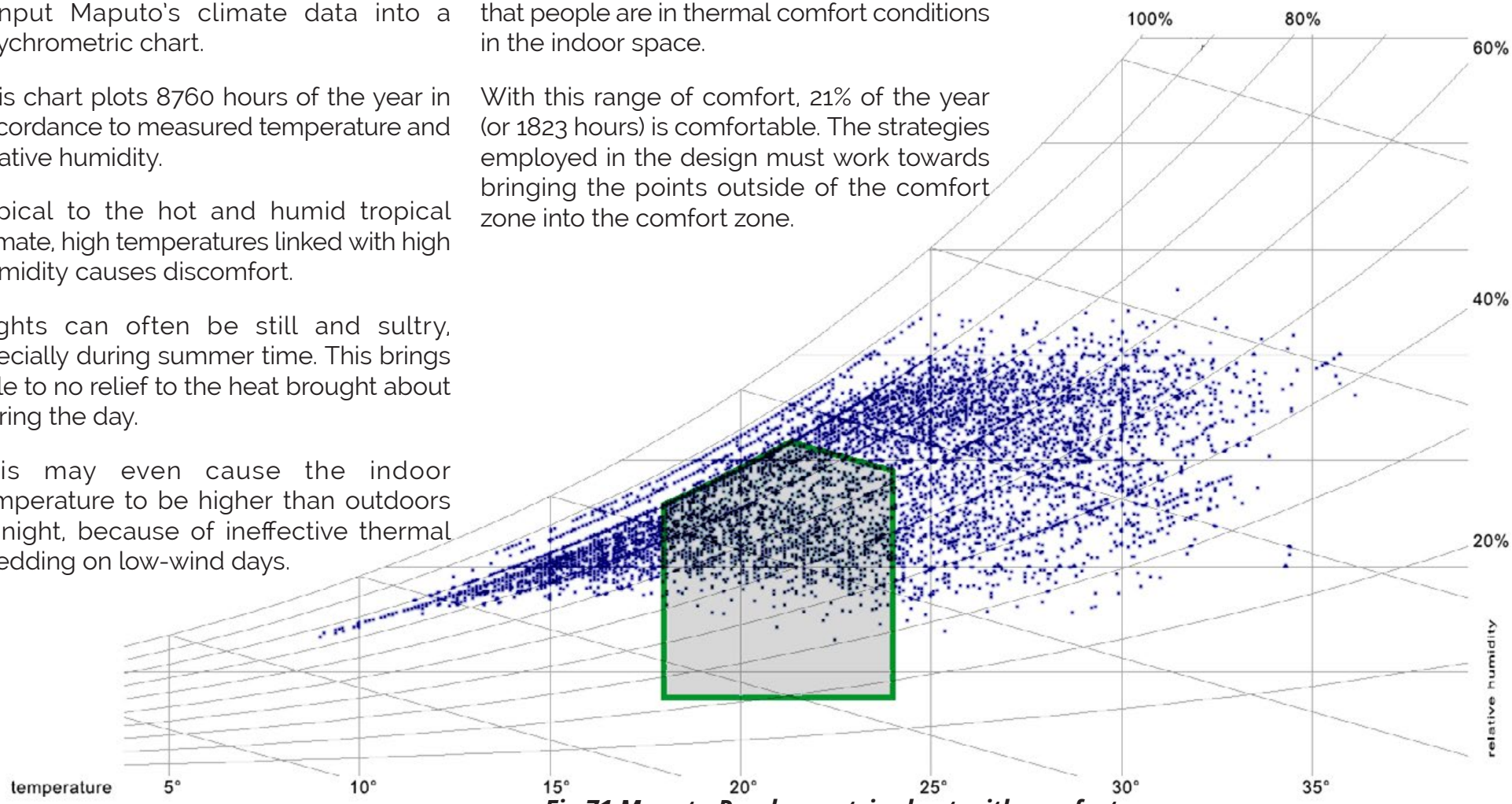


Fig.71 Maputo Psychrometric chart with comfort zone

DESIGN GUIDELINES thermal comfort

NATURAL VENTILATION ZONE

When the temperature exceeds 24 degrees or the relative humidity is quite high, it is possible to use natural ventilation to improve the thermal comfort in hot and humid climates.

Using cross ventilation is one of the simpler strategies when the indoor temperatures are very similar to the outdoor temperatures.

Working under the assumption that maximum indoor air speed is 2m/s, ventilation can maintain comfort levels indoors while the exterior air temperature rises up to 28 degrees.

With these parameters set, the conclusion is that Natural Ventilation strategies have the potential of reaching 44% of the year.

This is the strategy with the greatest potential impact over the thermal comfort in Maputo's climatic conditions..

See appendix for design examples.

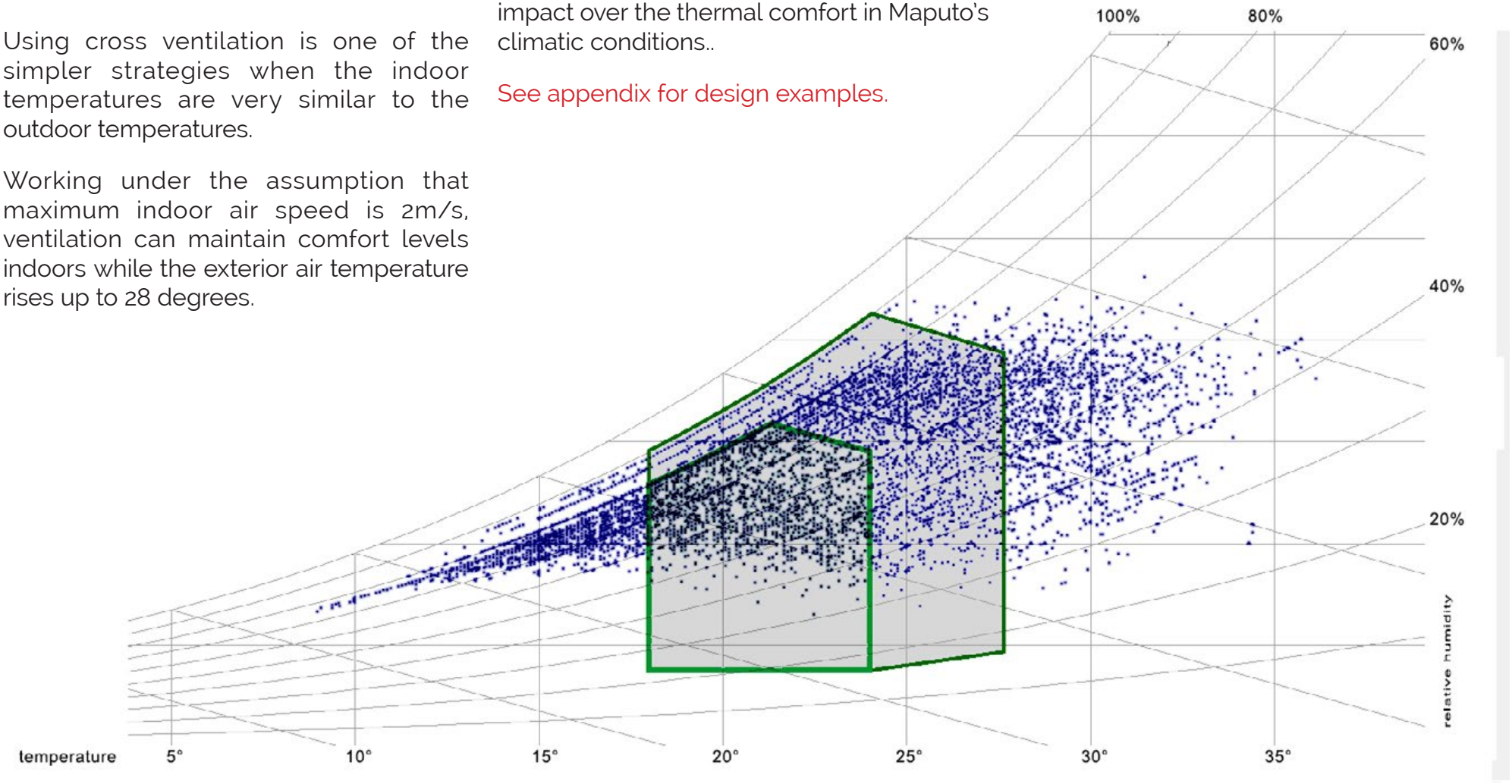


Fig.72 Maputo Psychrometric chart with comfort and natural ventilation zones

DESIGN GUIDELINES thermal comfort

HIGH THERMAL MASS AND NIGHT VENTILATION ZONE

By using high thermal mass elements in construction it is possible to reduce the variation in indoor temperature, as compared to outdoor spaces. This strategy has the potential of affecting 14% of the year (1257 hours)..

This occurs due to the stored heat in the building during the day being released to the indoor space during the night, when the outdoor temperatures decrease and the thermal structure cooling down during the night and remaining cool during a greater part of the day.

Both the thermal mass of the envelope and of the ground can be exploited to this endeavour.

This high thermal mass can be combined with night ventilation to provide passive cooling. This is most effective during periods of the year when the day to night-time temperature swing is big (winter time in Maputo).

See appendix for design examples.

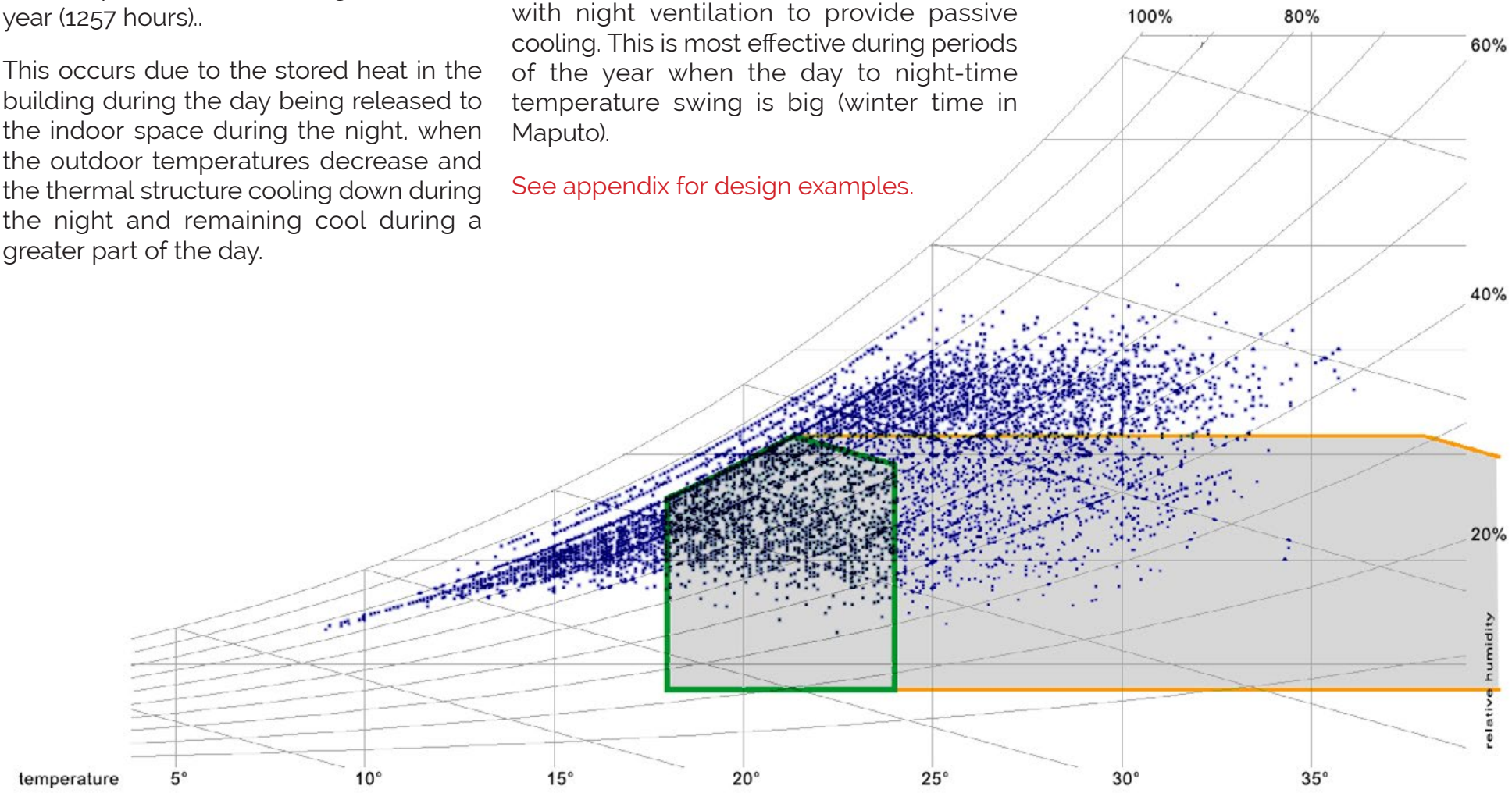


Fig.73 Maputo Psychrometric chart with comfort and high thermal mass with night ventilation zones

DESIGN GUIDELINES thermal comfort

SUN SHADING OF WINDOWS ZONE

The goal here is to control direct solar radiation to ensure thermal comfort, light and minimization of energy consumption as a result of mechanical cooling systems such as air conditioning.

The ideal sun-shading device will block solar radiation while allowing daylight and breeze to enter the window and an external view.

Strategies that shade the building can prevent increases in temperature through solar heat gain, so they should be designed to impact the building from the moment extra heat is not desired.

These strategies can deal both with shading openings into the building or shading the building surface itself.

These shading devices may be existing site features, such as neighbouring buildings or may be design interventions such as planted vegetation and fixed and movable overhangs.

See appendix for design examples.

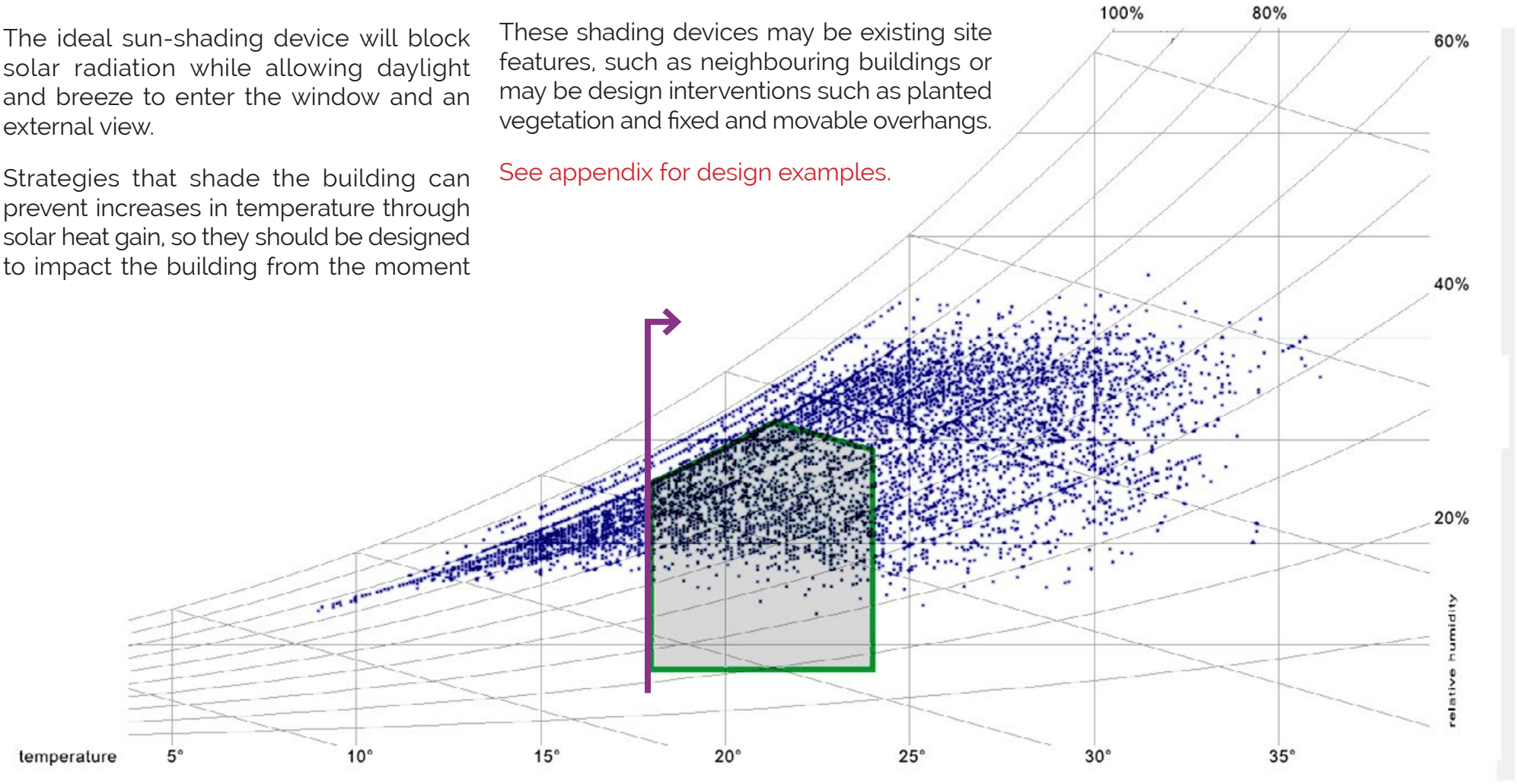


Fig.74 Maputo Psychrometric chart with comfort and sun shading of window zones

DESIGN GUIDELINES thermal comfort

INTERNAL HEAT GAIN ZONE

By using the internal heat gain it may be possible to increase indoor temperatures when it is very cold.

This zone covers 19% of the year and it occurs primarily during winter, when the day to night temperature fluctuation is big (July for example ranges between 27 and 9, as seen in the fig.x).

So it is important that the building be able to retain the heat is acquired during the day and release it during night time, to keep the temperature high and comfortable.

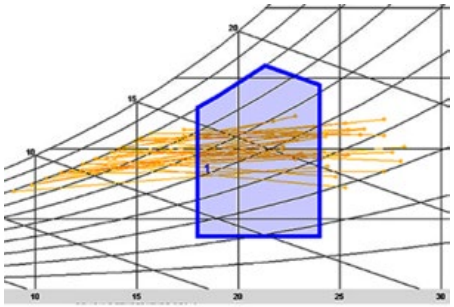


Fig.75 July day-night temperature variation

INTERNAL HEAT GAIN STRATEGIES

Heat gain from lights, people and equipment greatly reduces heating needs .

This may require the home to be kept tight, and well insulation to lower the balance point temperature.

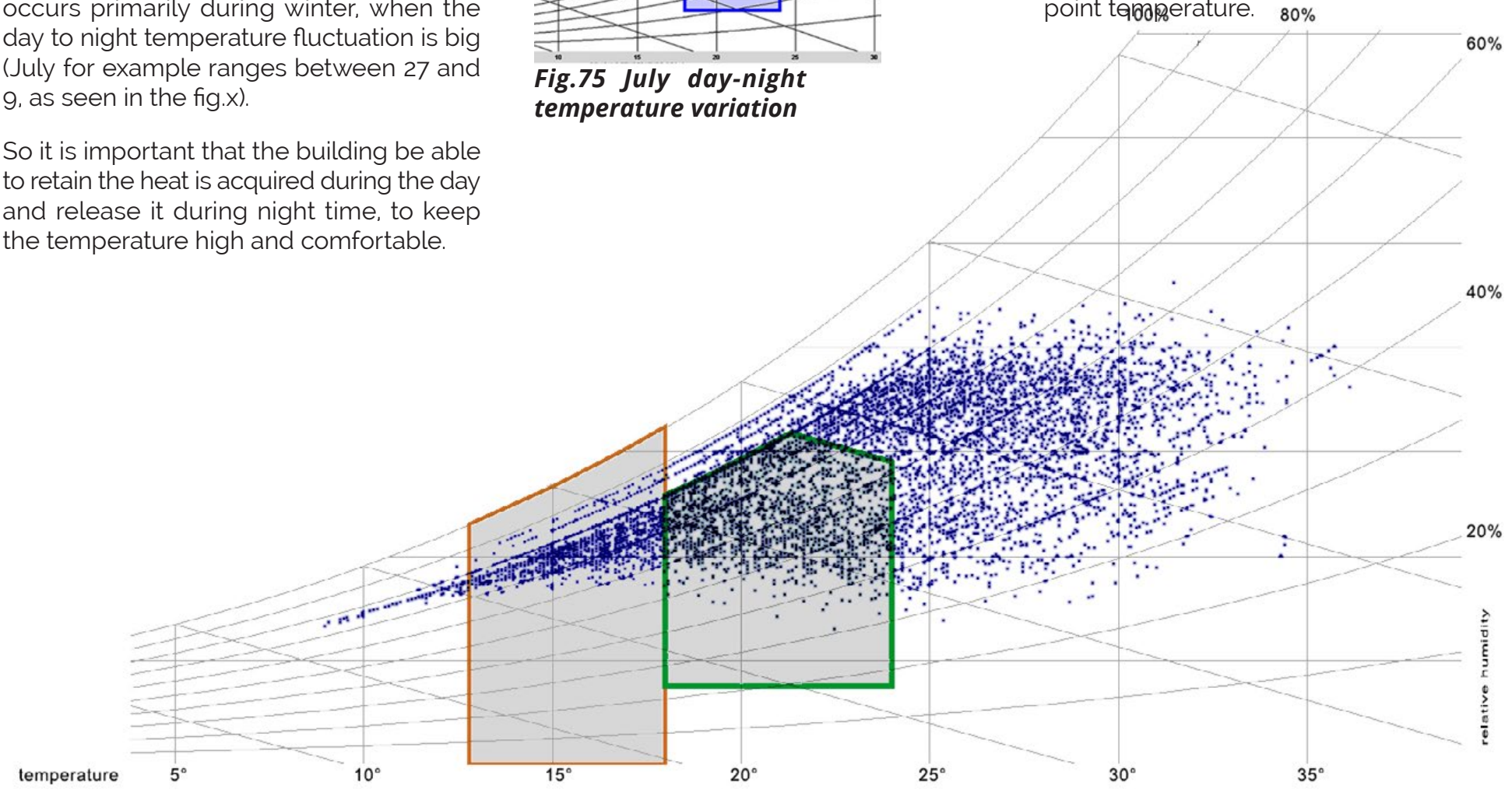


Fig.76 Maputo Psychrometric chart with comfort and internal heat gain zones

DESIGN GUIDELINES thermal comfort

ALL PASSIVE STRATEGIES

The combination of all these strategies has the potential of covering approximately 90% of the year.

The rest of the year are outliers from very cold nights and very warm days, which may require active strategies for heating and cooling.

The principle behind these passive strategies should be to prioritize the ones that have the greatest impact, because they have potentially the greatest return.

COOLING AND HEATING ZONE

To reach comfortable conditions in the remaining 10% of the year it may be necessary to employ active cooling and heating strategies such as air conditioning and heaters.

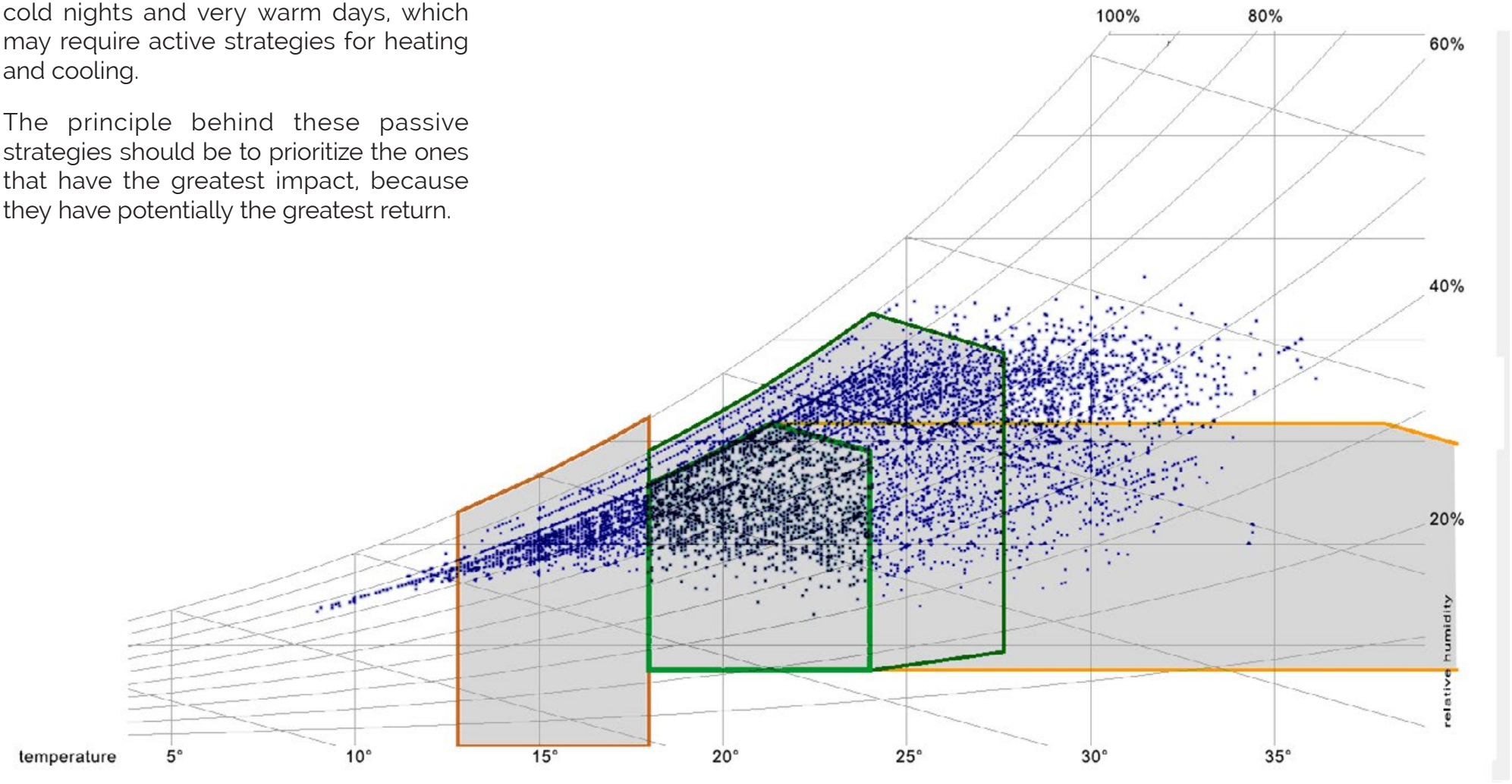


Fig.77 Maputo Psychrometric chart with passive and active zones

DESIGN GUIDELINES social comfort

BALCONY AND VERANDAH

Depending on whether the residence is on the ground floor or a higher floor it will exhibit at least one balcony or verandah.

These may double in function as a service area or an extension for the living spaces and bedrooms for additional shading and ventilation.

Fig.78 Balconies, Maputo

OUTDOOR SOCIAL SPACE

Referencing the comfortable climate and the social background associated with the 'open house' design there is a big emphasis placed on outdoor shaded spaces where the family can sit together for recreational purposes or eating meals together.

Fig.79 Covered outdoor space, Maputo

SERVICE AREA

This area originates from the colonial period where most families had a separate section for the help staff.

Today it is still in the building regulations that there must be space allotted for activities such as washing and drying. These may take considerable space since it is done by hand.

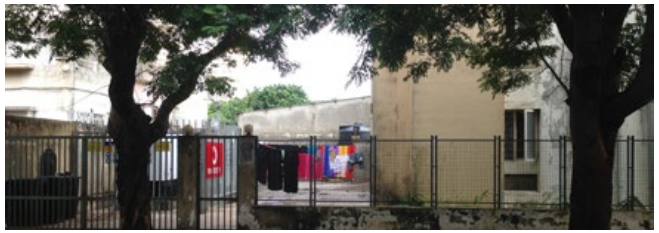


Fig.80 Service area, Maputo

OUTDOOR COOKING AREA

Food preparation can occur outside of the house to help keep the home free of smells.

Many households still use coal or wood stoves and the smoke is better dealt with outside the house.

Fig.81 Covered outdoor space, Maputo

SERVICE ENTRANCE

Another requirement that originates from the colonial period, all residential homes including apartments must have two access points. The secondary access is usually connected to the service area that normally supports the kitchen.

Fig.82 Service entrance, Maputo

DESIGN GUIDELINES environmental opportunities

OVERVIEW

Even though the primary focus tends to be on the economic side of the project, there are several environmental opportunities. These are guidelines I propose to be included in the home of tomorrow.

WATER CAPTURE & REUSE

Considering the low access to clean water through municipal connections, it is worthy to develop schemes that integrate water collection into the home design and facilitates the filtering and storage for long periods.

These could be integrated with green roofs that also aid in thermal comfort control.

Fig.83 Green roof

SEWERAGE & BIOGAS

Similarly municipal sewerage connection is rarely guaranteed and many areas may suffer from frequent power shortages.

On-site sanitation management is essential, and there exist alternatives that can be coupled with biogas generation for use as cooking fuel.

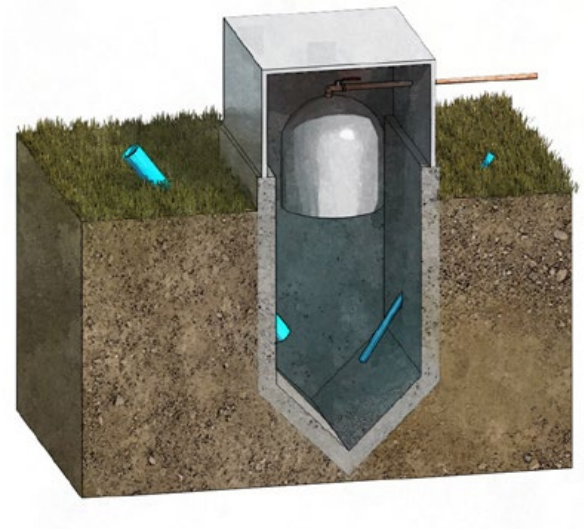


Fig.84 Biogas from compost system

BIODIVERSITY

Often overlooked in the suburbs as a unaffordable luxury because of maintenance, maintained gardens may serve to reduce soil erosion, still waters that breed diseases and create a more pleasing environment.

Fig.85 Poor landscaping

Fig.86 Soil erosion and still waters

DESIGN GUIDELINES environmental opportunities

ALTERNATIVE MATERIALS

Alternative materials are the most employed throughout the country due to their low cost. A poor construction standard however results in these constructions being of a precarious nature and in need of constant maintenance. They can however be viable alternatives to materials such as cement and steel.

Some reference projects include the Manica Football for Hope Center (2013) by Architecture for Humanity; and School in Chimundo by the Bergen School of Architecture (2009).

Fig.87 School in Chimundo with earthbag walls, glass bottle walls, bamboo screen doors and metal roof structure By Bergen School of Architecture (2009)

DESIGNING FOR EXPANSION

Homes following the 'open plan' design may result in disconnected rooms or buildings that use up more space and resources to build.

Following a thoughtful plan from the start can aid in better site layout and ultimately less need for resources to implement.

Therefore the 'evolutive house' may be a more appropriate choice.

Fig.88 Manica Football for Hope Center, with Compressed Earth Bricks (2010)

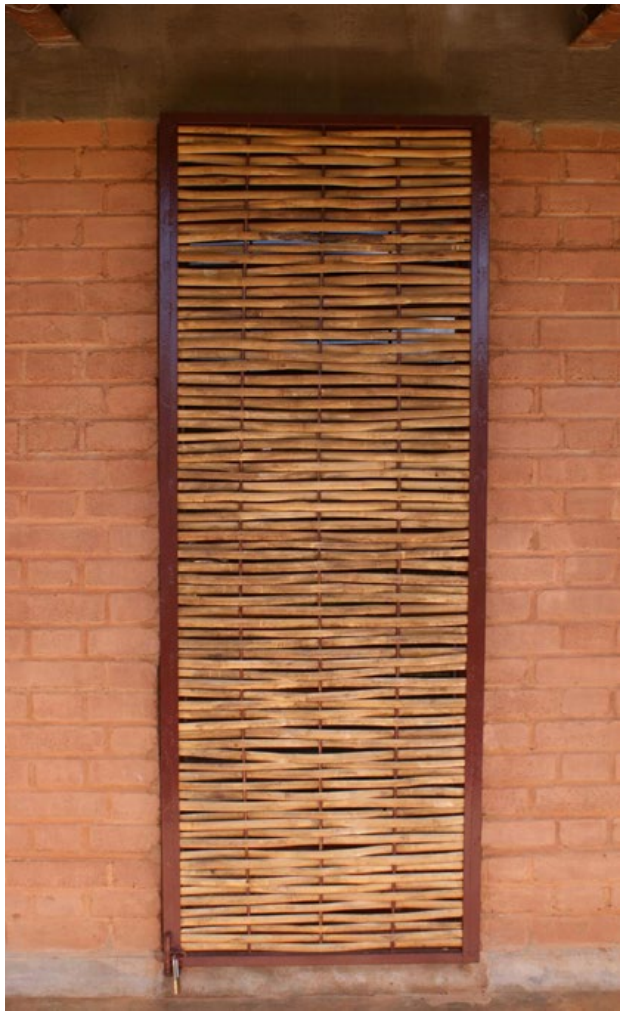


Fig.89 Manica Football for Hope Center, with Bamboo screens as shading mechanism

SUMMARY & COMMENTS

KEY PRINCIPLES

Thermal comfort strategies:

- Natural ventilation
- High thermal mass and night ventilation
- Sun shading of windows

Environmental opportunities:

- Capture and reuse water
- Biogas
- Increase biodiversity
- Use natural materials

CRITIQUE ON BUILDING MATERIALS

Most of the knowledge regarding local building materials has not been formally systematized in publications nor much discussed in academic or government circles in Mozambique.

The majority of the workforce has been informally trained, so only conventional materials have construction techniques that have been in some way standardised.

TIMBER IN CONSTRUCTION

Indigenous timber is suitable mainly for windows, doors and roof structures for small or medium spans.

At large spans the necessary member sizing makes it prohibitive in structural applications.

As such, roof systems that make use of timber elements must not have excessive spans, to limit the truss size.

VERNACULAR ARCHITECTURE REFERENCES

There are pilot projects in Mozambique, mostly done by foreign interest groups that demonstrate the capacity of natural materials as resistant and low maintenance buildings.

However these have not been widely published and so their impact as been minimal.

CHOICE OF TYPOLOGY

Considering that the majority of prospective home owners are of a low economic standing, the most appropriate house typology to develop is the 'evolutive house' since this allows the user to pace the construction to their specific financial standing.

Homes tend to evolve over many years by growing in size as the home owner acquires the financial means.

The home must allow for expansion as the need and the means grow.

CEMENT VS. EARTH

The material choice for the thesis proposal needed to address this predominance for cement products.

The cement industry is well established, and this has created the idea that cement blocks are better and cheaper than earth bricks.

Earth block buildings exist in Mozambique and show that the same quality of construction can be achieved with a material that has a lower embodied energy.


Economic Comfort
HOUSE OF TODAY
FOCUS
Thermal Comfort
Social Comfort


Economic Comfort
Environmental Opportunities
HOUSE OF TOMORROW
FOCUS
Thermal Comfort
Social Comfort

TODAY

Fig.90 Front view of core module

V. HOME OF TOMORROW

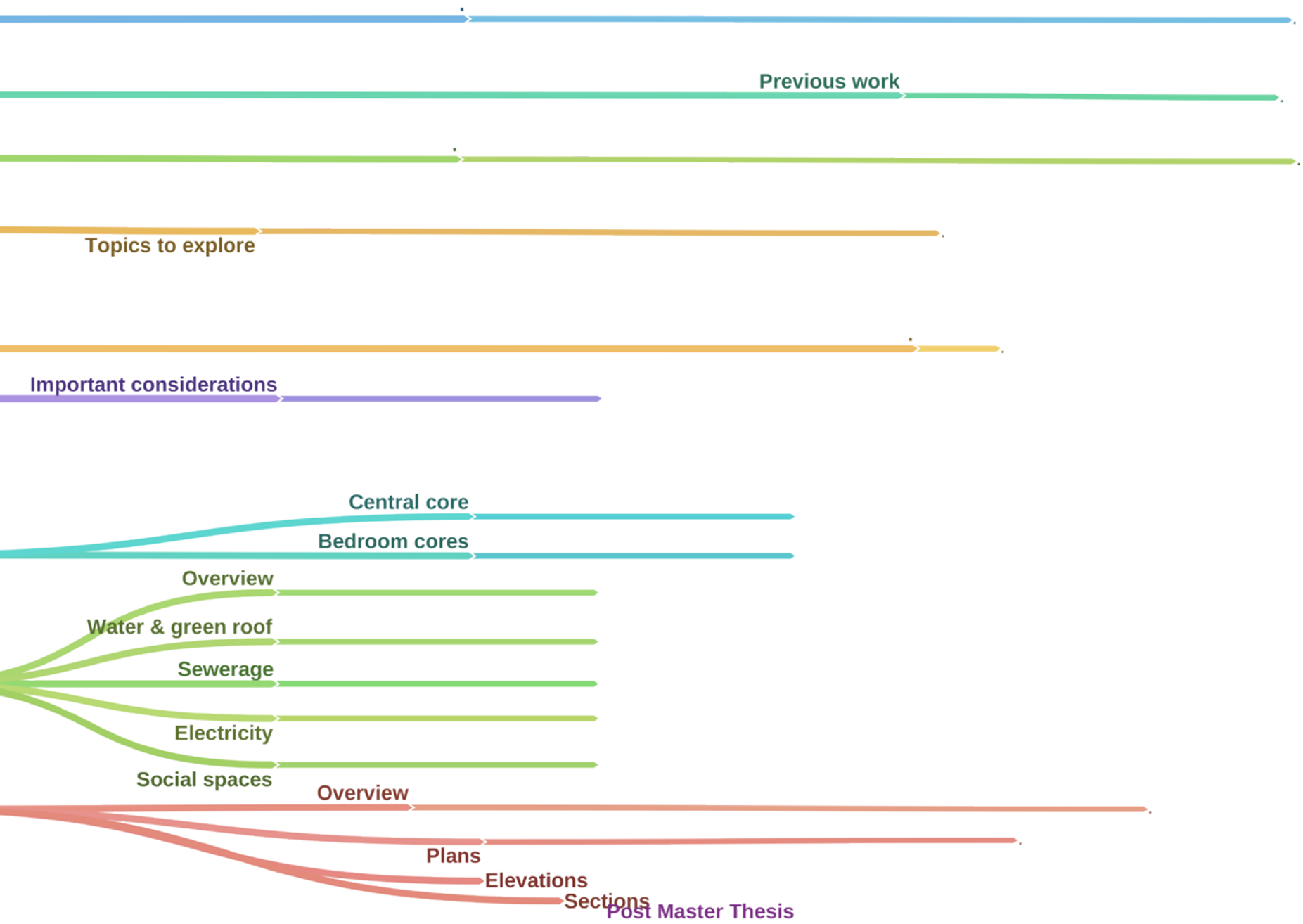
HOME OF TOMORROW

A design proposal for a single-family detached house, which employs or attempts to summarize all the topical conclusions from the previous chapters.

This proposal is preceded by a client brief and design guidelines and objectives to be achieved for residential development in the expanding Urban fabric of Maputo.

It will be as extensive as detailing employed guidelines, materials and techniques for construction..

1. DESIGN ASSUMPTIONS
2. PROJECT BRIEF
3. CLIENT DESCRIPTION
4. CONTEXT ANALYSIS
5. PROJECT OBJECTIVES
6. SITE DEVELOPMENT
7. HOUSE DEVELOPMENT
8. MODULES
9.SYSTEMS
10. TYPICAL HOUSE


Previous work
Topics to explore
Important considerations
Central core
Bedroom cores
Overview
Water & green roof
Sewerage
Electricity
Social spaces
Overview
Plans
Elevations
Sections
Post Master Thesis

PROJECT BRIEF OF EXISTING PROPOSAL

ON-GOING PROJECT

This Master Thesis project proposal is based on an existing on-going project that is being developed.

The existing project is in the design phase. The project has already been defined in relation to the number of units that will be developed on site and the sizes of the plots, as well as the road layouts.

The author of the thesis is participating in this design process by testing proposals for the homes designs, given the requested house typologies by the developer.

The focus of this thesis will therefore be shifted towards the design of the home units to be built in the condominium.

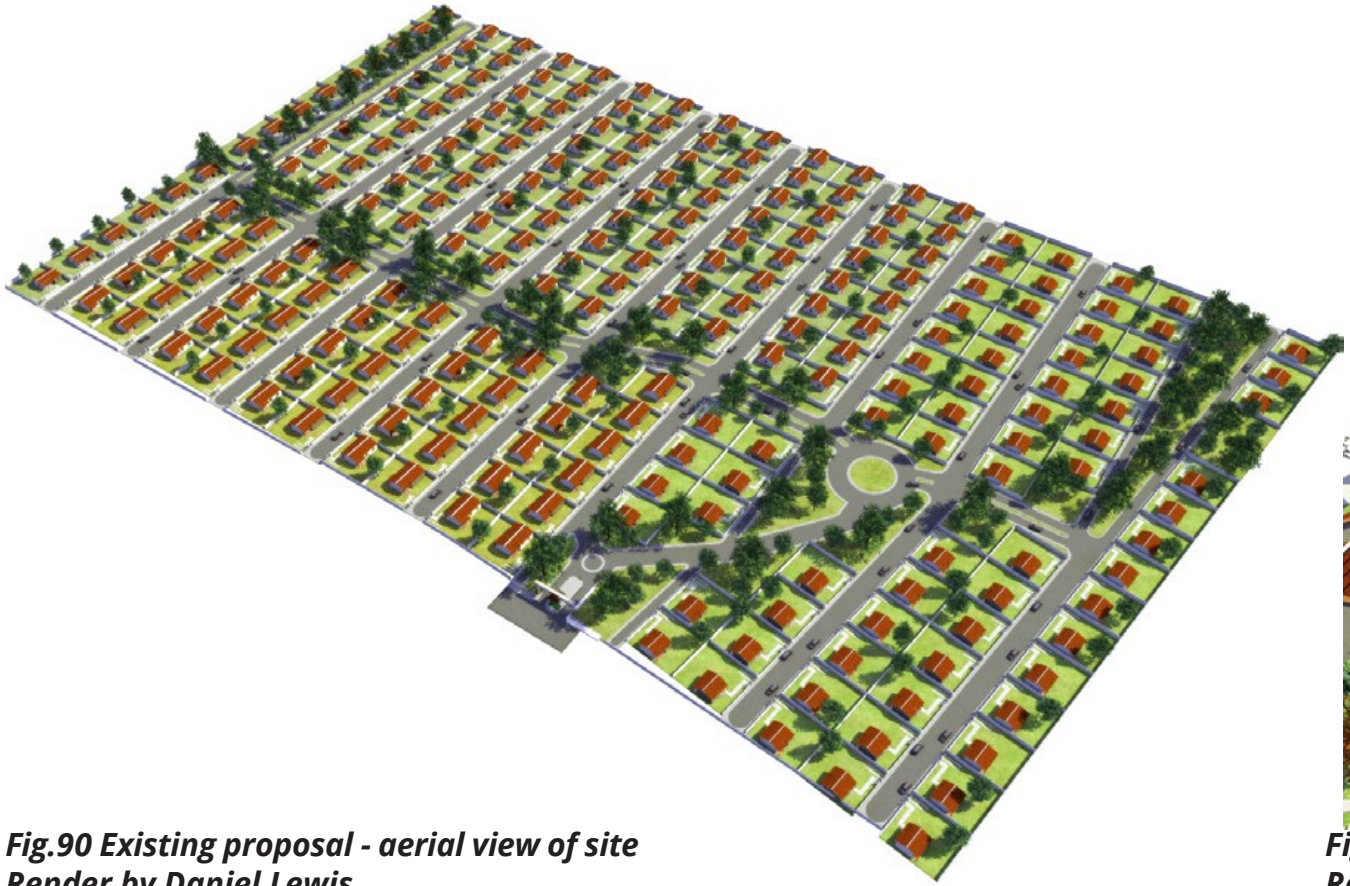


Fig.90 Existing proposal - aerial view of site
Render by Daniel Lewis

Fig.91 Existing proposal - street view
Render by Daniel Lewis

CLIENT DESCRIPTION

DESCRIPTION

The project description calls for the development of a condominium that is comprised of 200 detached family homes, water and sewerage management systems and access infrastructure.

This site is located in one of the periphery city-districts, Zimpeto.

The home typology must be flexible to accommodate varying requirements from the client in regards to number of bedrooms.

The initial proposal is a one or two bedroom home that may be upgraded to up to four bedrooms.

The water management system will have a municipal connection but must allow flexibility for periods of time when such connection may fail.

The sewerage system will not have a municipal connection and as such must be able to function independently.

Fig.92 Existing proposal - street view
Render by Daniel Lewis

DEFINING THE USER

The prospective client for this project belongs to the emerging middle-class.

They are part of the market segment that has resulted in the greatest amount of physical expansion of the urban context.

In many cases they are looking for a piece of land in which to begin building their own home, following the 'auto-construção' or self-built.

Because of a lack of financial means, this often times means that they will begin the home with the minimum amount of area and rooms and over time continue to build the house, even after they have moved into the land.

The client therefore buys the land and pays the developer for the construction of the home, which the client now owns.

Fig.93 Existing proposal - street view
Render by Daniel Lewis

EXISTING PROPOSAL

EXISTING SITE LAYOUT

The previous proposal attempted to reconcile an ambitious number of homes in a relatively small plot.

These homes follow the 'evolutive home' concept where from the beginning they are expected to grow at a later stage.

There is a large emphasis on vehicular circulation and individual parking spaces.

This results in a poor ratio between public green spaces and private spaces, so the focus is clearly on maximizing the size of the individual plots over common spaces.

Fig.94 Existing site layout proposal
Render by Daniel Lewis

EXISTING PROPOSAL

EXISTING HOUSE TYPOLOGIES

The proposed homes were of simple construction and allowed for the expansion of the unit up to a total of three bedrooms.

This expansion occurred laterally, freeing up the front and back areas of the home for permanent service and social spaces.

Due to the lateral expansion of the homes, the bedrooms suffered in terms of ventilation. The rooms only present fenestrations towards one exterior wall, which is not ideal for cross ventilation.

The sloping roof was proposed as either ceramic tile or metal sheeting, for its lower cost than concrete slab.

There is a tendency towards grouping the wet areas (kitchen and bathrooms), so the plumbing and sewerage systems are all facing the same wall.

There is no designated interior service area.

The living space is smaller in area than the bedrooms.

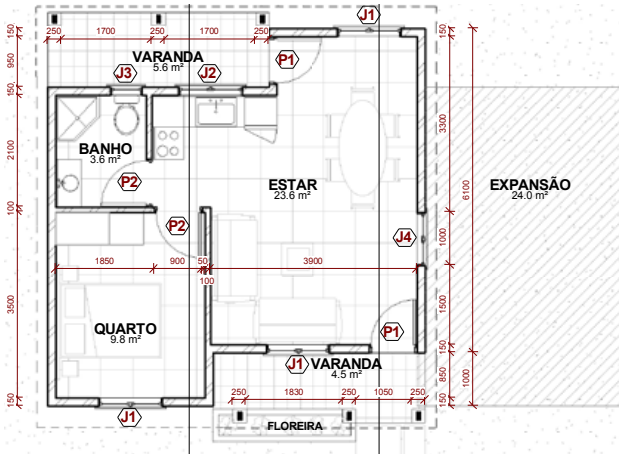


Fig.95 Existing one bedroom unit plan

Fig.96 Existing one bedroom unit view Render by Daniel Lewis

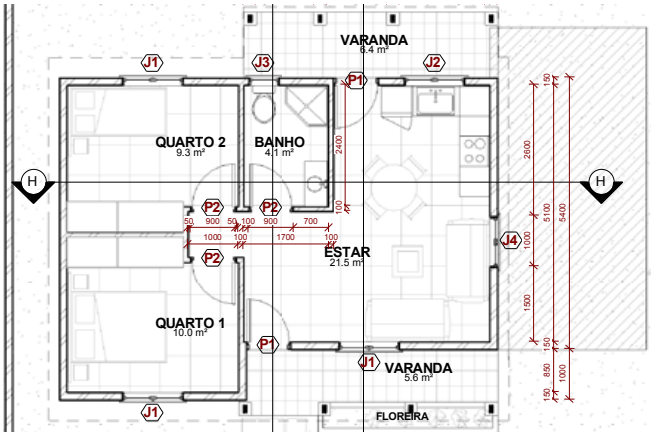


Fig.97 Existing two bedroom unit plan

Fig.98 Existing two bedroom unit view Render by Daniel Lewis

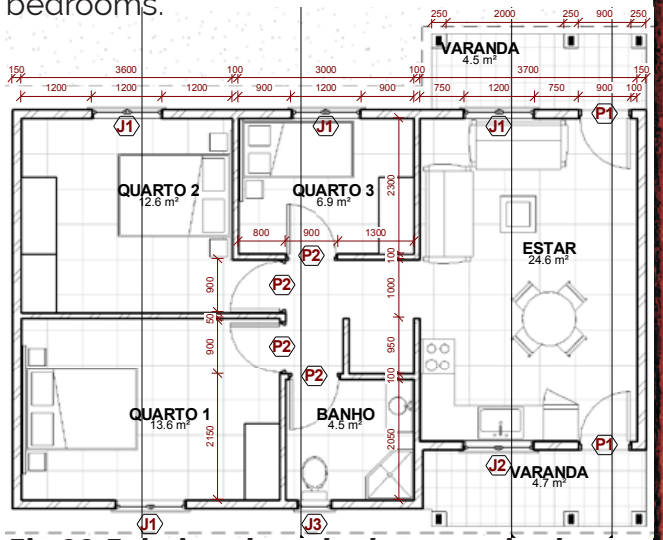


Fig.99 Existing three bedroom unit plan

Fig.100 Existing three bedroom unit view Render by Daniel Lewis

CONTEXT ANALYSIS

ZIMPETO

One of the city suburbs 15km north of downtown, it has experienced an increased infrastructure development in recent years.

It lays in the direct path between Maputo and the rest of the country, which results in an extremely high volume of traffic going through.

It is the site of Zimpeto National Stadium, the biggest in the country, where the 2011 All-African Games were hosted.

This event spurred construction in the area which resulted in several condominium developments in its vicinity, including 'Villa Olimpica' and 'Complexo Intaka'.

These projects combined developed over 6000 homes, from apartments to row houses to detached houses.

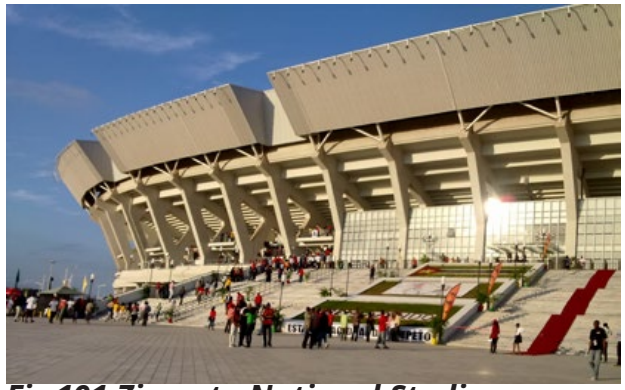


Fig.101 Zimpeto National Stadium

Fig.102 Map of Zimpeto
Image by Google Maps, edited by Mauro Paul

CONTEXT ANALYSIS

With such a high volume planned for development in this area, the municipality is planning considerable infrastructure upgrades that may keep up with the upsurge of new homes. This includes new schools, a police station and a market place.

FLOOD PLAINS

This area is located directly to the east of the Infulene River, in a relatively flat area.

This means that house foundations must be able to resist possible rises in the water bed level, as well as an increase in the salinity of the soil

Fig.103 Vila Olimpica, Zimpeto

Fig.105 Vila Olimpica, Zimpeto

Fig.104 Complexo Intaka, Zimpeto

Fig.106 Complexo Intaka, Zimpeto

THESIS PROJECT PROPOSAL OBJECTIVES

OVERVIEW

The following thesis proposal acts as a conclusion of the previous chapters and tries to reconcile the existing Design Guidelines with environmental aspects that have been identified as feasible opportunities in the Mozambican context.

INCREASED SERVICES RESILIENCE

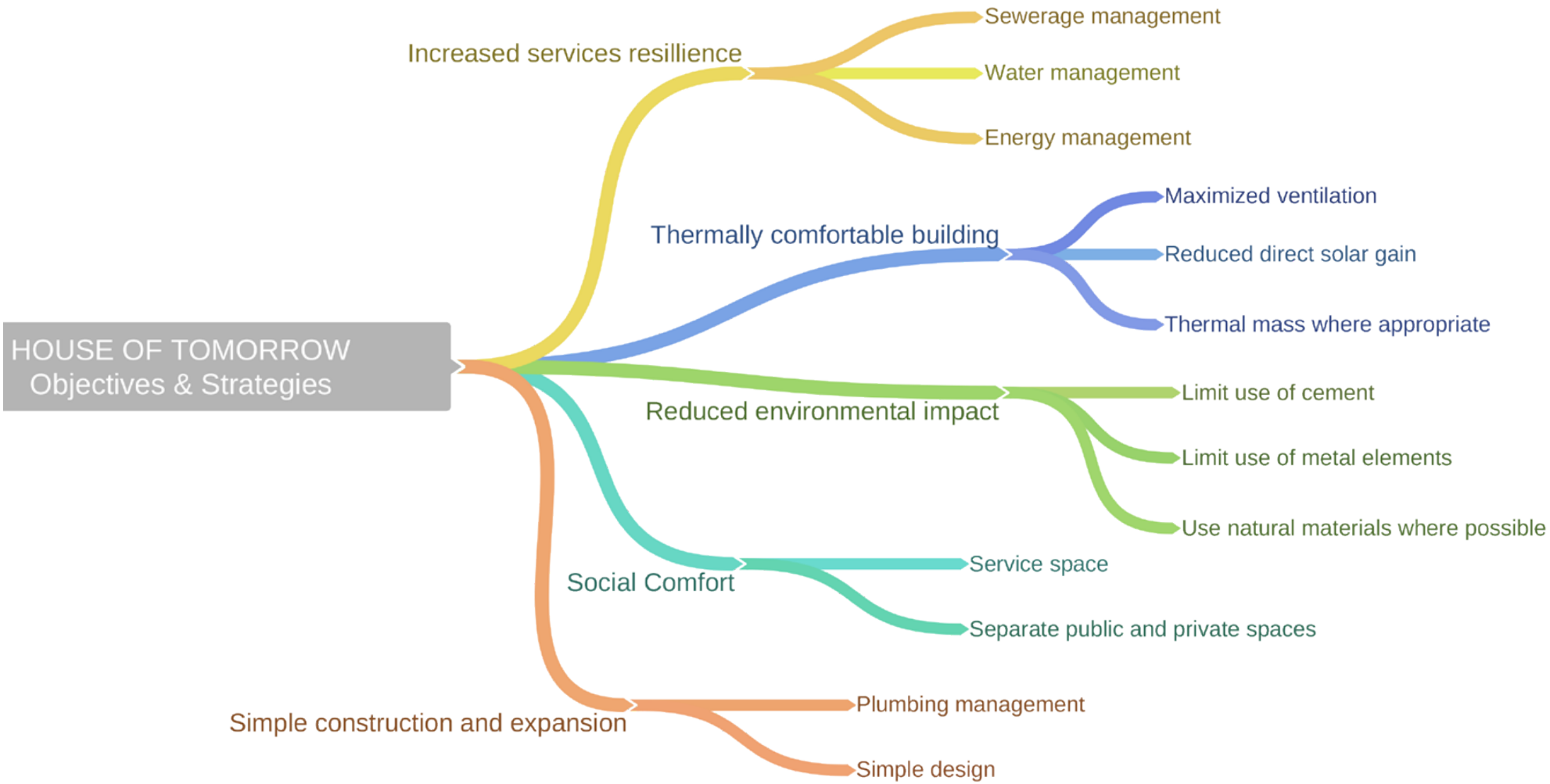
Municipal provision of services and infrastructure is not always guaranteed in Maputo, specially in the suburbs.

As such, a successful Home of Tomorrow proposal must address this by deficiency by providing alternatives.

REDUCED ENVIRONMENTAL IMPACT

The construction industry in Maputo is centred on cement and steel products such as cement blocks and reinforced concrete.

A successful Home of Tomorrow proposal steers away from such polluting industry towards using natural materials whenever possible.



THESIS PROJECT PROPOSAL OBJECTIVES

SIMPLE CONSTRUCTION AND EXPANSION

The majority of home builders do not have the financial capacity to execute their dream residence in one go.

As a result, the Home of Tomorrow proposal follows the evolutive house design concept, that allows and plans for the extension of the home in the future.

This flexibility is limited to the first-time choice the client makes when first beginning the project, by deciding how many bedrooms the home will have, ranging from one to four.

THERMAL COMFORT

These guidelines are a result of the analysis in the previous chapters, to understand what makes the good Home of Today.

The Home of Tomorrow thus addresses the thermal building performance by allowing for proper ventilation of spaces, shading to reduce solar gain and employing the appropriate thermal mass for comfortable indoor temperatures.

SOCIAL COMFORT

Social comfort is addressed through the provision of spaces in the design for service areas separate from the living areas.

The home follows a closed-plan approach, typical in Mozambican culture, where bedrooms are clearly separate from day-time living areas and the kitchen is separate from the living room.

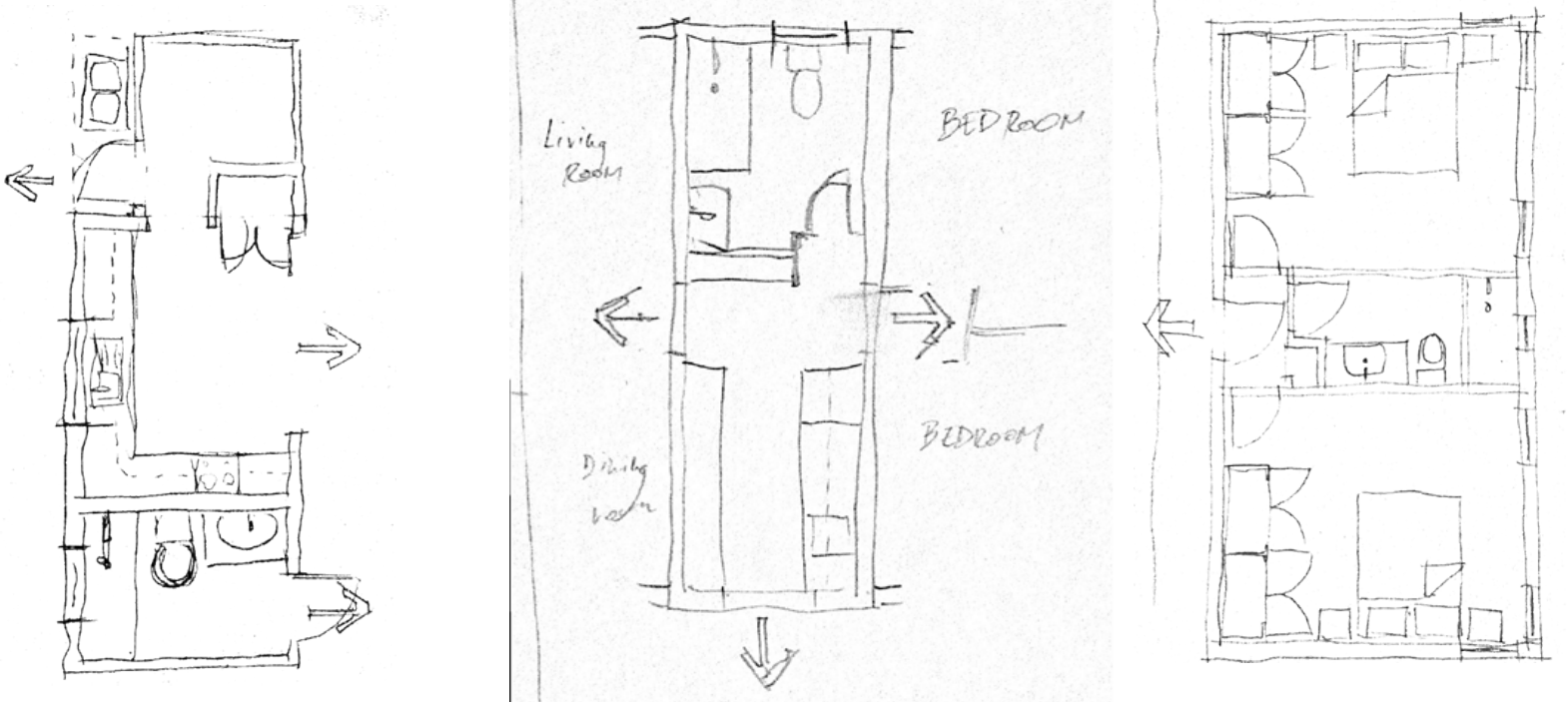


Fig.107 Initial concept development

THESIS PROPOSAL CONCEPT STRATEGIES

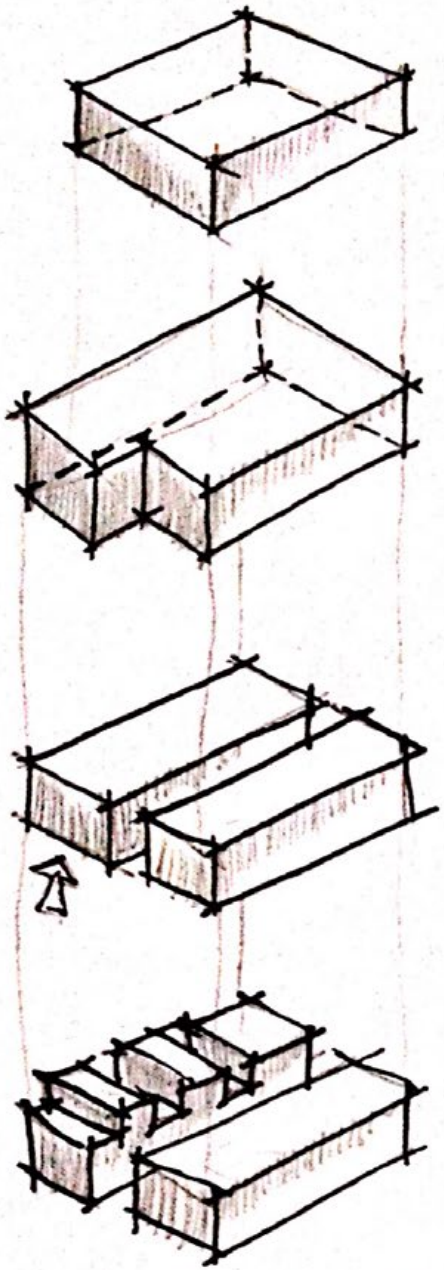


Fig.108 Ability to expand over time

MODULAR DESIGN

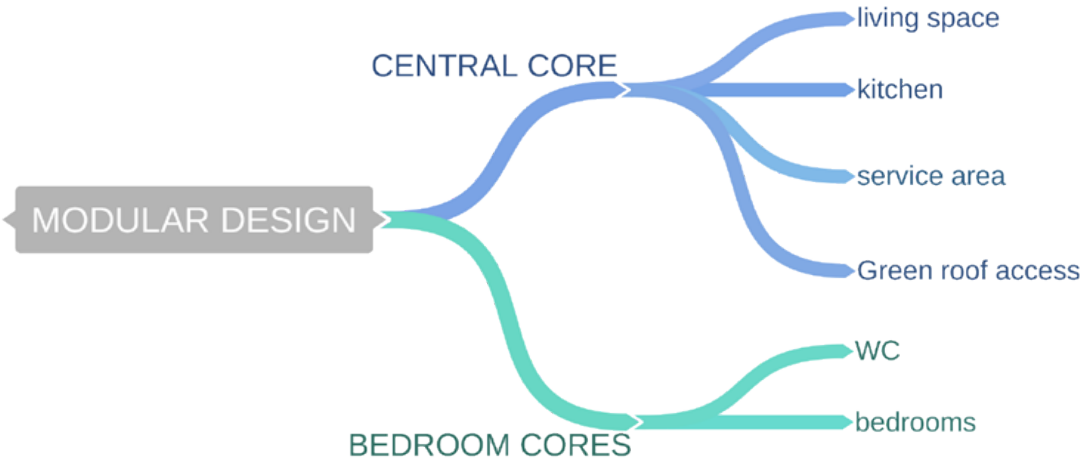
Condominium developments are often characterized by the same home design repeated throughout the site, which may detract from the sense of individuality of a home from a lack of distinguishing features.

The thesis proposal deals with this by creating a variety of modules with different designs that the user can pick between, to create a more personalized design.

DESIGNING FOR EXPANSION

The bedroom modules are placed on opposite sides of the home, so future expansion construction can occur at a measured pace while the user is still living on-site.

The home follows a central axis of circulation, so the home is simple in plan and construction execution.



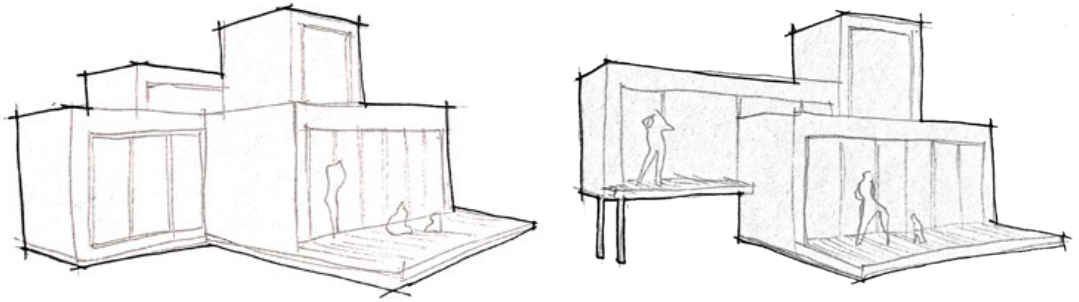


Fig.109 Achieving variation with similar homes to enhance individuality

THESIS PROPOSAL CONCEPT STRATEGIES

DESIGNING FOR VENTILATION

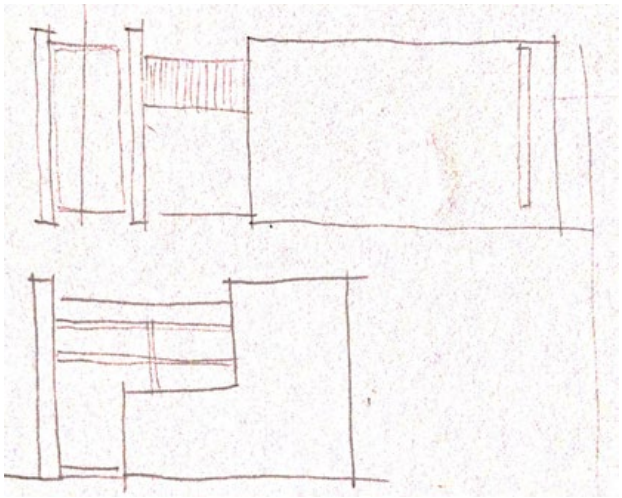
As determined in the previous chapter, the most efficient thermal performance strategy is adequate natural ventilation.

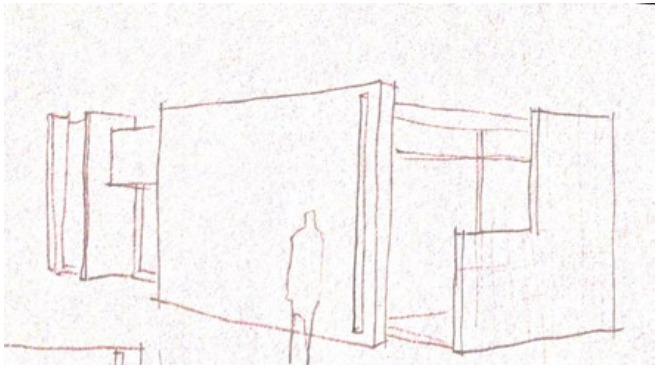
As such, rooms should allow for maximal cross-ventilation. Alternatively, ventilating the suspended ceiling spaces or with pipe cooling in the roof slabs.

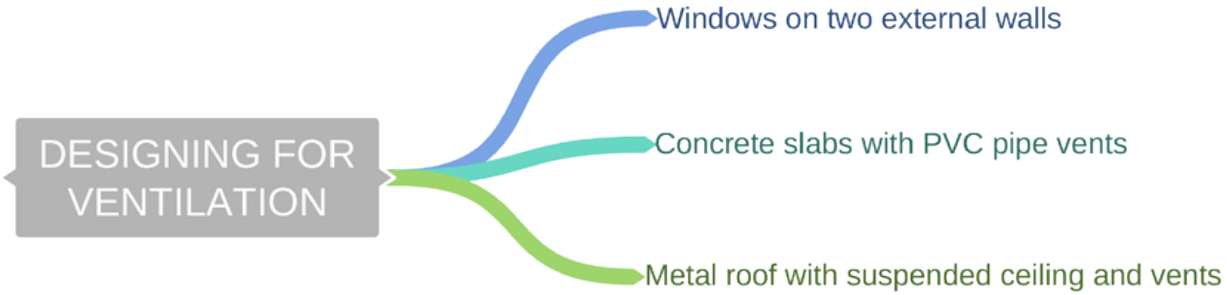
CONSTRUCTION MATERIAL CHOICE

A viable alternative for cement block construction in Mozambique is the Compressed Stabilized Earth Brick (CSEB).

Earth is widely available in Maputo, and these bricks can easily be manufactured on-site using soil from the foundation.







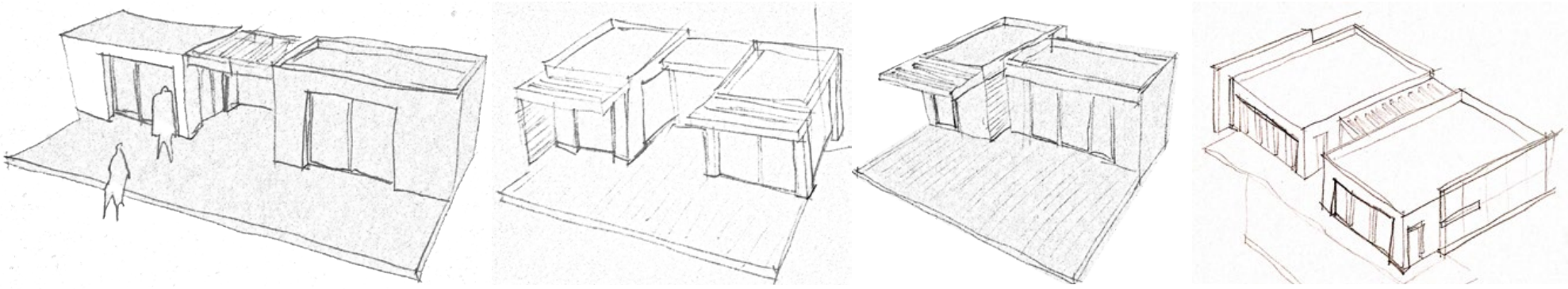


Fig.110 Modular approach, so the individual elements can rearranged to suit the specific needs of the user

THESIS PROPOSAL - CENTRAL CORE MODULE (C)

DESCRIPTION

The central core includes the living space, kitchen, service area and staircase to the green roof.

The green roof houses a water tank that supplies the interior of the home and a solar water heater system..

The central core is the same for all homes, and with a central axis of circulation allows for bedroom modules to be added to either side.

Roof collects rainwater into underground cistern.

Green roof improves thermal performance of concrete slab.

Concrete slab is constructed through beam and block method, with the beams being precast concrete lintels and the blocks are ceramic. This is to reduce the amount of concrete.

PVC pipes run through the blocks and are exposed to the outside to provide cooling.

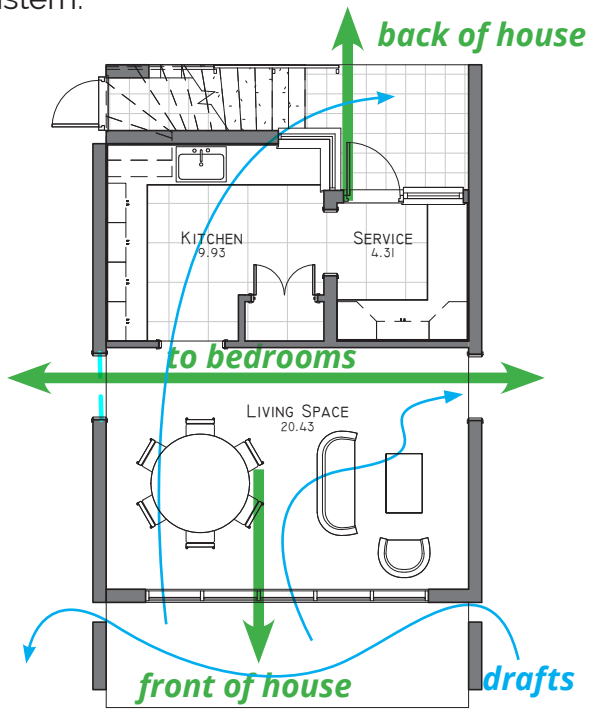


Fig.111 Central core module plan

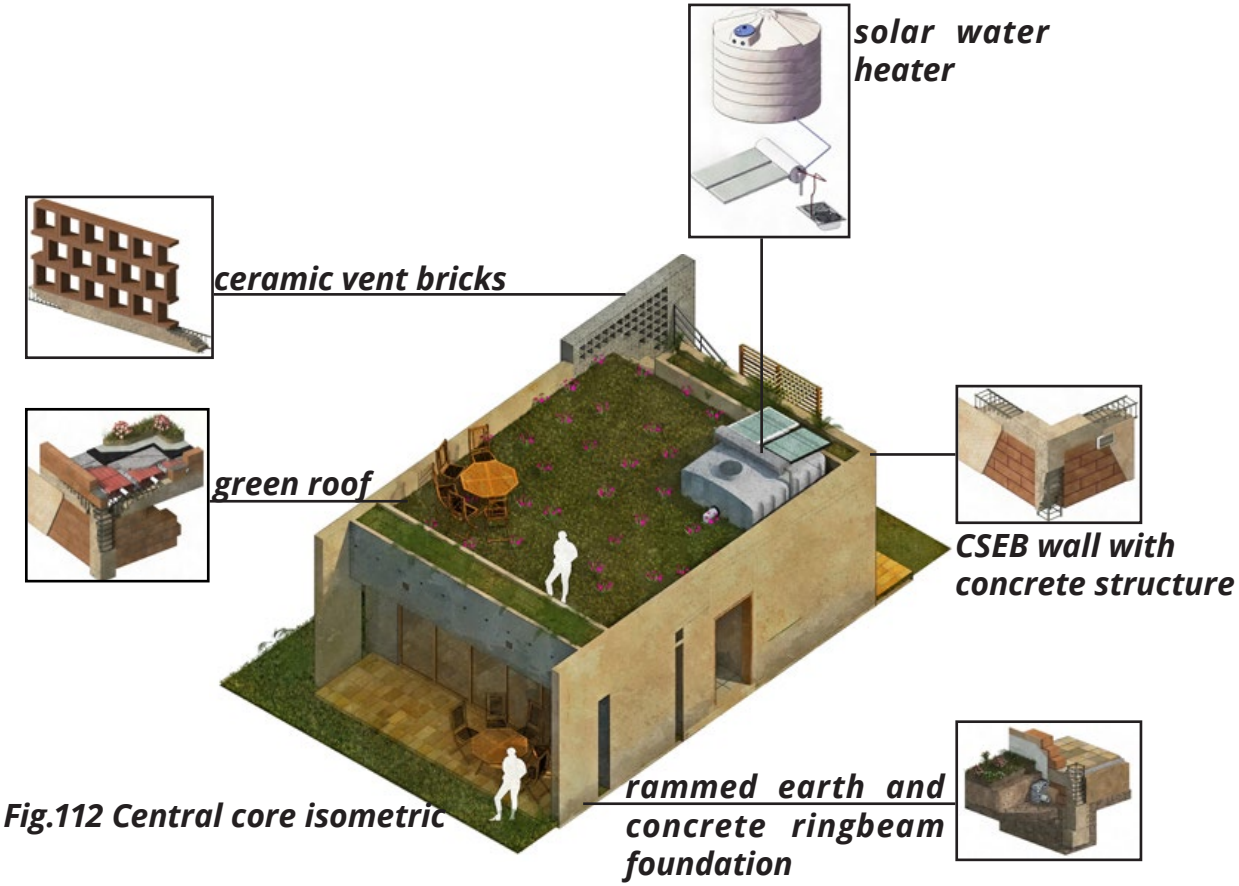


Fig.112 Central core isometric

THESIS PROPOSAL - CENTRAL CORE MODULE (C)

Fig113 Core module, back of house

PVC pipe through concrete slab

ceramic brick vent for suspended ceiling

east facade openings less than 5%

bamboo screen

outdoor covered social space

Fig.114 Core module, front of house

THESIS PROPOSAL - BEDROOM MODULE (A)

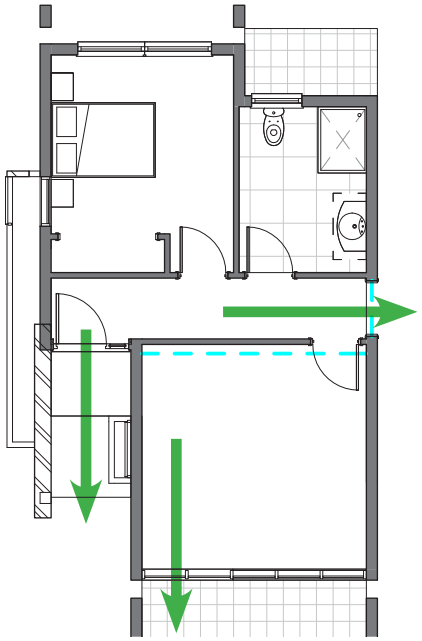


Fig.115 Module A1 Entrance option with extended living room

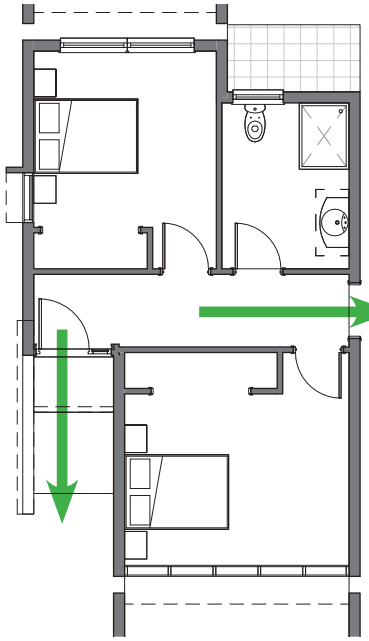


Fig.116 Module A2 Entrance option with two bedrooms

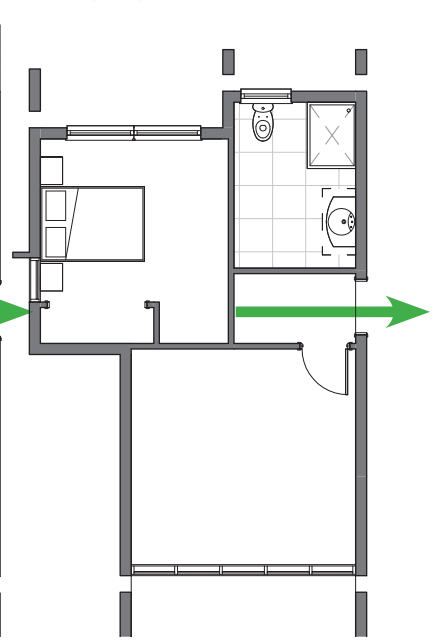


Fig.117 Module A3 Extension option with two bedrooms

DESCRIPTION

The bedroom modules have sloped roofs with metal sheeting as a material for the possibility of lightweight construction.

As such, the CSEB wall does not require the added structural ability of concrete pillars or ringbeams.

This roof allows for the collection and storage of rainwater.

There is a suspended ceiling over the corridor space that ventilates directly to the outside through stack ventilation.

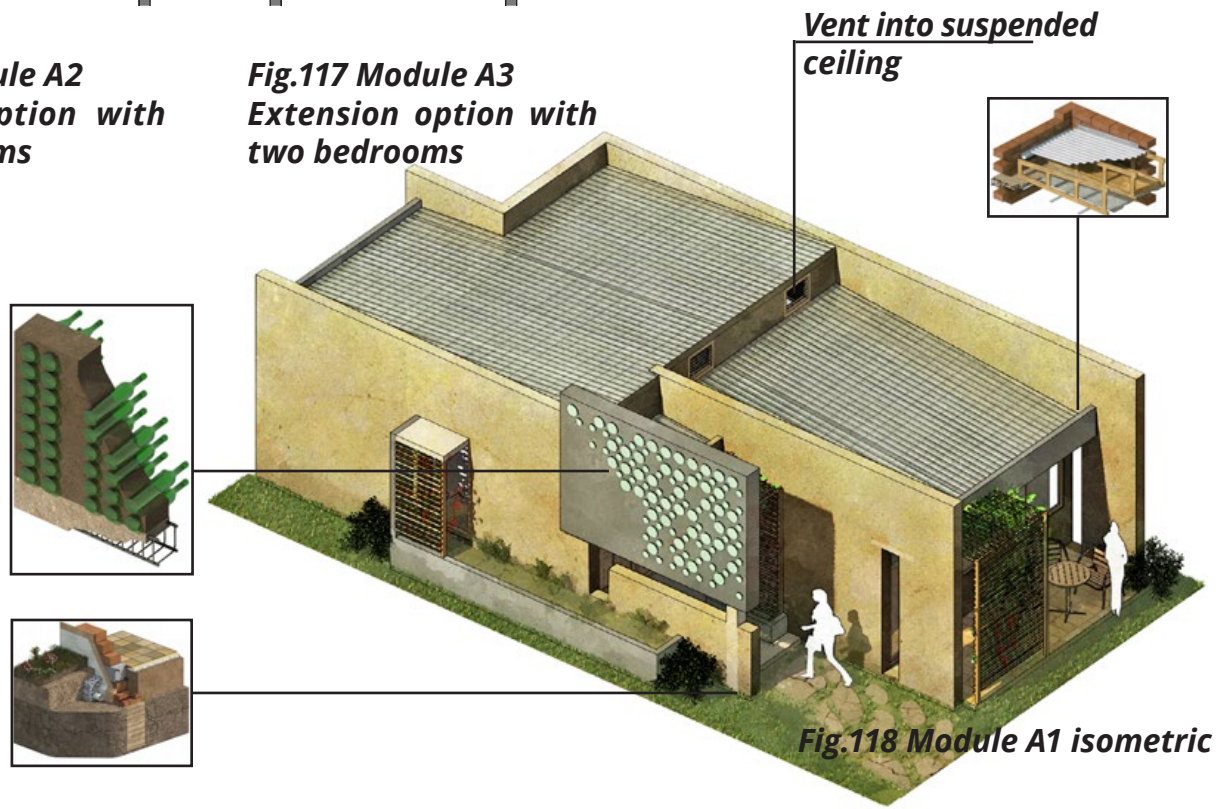


Fig.118 Module A1 isometric

THESIS PROPOSAL - MODULE (A)

Fig.119 A1 module, entrance view

THESIS PROPOSAL - BEDROOM MODULE (B)

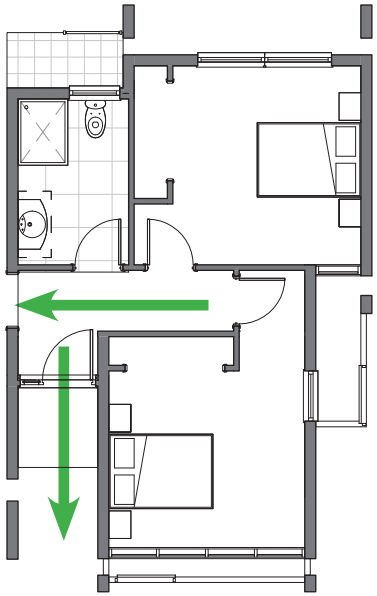


Fig.120 Module B1 Entrance option with two bedrooms

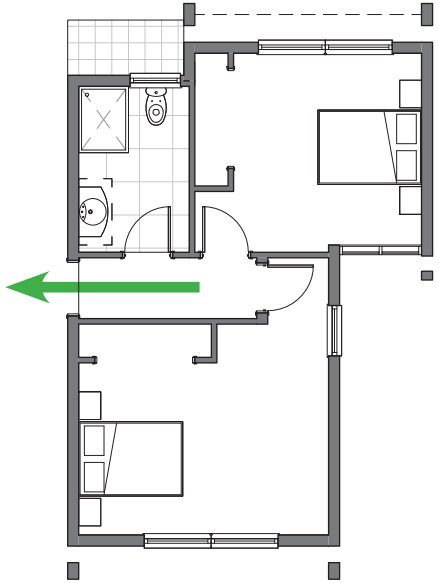


Fig.121 Module B2 Extension option with two bedrooms

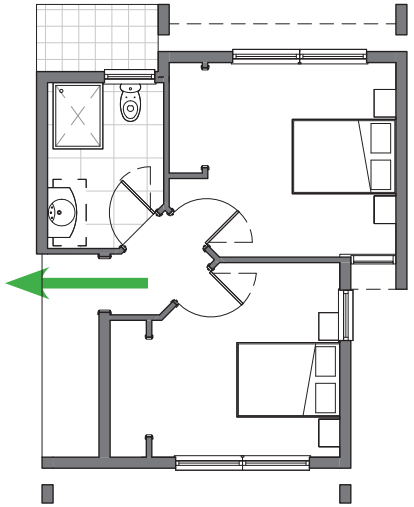


Fig.122 Module B3 Extension option with two bedrooms and additional living room space

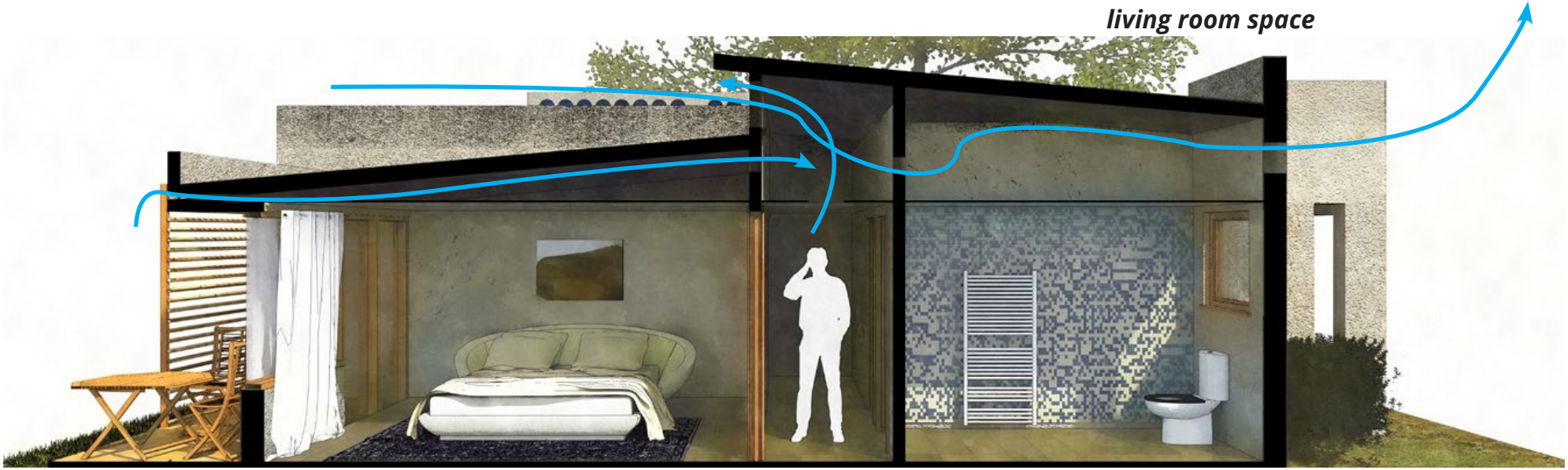


Fig.123 Module A1 section showing possible ventilation routes

THESIS PROPOSAL - MODULES

Fig.x124 B1 module, front view

THESIS PROPOSAL - EXAMPLE HOUSE

CENTRAL CIRCULAION AXIS
This allows for easy expansion of the home, as the bedroom modules can be added on either side of the core.

WET AREAS GROUPED
This allows for an easy installation of plumbing systems, which can be a problem when dealing with untrained builders.

All the wet areas face the same exterior wall, and can have shared connections to the septic tank.

LIMITED EAST AND WEST OPENINGS
This is to aid in reducing solar gains. The total area of opening to these sides does not exceed 5%. of the facade.

Fig.126 Example home

THESIS PROPOSAL - EXAMPLE HOUSE

DOORS AND WINDOWS WITH VENTS
All fenestrations have vents and breathers to maximize the airflow between the rooms

SHADED OPENINGS
All openings are shaded with at least a 50% cantilever

MINIMIZED OPENINGS
A maximum of 20% area is open to the north facing side.

DESIGN OPTIMIZED FOR CROSS VENTILATION
All rooms present opportunity for cross ventilation by having openings to two exterior walls

Fig.125 Example home

FOUNDATION AND GROUND CONSTRUCTION

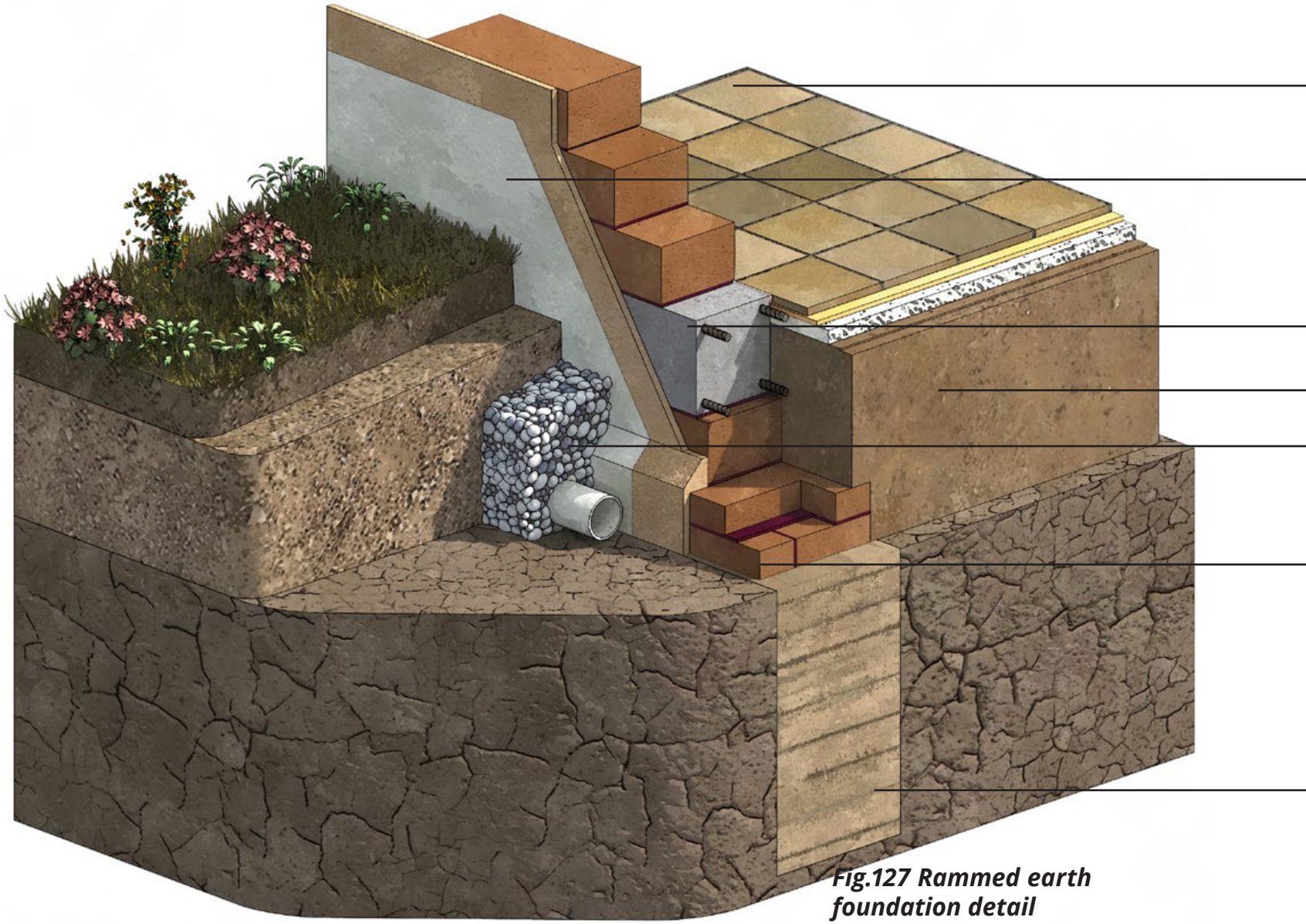


Fig.127 Rammed earth foundation detail

FOUNDATION AND GROUND CONSTRUCTION

Interior finish: Ceramic tiles over screed

Waterproofing: Earthen plaster (limewash for 1 metre above ground for added protection against rain splash back)

Reinforced Concrete plinth beam

Compressed earth fill

Drainage system: Coarse gravel fill with drainage pipe with fall to rear of property

Foundation wall: Compressed Stabilized Earth Block (CSEB)

Reinforced concrete pillar

Foundation wall footing: stabilized rammed earth (subsoil, sand, 5% cement)

Concrete pillar footing: Concrete pad over stabilized rammed earth

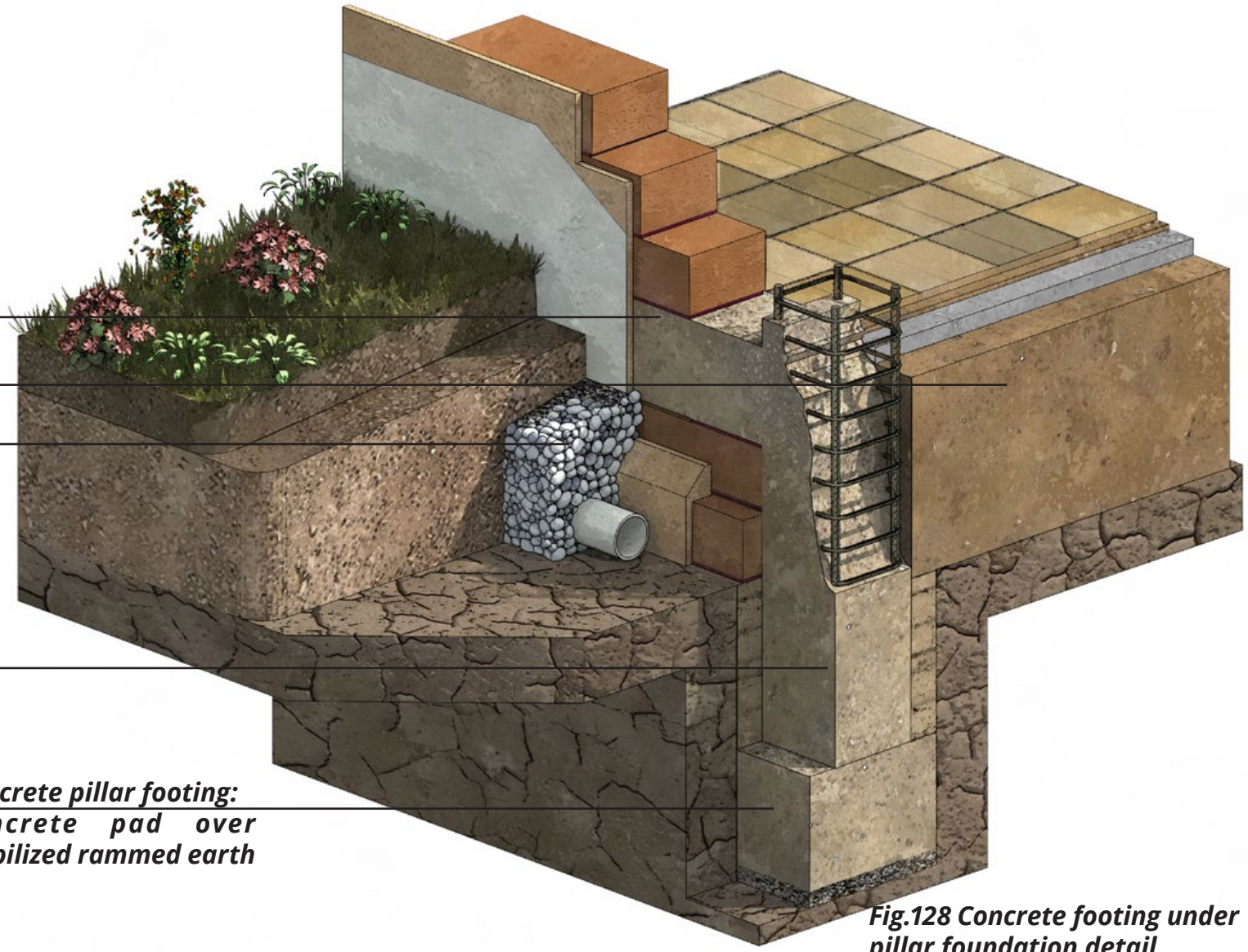


Fig.128 Concrete footing under pillar foundation detail

WALL CONSTRUCTION

Compressed stabilized earth blocks have been used in Mozambican construction before.

They are made of a mixture of subsoil, clay, aggregate and for added water resistance and structural performance they can be stabilized with 5% cement.

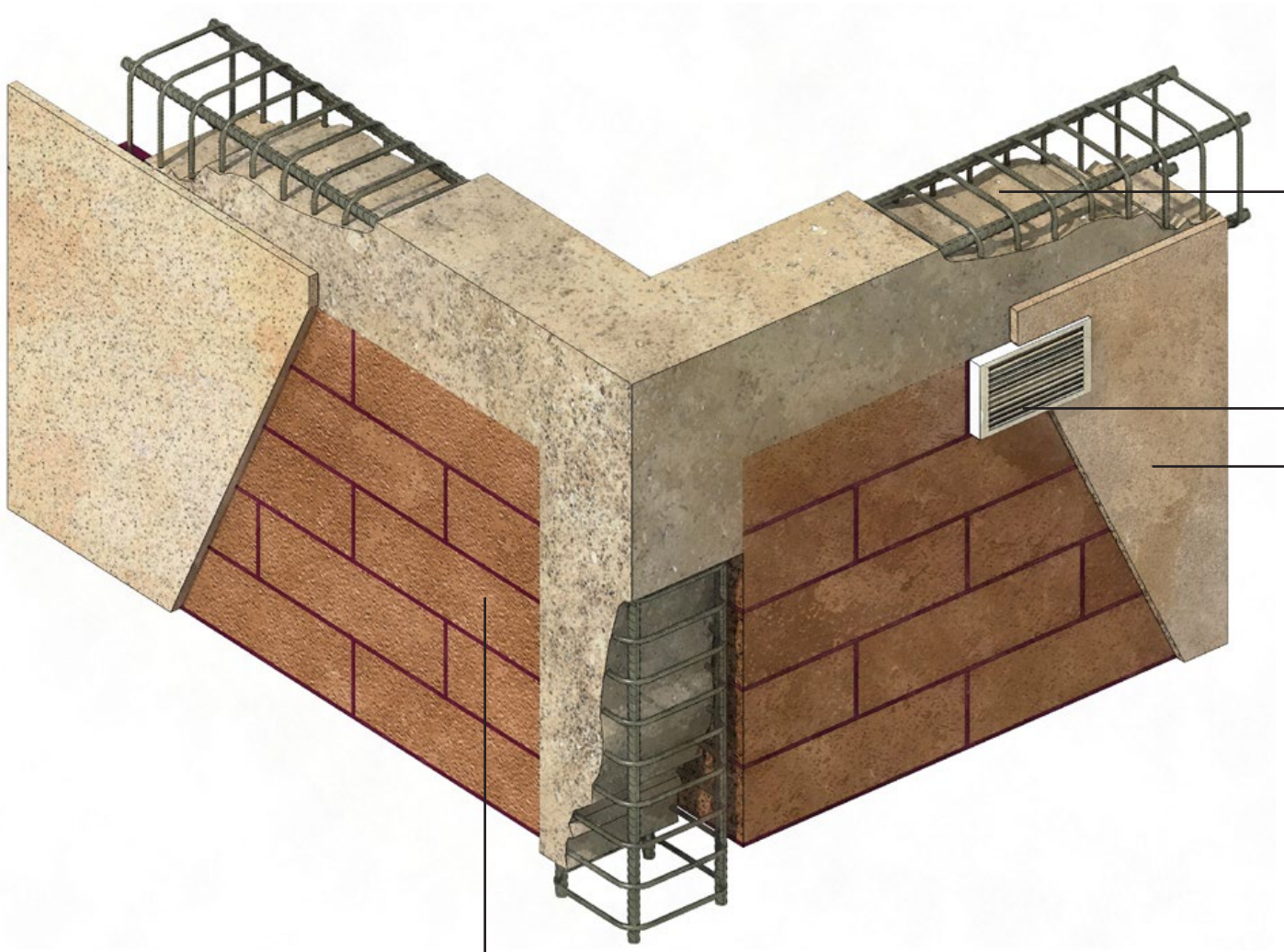
It is possible in many cases in Maputo to use the soil from the site foundations.

It is self supporting and structural, so it can support light roof loads such as timber structures and metal sheeting.

However to support a structure such as a concrete slab and green roof the ideal scenario is to use concrete pillars and a ringbeam to cap the walls.

The wall is finished with an earthen plaster, also stabilized with 5% cement to improve water resistance.

A limewash coat should be used in the first metre from finished ground level to protect the wall from splash back during rain.



Compressed Stabilized Earth Block:
Subsoil, clay, aggregate, 5% cement
Mortar: Subsoil, clay, 8% cement

Fig.129 CSEB wall, pillar and ringbeam detail

Ceramic hollow vent brick

Concrete pillars capped with concrete ringbeam

Ceramic hollow brick as wall vent

Earthen plaster: Clay, sand and straw, stabilized with cement for added waterproofing. Optional colour additive
Limewash: for protection against rainwater splashback. Optional colour additive

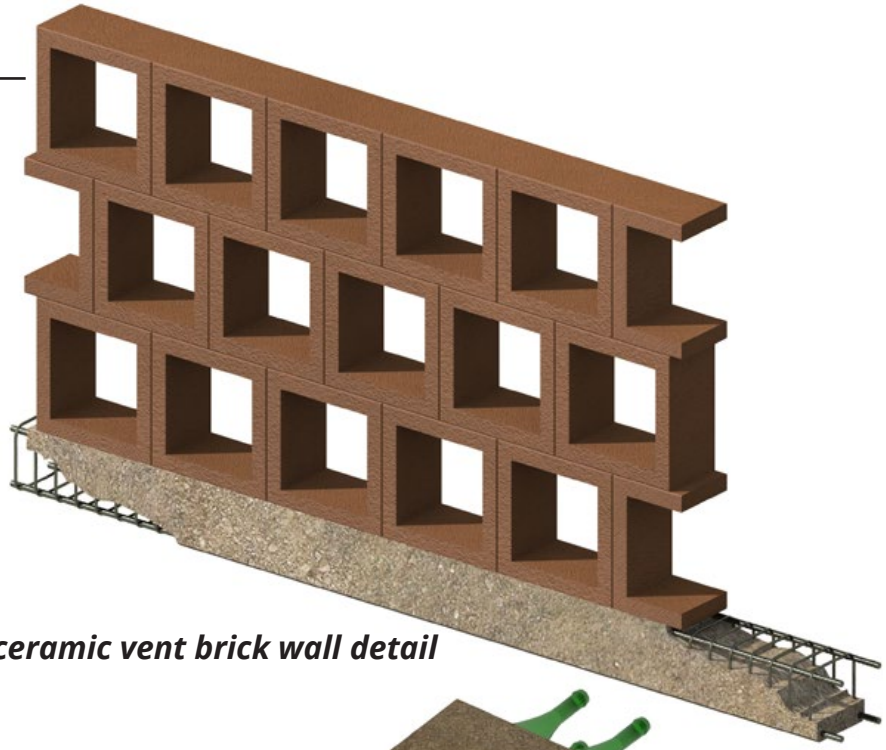


Fig.130 ceramic vent brick wall detail

Glass bottles laid on adobe mortar with 8% cement for waterproofing

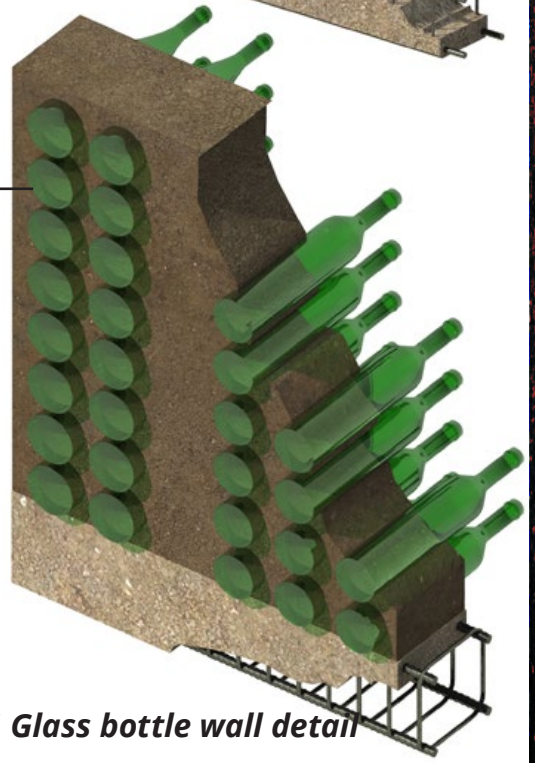


Fig.131 Glass bottle wall detail

ROOF CONSTRUCTION OVER CENTRAL CORE

The living space has a concrete slab as a roof for its high thermal mass properties. This space is mostly used during the day, so a high thermal mass means that the temperature increase is much slower.

Beam and block slab was chosen because it has a reduced cement content than traditional monolithic slabs.

Additionally the hollow ceramic blocks are lighter than the concrete blocks, which reduces the total weight of the roof construction.

PVC pipes are run through the blocks to aid in ventilating the slab.

The additional green roof mass adds to the thermal properties of the roof to stabilized the temperature variation through the day.

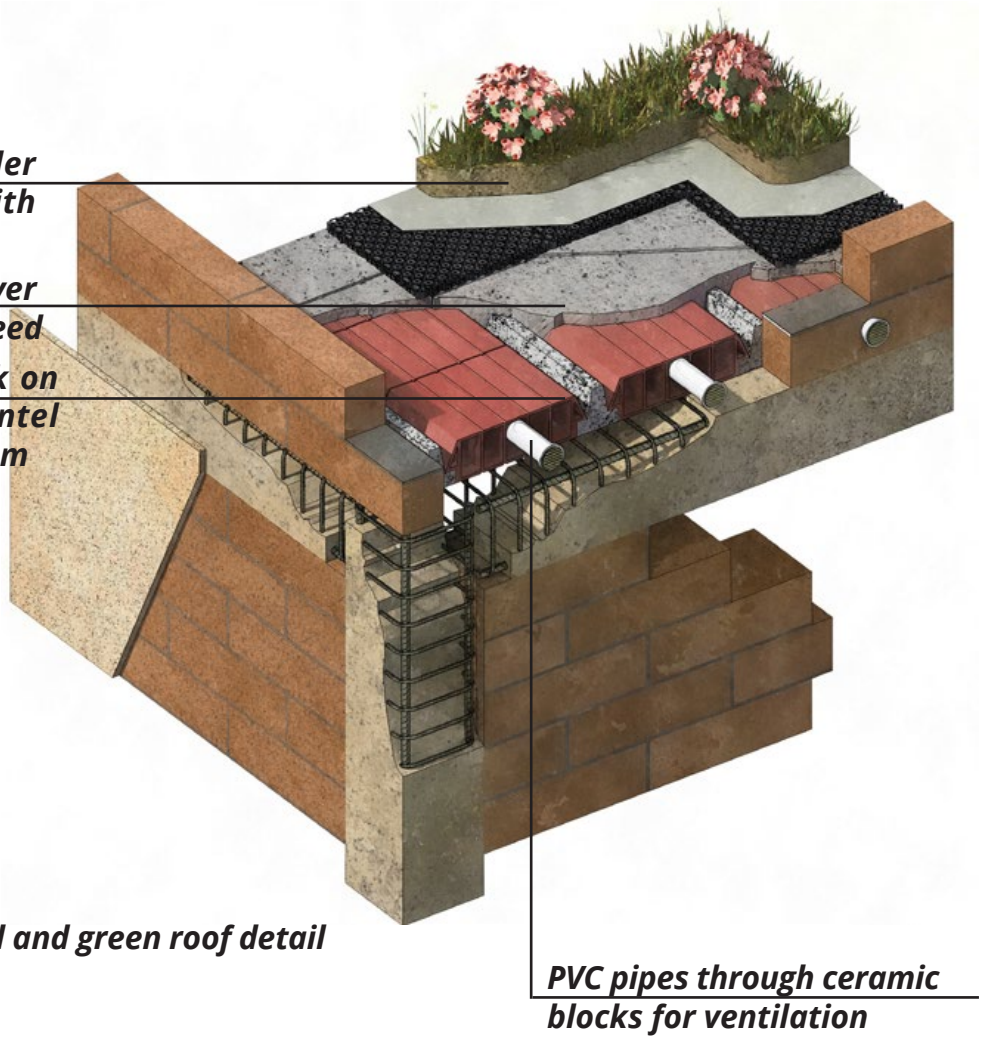


Fig.132 Wall and green roof detail

ROOF CONSTRUCTION OVER BEDROOM MODULES

The bedroom modules have metal sheet roofing supported by a timber structure, for its lightweight properties.

This is because the bedrooms are mostly used during night time and a low thermal mass means that the temperature will be cooler then.

This timber structure lies on CSEB walls without ringbeams.

The water collects at a gutter channel that leads to underground rainwater collection .

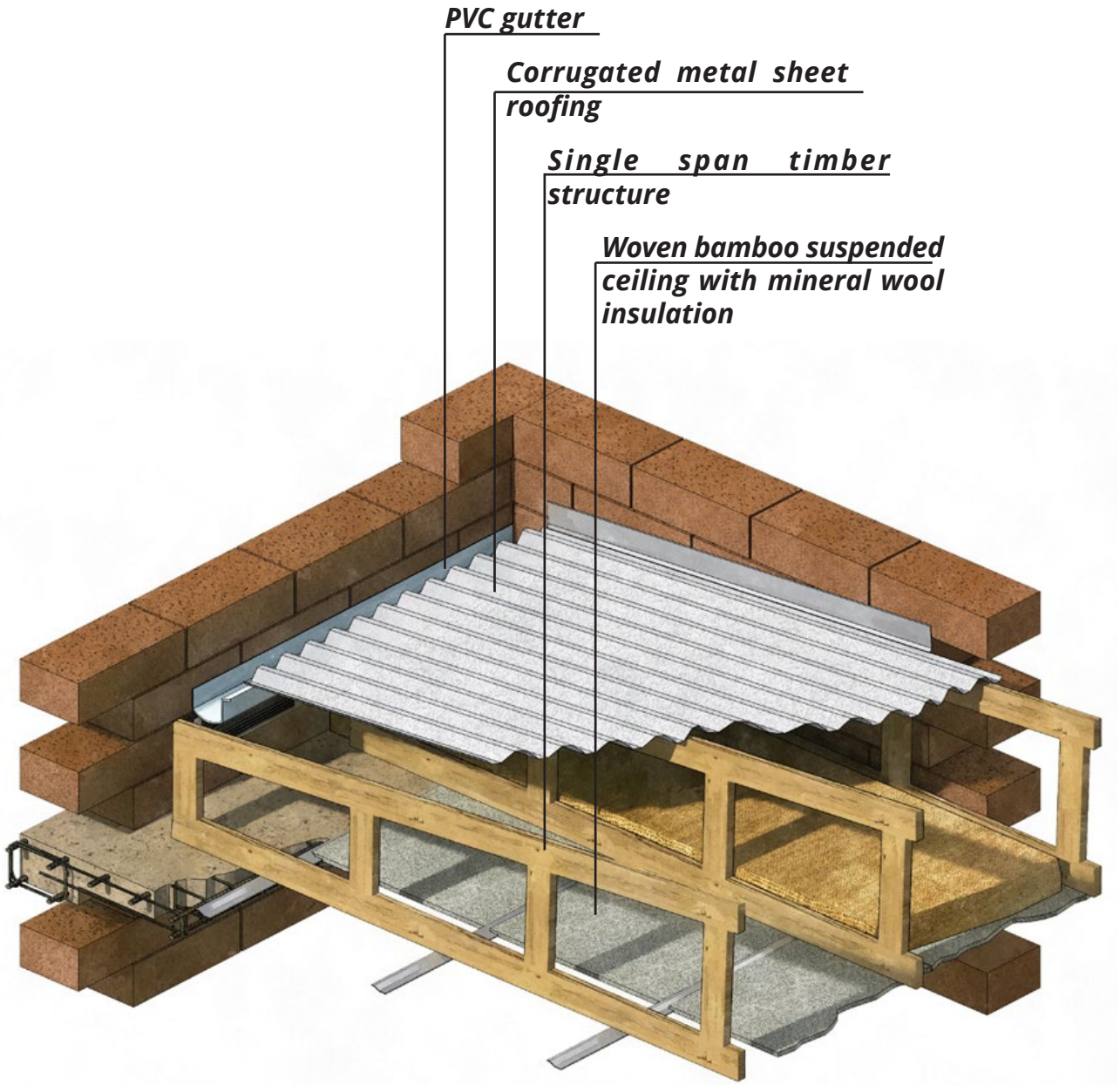


Fig.133 sloped roof and ceiling detail

SOLAR WATER HEATER SYSTEM

The solar panels take advantage of solar energy to heat water. This technology has insignificant cost compared with spending on electricity for water heating.

The solar heating collectors is installed on the green roof of the central core, oriented North and 30° tilted.

This system for heating water for everyday use in a home can be built with accessible means.

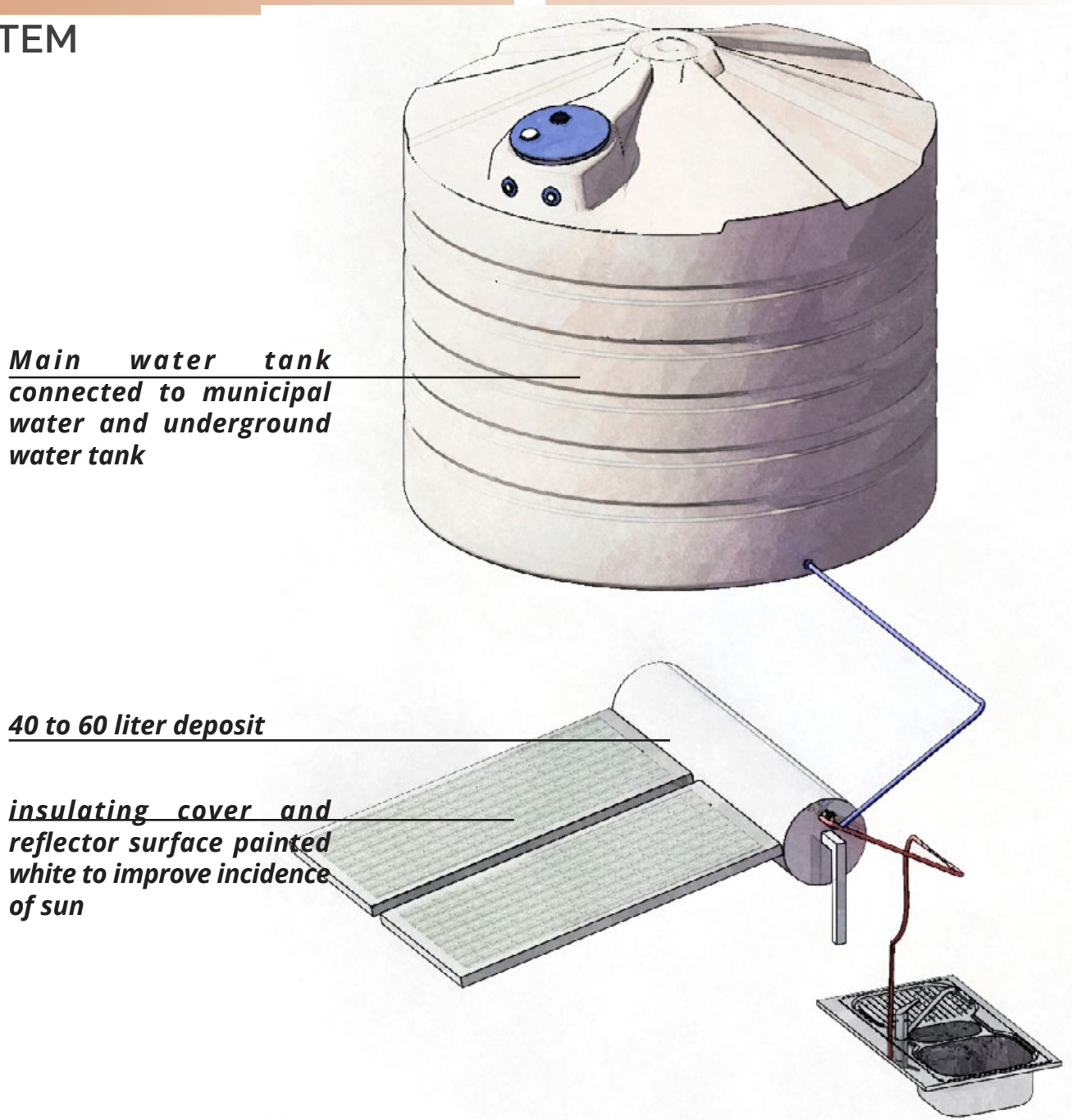


Fig.134 Water heater system detail

BIOGAS SYSTEM

The waste that is produced by man and dumped in the environment, releasing toxic gases, can be "purified" and harnessed, through the elimination of its toxicity and transformation into energy - methane gas.

The biogas system is associated with the recycling of organic waste or other produced daily.

The results from the anaerobic methane fermentation of organic waste, in the absence of oxygen, causes decay of organic matter into biogas.

It is not toxic and can be safely used. The sludges resulting from production process, rich in nitrogen, can be used as fertilizer. The production of methane gas is an alternative to the consumption of fuel.

The simplest method for constructing a small biogas production unit requires only a tank, which is used both for fermentation, and for collecting gas.

The waste is mixed with water before being leaked into the tank. The mixture can be 50% water and 50% of waste.

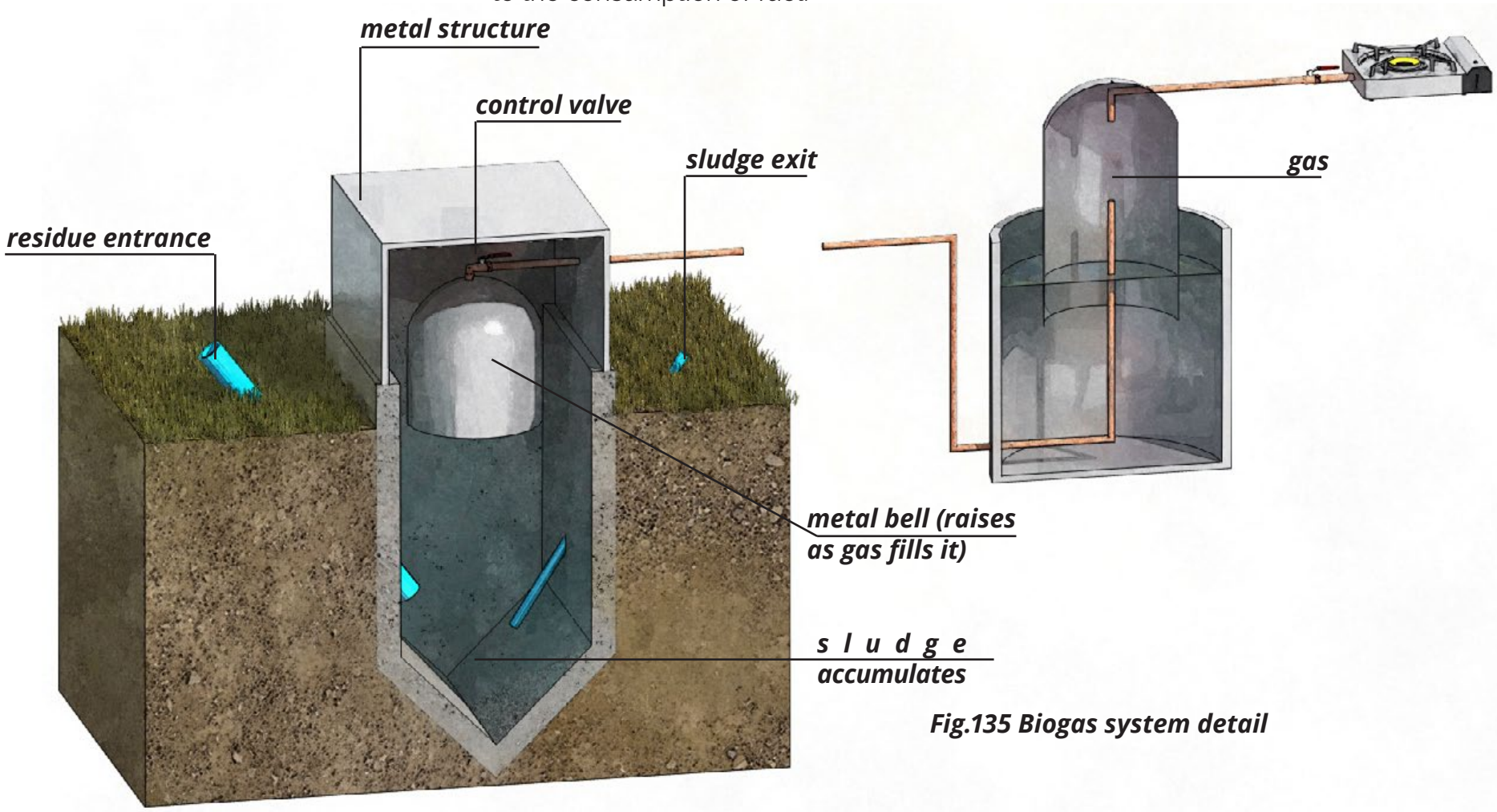


Fig.135 Biogas system detail

SEWERAGE SYSTEM

SEPTIC TANK

A septic tank is an effective and inexpensive method for the disposal of organic waste and small amounts of black water in detached houses or a housing scheme, where there are no sewage systems.

It is an impermeable tank, generally underground, built according to specific requirements, while maintaining the water at rest causes sedimentation and creaming.

With time, the volume of cream and sedimentation tend to disappear leaving water between the two layers by the action of microscopic beings that develop in the tank. The indoor environment needs to be conducive to the development of these beings - without oxygen or light.

These anaerobic microbes survive on organic waste, turning them into liquids and gases. With this processing, the waters are so exposed to air which oxidizes quickly, making it harmless by the action of other bacteria which require oxygen to survive.

GREASE AND SOAP SEPARATION BOX

Between the house and the septic tank there is a a box that holds the fat from the kitchen washing. This box also receives water from bathing and washing clothes that can be reused for watering a garden.

Water without fat passes through the box, which also functions as a filter, and is then conducted to the garden.

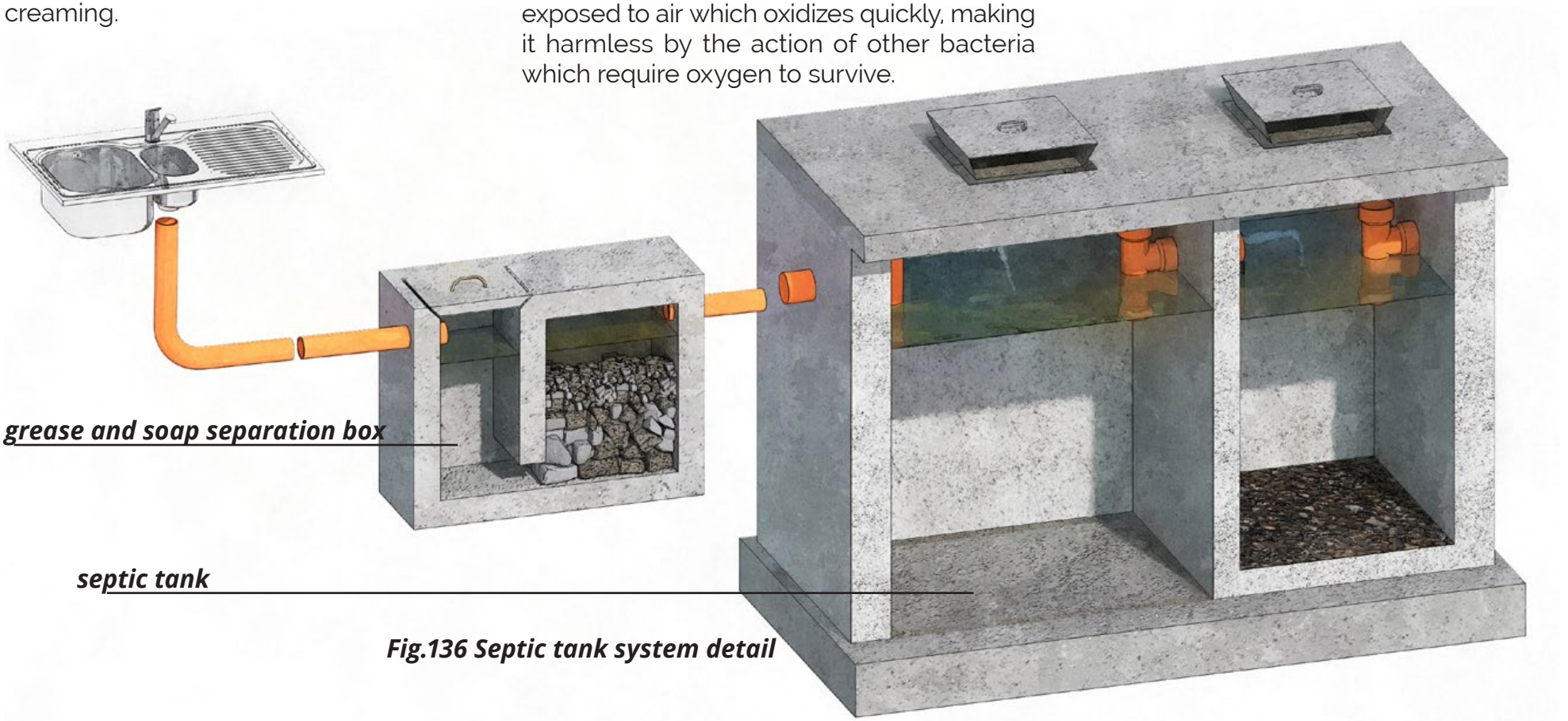


Fig.136 Septic tank system detail

RAINWATER SYSTEM

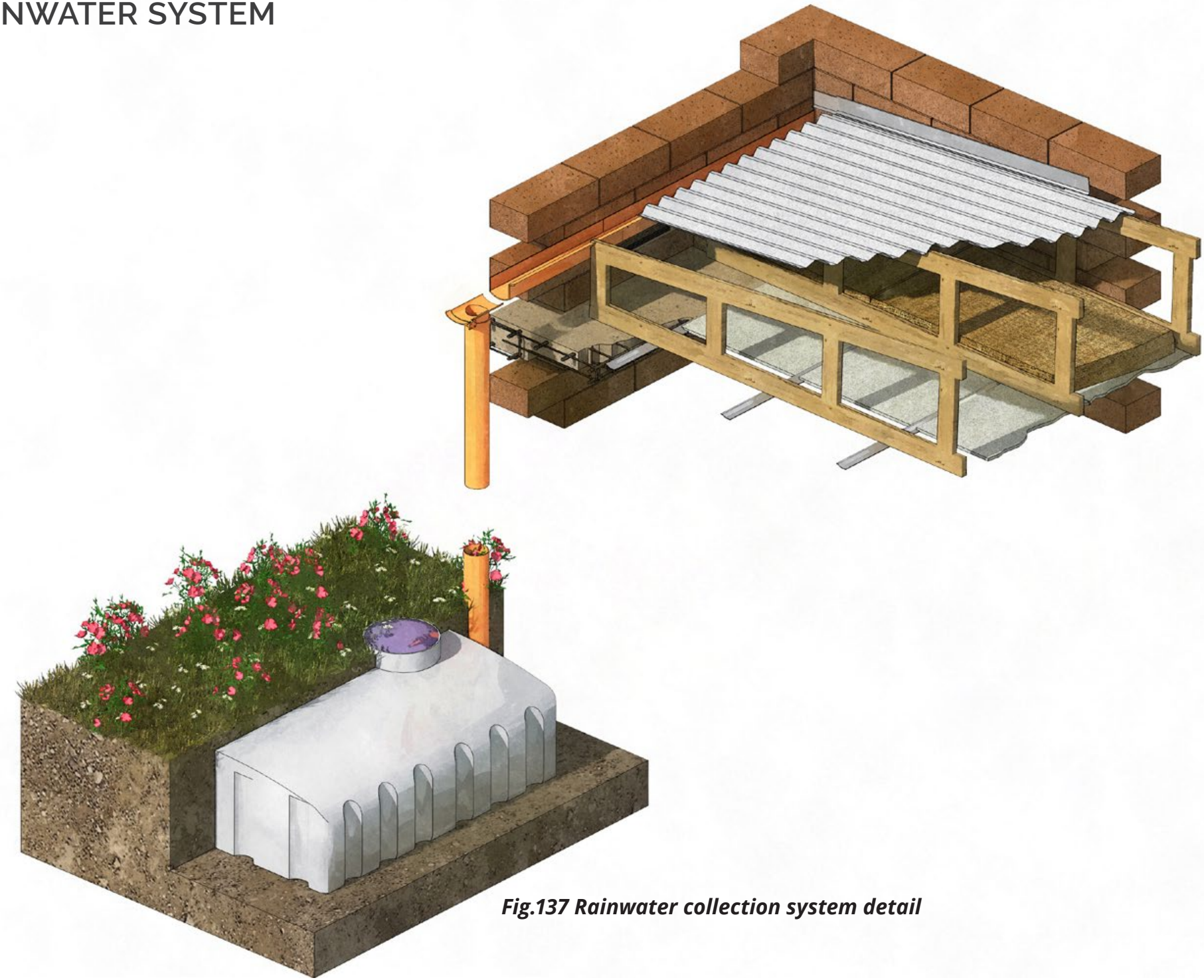


Fig.137 Rainwater collection system detail

PROJECT CONCLUSION

THE HOME OF TODAY

The discussions resulting from the interviews make it clear that the common thread for designers in Mozambique is creating a building that can last, regardless of client intervention after the construction phase.

This attitude does not address the impact of buildings that have long life spans but do not present a flexibility in design, function and use. This can result in a large building stock in several decades that is very poorly adapted to the requirements of future generations.

Similarly, by focusing on construction techniques that are linked with materials that require periodic maintenance, such as thatch roofs, may result in dealing with another aspect sustainability - social impact of providing jobs in the built environment industry. This is an important consideration in this context, where a large percentage of the population struggles financially.

THE HOME OF TOMORROW?

Sustainability in Mozambique today is limited only to 'what is considered sustainable to the person building it.' This is an unfortunate approach that ignores the impact of the built environment.

This thesis studies the contextual restrictions in terms of economic and social aspects and identifies 'environmental opportunities'.

These are concepts that can be easily adapted or incorporated in the Mozambican context that would not involve substantial additional capital to implement, but would have beneficial environmental impacts when compared to the conventional construction practiced today.

MATERIAL CHOICE

- The building industry in Mozambique today is very focused on cement products.

This is a result of an Eurocentric approach to construction techniques, which has resulted in a neglect of vernacular and traditional local building techniques that employ natural elements.

The existing examples of a vernacular approach are primarily by inexperienced builders done for the population with the least financial means. This results in poor construction quality, which perpetuates the idea that natural materials are inferior quality.

The value of this thesis proposal is to break that stereotype that natural materials translate to inferior building quality and finishes.

Thus the choice of building materials that rely little on the cement industry was a conscious one.

At the same time, the limited financial capacity of the average home builder means that the building must be able to be relatively maintenance free for long periods of time. This is why CSEB was preferred over other materials such as bamboo, and metal sheeting over palm leaves, which are biodegradable and thus have a lower life expectancy.

PROJECT CONCLUSION

WOOD IN CONSTRUCTION

The interview discussion also highlights the high cost of building with wood in Mozambique.

This is a consideration that was taken in the thesis proposal, where the only structural elements made of wood is the roof structure of bedroom modules.

The alternatives would prove to be cheaper as an initial building cost for the client, but would strongly go against one of the core principles of the Master Thesis of creating a proposal that also deals with the environmental impact of the building.

URBAN PLANNING

The thesis explores existing design guidelines and speculates on additional elements that may be incorporated, mainly in the environmental arena, but specifically at an individual building scale..

This work can be taken forward by zooming away into a neighbourhood or even district planning scale to understand the relationship of several homes, for a better incorporation of these services (sewerage, water management, biogas).

TAKING THE PROJECT FORWARD

The thesis focuses on the home as a building object, without exploring its specific relationship with the site. This was done purposefully, linked with the concept of modular design so that the proposal could be a generic model to be utilized in different contexts.

This can be improved on in the future by identifying future potentials in specific implementation sites, so the building can be tailored to that context. This would lead to a development of the yard as possible social component of the design.

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FIGURES

NOTE: Figures created by the author are not listed.

Fig.5 Mozal in Maputo, n.d. photograph, viewed 10 February 2015
<http://web.archive.org/web/20080430144716/http://www.mozal.com/>.
Fig.6 Maputo suburb with typical constructions, n.d. photograph, viewed 10 February 2015

<http://sprysafricanadventure.blogspot.se/2012/10/maputo-mozambique-oct-12-13-2012.html>

fig. 19 *Maputo Solar Chart*, Bonito, J. M. (2011) ***Arquitectura Moderna na África Lusófona: recepção e difusão das ideias modernas em Angola e Moçambique***, MSc thesis in Architecture, Technical University of LisbonFig.21 Map of Maputo in 1878, then known as Lourenço Marques

Fig.22 *Expansion plan for Lourenço Marques, 1887,* Bonito, J. M. (2011) ***Arquitectura Moderna na África Lusófona: recepção e difusão das ideias modernas em Angola e Moçambique***, MSc thesis in Architecture, Technical University of Lisbon

Fig.21 *Map of Maputo in 1878,* Bonito, J. M. (2011) ***Arquitectura Moderna na África Lusófona: recepção e difusão das ideias modernas em Angola e Moçambique***, MSc thesis in Architecture, Technical University of Lisbon

Fig.23 *Downtown street, 1890s,* n.d. photograph, viewed 15 February 2015

<https://delagoabayword.files.wordpress.com/2010/10/rua-araujo-1900-s1.jpg>.

Fig.24 *Indigenous street, early 1900s*, n.d. photograph, viewed 15 February 2015

<https://delagoabayword.wordpress.com/category/racismo/a-se-catedral-de-lourenco-marques/>.

Fig.25 *Lourenço Marques plan, 1929,* Bonito, J. M. (2011) ***Arquitectura Moderna na África Lusófona: recepção e difusão das ideias modernas em Angola e Moçambique***, MSc thesis in Architecture, Technical University of Lisbon

Fig.26 *Indigenous neighbourhood, 1910* n.d. photograph, viewed 15 February 2015

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Fig.27 *Railway station, built 1916*, n.d. photograph, viewed 15 February 2015

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Fig.28 *Downtown avenue, 1920s*, n.d. photograph, viewed 15 February 2015

<https://delagoabayword.wordpress.com/category/racismo/a-se-catedral-de-lourenco-marques/>.

Fig.29 *Streamline modern style, 1930-40s Lourenço Marques*, n.d. photograph, viewed 15 February 2015

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Fig.30 *Modern style building, 1950s Lourenço Marques,* n.d. photograph, viewed 15 February 2015

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FIGURES

FIGURES

INTERVIEW QUESTIONS

Notes:

1. I will use my better judgement to pick and choose some of them to be the guiding questions for the rest of the conversation, depending on their own interests as well.

2. There are different questions for practicing and teachers. But many of the academics are still practicing. So the actual interview may be a mix between set A and B. This distinction is more helpful for me, when I categorize the relevancy of each answer for the different thesis chapters.

3. The phrasing of the question is less important than the insight the answers might give me to their views on sustainable design in Maputo.

4. The interviews will be conducted in portuguese, but for the sake of thesis structuring and relevancy, I first thought of them in english.

QUESTIONS FOR PRACTICING ARCHITECTS:

1. Rhethorics: definitions and principles

A) What is your understanding and opinion regarding sustainability and sustainable design as it is practiced in Maputo, from a designers perspective?

B) How do you see the current urban and suburban home developing, in regards to sustainable design?

C) What are the design goals you seek to achieve in all your projects, regardless of specific client briefs?

D) What impact or weight does the typical clients knowledge/expectation have on your ability to set these design goals?

E) What are the resources and references you currently use to achieve your design goals? How do you see their work as relevant to these goals?

F) What resources or knowledge do you believe would be most beneficial to designers in Maputo, that they may currently not have access to, to aid them towards better sustainable design goals?

G) What reaction have you noted from the public and designers exposure to local and international sustainability-oriented projects?

H) How big a role do you think the clients and public have, in aiding the urban home landscape develop towards sustainable design?

I) What are the challenges in your experience, to shifting the public participation in sustainable design from a passive to active viewpoint?

2. Construction in the context: material and technology

A) What are the types of homes that clients are interested in developing? Has this changed?

B) What are the construction materials that you used in the past, and how have they changed now?

C) What materials do you know are available, which you have not employed? Why not?

D) Similarly, how have your construction methods changed, if at all?

E) Which methods have you chosen to not make use of, and why?

F) Along with client budget, what are the other contextual considerations that affect material choice and construction technology employed?

QUESTIONS FOR ACADEMIC ARCHITECTS:

1. Rhethorics: definitions and principles

A) How is sustainable design understood from a design principle point of view, and what role does it play in academia in Maputo?

B) What is your understanding and opinion regarding sustainability and sustainable design as it is practiced in Maputo, from a designers perspective?

C) How do you see the current urban and suburban home developing, in regards to sustainable design?

D) What fields/principles have changed or been introduced, with a greater emphasis in sustainable design?

E) what are the design goals you seek to achieve in all your student projects, regardless of specific client briefs?

F) What impact/weight does the typical clients knowledge/expectation have on your students ability to set these design goals?

G) What reaction have you noted from the public and designers exposure to local and international sustainability-oriented projects?

H) How big a role do you think the clients and public have, in aiding the urban home landscape develop towards sustainable design?

2. Education in the context: student discourse and aptitudes

A) From your professional perspective, what are the strengths and weaknesses of the existing education, in regards to integrating sustainable design principles in students?

B) What are the challenges students face, once practicing, in applying these same principles?

C) What are the resources and references you currently use in teaching these design goals? How do you see their work as relevant to these goals?

D) What resources/knowledge do you believe would be most beneficial to students in Maputo, that they may currently not have access to, to aid them towards better sustainable design goals?

INTERVIEW: MIGUEL CESAR

Interview with Miguel Cesar Santos, partner architect at ArquiPlan, lecturer and course coordinator of Architecture and Planning at Instituto Superior de Ciencia e Tecnologia de Moçambique (ISCTEM) .

Note: The interview was conducted primarily in Portuguese and transcribed into English afterwards.

What is your understanding and opinion regarding sustainability and sustainable design as it is practiced in Maputo, from a designers perspective?

MC: To talk about sustainability in Africa is already an almost immeasurable step.

Sustainability in Africa is a concept that can be considered utopian at this time. It seems that everyone has the idea that sustainability is an issue that even the poor can do and that's not true. To be sustainable one must spend a lot of money.

Our population is mostly technologically low, whether rural or urban. Our population is rural living in urban areas. Even those living in high-rise buildings have rural attitudes. They have absolutely no awareness of what sustainability is. It is an extremely difficult concept to understand and apply.

We offer sustainability as a discipline in the Architecture and Planning course at ISCTEM, in which I participate. Students have during a semester the theme of sustainability: what is a sustainable home.

Then what we try to instil in students is that sustainability should start in the choosing of the materials themselves that become the house. But we must not confuse sustainability with precarious materials. No one wants to build a house that is precarious and that may fall apart in a short period of time.

They want a home that is economical, that they can maintain over time and that the materials used do not endanger the environment.

Unfortunately in Mozambique the middle class, which in the European context is the dynamic class that drives progress, is inexistent. We have no middle class.

We have people who come to a high academic degree: doctors, masters and graduates, but the salary they earn is not a middle class salary. It is a lower class salary. So there is a struggle for them to keep up with life in a comfortable level. With the little money they get they want to be able to build something that reflects their qualifications and their social status.

They don't have much money to spend, but want to reach that level. It is the architect's role then, to be able to accomplish very much with very little.

There are sustainability concepts in Europe that do not fit at all with our context. Sustainability in architecture here is trying to achieve quality, anything that lasts long and that at the same time is very easy to maintain.

We at ArquiPlan have been specializing in schools and hospitals in recent years and we are using materials from the start may seem a bit expensive but at the same time we have to think that for 25 or 30 years there is no money for maintenance at all.

I'll tell you a little story that seems ridiculous but is true. We did 15 years ago a hospital in Mocuba. We placed in the surgical theatres ultraviolet lamps that serve to sterilize the environment. After 13 years we visited the hospital because it is a rule to see what the maintainability was achieved in the hospital.

We were going to go into a surgical theatre when the nurse shouted "no, do not enter because I'm doing sterilization!" We look at the lamps and saw that they were regular fluorescent lights.

She had picked up the broken UV lights, gone to the market and exchanged them with normal fluorescent lamps. And thought that was sufficient to continue with the sterilization process.

This is the level that we the architects need to re develop a project. Always stay ahead of the problem and see what will happen when this object is delivered and built here. Five years go by and we must ask 'what happened to this object? Did it stand or not? What broke?'

There are many health centres in remote rural areas, where to do 200 km it can take a whole day of traveling because there are no roads, no infrastructure.

You have to go in 4x4 cars and never go alone, always going with a satellite phone to call for help if necessary, and in our case it has been necessary. We have had serious accidents on the road.

And when we arrived there the car in which we travelled was a spacecraft because no one had seen a car in the last 30 years. The car mirror was the end of the world, everyone wanted to look at the car mirror, and we were in 2014.

The technology that we brought just to make a small survey of the area was several centuries above what those people had. The administrator of the district when visiting there, goes once a year and arrives by bicycle because they have no other way.

Electricity is a subject for debate in a few years, perhaps. The level of that population is very low in social and technology terms. We think "the health centre that will be here, what will happen to it?" We will put a flushing toilet and they will be there using the handle until they understand how this works.

Should the window have a hinge? Should it have a clasp? Or must we design a piece that serves both as hinge and clasp? This led us to have the long and arduous task of preparing the centre for the strong pressure it would receive from the population. The centre had to endure all they do not know and that they will have to learn in practice.

Then we are confronted with a situation where we do not know very well if we follow the Ministry of Health rules or if we give up some rules to get the centre to become sustainable.

We are in the same country where the Maputo Central Hospital, which is 2400km away from this health centre on the border of Zambia, is on a very high level of technology, with all the specialized medical equipment. And this health centre requires us to discuss whether the windows can have hinges or not.

We live with these two realities. I've been designing a high-tech medical laboratory. For the first time in Africa, excluding Johannesburg which is an atypical case, we will have a security level 3, which means that people who enter this laboratory use hazmat suits and have rigorous security protocols for handling viruses and bacteria and other genes that exist.

At the same time we have the man who makes a malaria test in the most remote health centre we made and because he has no extra blades, he must wash the blades of the previous patient. He has to wash, disinfect in the sun and then re-use it.

INTERVIEW: MIGUEL CESAR

We have these extremely different levels. The laboratory is highly specialized and the question is whether the state will be able to maintain this lab. It is so expensive that only their annual maintenance destroys any state budget.

They will enter discussions regarding where they are going to arrange funds to be able to keep this lab, because it is extremely important for the country. It has all the technicians, specialized all over the world. The problem is the budget, because we have health centres where the technician has to wash the blades and re-use the same gloves.

So sustainability for me is to achieve longevity with minimal maintenance. To build with materials that under any crisis situations does not require client-side maintenance. And that we have been able to accomplish.

> You mentioned precarious materials, that it is very easy to confuse sustainability with certain classes of materials and for you the longevity of the material and the building are very important. In such a remote context as this, what kind of materials can you use?

After much discussion, we have managed to combine several strategies.

Building in reinforced concrete at this distance is impractical because it is necessary to carry everything and in the end we can not even ensure the concrete strength. There is no laboratory close by to deliver the cube to and test to see resistance. There is no sure water for the concrete and we do not have the proper inert.

To ensure that the concrete is B25, the minimum resistance for a structure with a second storey, we don't have the ability to technically verify if it is true that the concrete is produced with these qualities. Some of the health centres were made of concrete. The contractors did a huge effort to be able to meet with the project then.

What we have used many times is metal structures with steel frames that are made not there but in factories, demountable so as to be as Lego, that they are movable and easily assembled. It has an ideal size to get on a 4 or 5 ton truck with traction that can travel on rough land. is transportable and are easy to assemble.

Half a dozen screws, half a dozen parts and we have the structure that supports the roof.

When it exists, local stone. Instead of building concrete foundations we build the so-called Cyclopean Concrete. Choose the big rocks and large stones to lay them with the crossing stack bond, with mortar and we build the foundations so.

We leave a space to work as anchor for the metal frame thus we have a foundation made with local materials, stone, and with a structure that comes from the factory, which is transported.

What can be done in local stone is done in local stone. If there is none, we must bring in cement blocks.

Painting is always a problem. The painting of metallic elements always presents a challenge, because we have several different climatic conditions in the country that act differently in steel. So the painting is done in the factory. The company that makes the structure delivers it painted and ready. Small retouches are done on site.

We do not use plaster or normal paint on exterior surfaces. The teams are trained so that the walls are laid perfectly smooth, without holes. The blocks are set very firmly in principle to have a smooth finishing. Then on the outside is used a product called Cemor, a cementitious paint. It coats the wall and does not let water in. We do not spend money on plaster, because it forms a sticky surface. Cemor has a 25 year warranty without any maintenance.

The interior surfaces of the health centre need to be plastered without any doubt. It's all plastered and painted.

Suspended ceilings are used almost glued to the roof. To create a very good thermal tolerance glass fibre mats are glued between the false ceiling and the roof.

We use as many windows as possible to permit good cross-ventilation, in order to not have to think of air conditioners because in some cases it is not possible since there is no electricity.

We use photovoltaic material to generate electricity in three places within the health centre: have light at night in the delivery room because women usually give birth at night; lit emergency light; refrigerators which store perishable medicines and vaccines.

But then we know that the nurse is disconnected from the world. They studied in Maputo or Nampula, and when they come to this desolate health centre they are cut off from the world.

So we have done work with the Ministry of Health where one of the photovoltaic panels are for two things: charge the cell phone for him to be communicable and have a TV.

We have a highly sustainable architecture where we have to introduce the latest technology to solve this social problem of nurses and at the same time solve the technical problem that are perishable vaccines.

The materials that are used in the interior floors are ceramic. There is no timber in the floor. It is all ceramic in order to be washable.

The windows, when possible are done in iron. When it is not possible they are wooden. Some of the structures we use are Micrusse, a national wood not attacked by pests. It is extremely tough, very difficult to work, as it is called 'iron wood' and it has to be worked wet. When dry it does not allow the saw, a nail or drill. So it is crafted wet and can be used to build the roof structures, beams and lintels over doors and windows. It has very high strength.

All other traditional materials such as grass, laca laca or other types of wood are no longer used because it does not cheapen the cost. After 10 years we have to take everything out and rebuild. In the long term they are more expensive than it looks.

The roof is always metal sheets. We generally use a sheet which is of South African manufacturing. The interior section 0.6mm and as we come closer to the edge 0.8mm. We always used it in its total length, there are no intermediate cuts, no wastage.

We do a study of the construction companies and have compulsory visits to their factory site to see how they work, to guide them to the methods and the rigour that we want. And when we find that the teams do not have the ability we require we organize mini schools to prepare for it.

What are the construction materials that you used in the past, and how have they changed now?

Totally. The country leaped forward. What was available on the market 20 years ago was one thing. Now the range of choice is very large. And within this range, it is important to stay within those that fit the context. Usually the money that comes to these things are not elastic. They are predetermined amounts and we have to draw according to those zeros that are there in front of us..

Regarding the choice of materials, we lean towards those that give us greater durability.

Galvanized iron for piping was very common before. We took all that is galvanized and all that is metal out of water adduction..

There currently are materials that are vulcanized, there are materials that are threaded. Companies are already introducing this technology, so that there is added durability on something that is very complex, which is the water supply system.

Regarding water supply, we make the hole closest possible to the health centre to cheapen the pumping process. But here we have always a double standard, because the population around has no water and the health centre will be the first water supply point.

INTERVIEW: MIGUEL CESAR

Generally what the Ministry of Health does is to give availability of the water hole to the population use. The less sick people there are, the less problems the Health Centre will have.

But there are remote sites with no water. Sometimes we must dig 120, 130 metres deep to catch water. And in places where there is no energy we use solar panels and solar pumps.

Similarly, how have your construction methods changed, if at all?

In some places we had to return to the arch. So the problem here is that to overcome the gap in a window, we normally use a concrete beam. There are sites where finding stones and sand for concrete is too hard, so we again introduce the arch in the construction performed in blocks.

You must train the bricklayer once and he then repeats the process. Teach them how it works, how it is drawn with a stick and string, and he then understands how it works. This is to remove the steel from the construction.

We often use bearing walls. The wall itself is bearing, without the use of concrete piles or concrete belts.

We found many places with no stone. Or where there is limestone and in the presence of steel it is corroded because it has a very large salt rock content.

We have other cases where it is extremely difficult to built in concrete because of the lack of sand and other cases where to carry inerts to the site to do the concrete is expensive. So we have to play with all these factors each time we find a situation, see what is the most correct way to put the building up.

We made buildings without a reinforced concrete structure, using cross-walls and walls with buttresses, all using the cement block.

Something the English introduced here in South Africa which is called "brick force", an element wire that comes in rolls applied every two rows to give a greater resistance to compression in the cement block wall.

The very foundations do not have to be done in concrete. We use the wider cement block and fill it with mortar and stones and reinforce it with the brick force.

At the main points of failure we place buttress wall to stabilize the system. And then they are not only used as buttresses, but also as a piece that will solve the entrance of the house for example, which is at the gateway, always trying to find a way to make good architecture with less money. Good architecture with good engineering.

Our engineers are not trained for this. The universities give too much focus to large reinforced concrete courses and metal structures and too little to other technologies such as bearing masonry.

Wood construction here is not very common. It does not appear much in architecture, besides in ceilings and roofs. They are rarely in walls and floors. Is that because of the cost?

This is not only the cost of wood. We are in a humid tropical climate and even in the dry tropical we have two types of insects. The 'muchem' and the 'broca'. These two types of insects are not gentle with timber. All that is softwood, which has a very high cellulose content, they eat it.

Pine woods, 'beto', are all eaten, there is nothing left to tell what happened. In South Africa there are areas that are already using houses made of wood but with extraordinarily expensive treatment processes. They undergo autoclaving, where a insecticide gas is introduced to impregnate the wood. The pine wood goes green. The eucalyptus also gets the green tint that is results from the impregnation of chemicals in the wood.

For a country as industrialized as South Africa it is normal. Here the use of pine wood would have a very high cost for those who want to build. We would have to import the wood.

Our national wood unfortunately is not structural. Pine is extremely structural but national woods have short shaft, they break very easily.

To have structural wood with domestic woods we have to do very deep trusses and the national wood has an extraordinary weight. A wooden door can weigh 120kg. We need two men to put the door in place and work the door.

They are also mixed with a very high drying time. The Chamfuta and Umbila wood for example need 45 days after being sawn to dry, to achieve the workability rate in the 45% humidity. Only after about 1 year does the wood reach 3% moisture and can be said that it is now dry. And then the door is still very heavy.

We also have extremely heavy timbers. There is for example the Missanda which has a beautiful colour, turquoise when dry. One meter by one meter by 10 cm, 5 men to lift because it is extremely dense. Not even a nail enters it, It looks like stone. During the drying process it fossilizes.

They are very beautiful woods that are used in furnitures. The woods are used for decoration, widely used for outside outdoors and plywood surface that need to be beautiful. They are extremely expensive and difficult to work.

From your professional perspective, what are the strengths and weaknesses of the existing education, in regards to integrating sustainable design principles in students?

ISCTEM's Architecture and Planning course is very new, we are seven years old now. It was opened with the motto "know how to do". It not only had a theoretical but also practical approach. This practice is extremely difficult to do within a university. The new universities are extremely academic. There is great emphasis in theory and the great thinkers.

But it does not prepare students for what will happen in the labour market. So most of the students are coming out with some very large gaps and conflicts with the architectural offices where they are going to work, where they are forced to work as a team. They will not draw the most beautiful building in the world. They must first learn to be architects.

Neither UEM (Universidade de Eduardo Mondlane) nor ISCTEM prepare students for this, despite our lessons have in focus this requirement that the student know how to use the tools that they are going to use when in practice, We do as much as possible during the course to go visit sites outside the classroom. Ask questions of what is being built out there so that their curiosity feeds the answers that teachers can give. This is the goal.

The student is always faced with the need to think. We in ISCTEM do not like the student who does not think. The student who does not think should go home.

Our students come with a very large gap from secondary education. There they are not taught to think, but are instead taught to absorb what the teacher is saying. Here they are forced to think..

What are the resources and references you currently use in teaching these design goals? How do you see their work as relevant to these goals?

There are no good national references from the last 20 years. What is being done in architecture now is that there are obelisks to each person. The person says "now I have money, I want a palace!"

INTERVIEW: MIGUEL CESAR

I have a colleague who began building the palace when had three children in school, all in secondary education. Ten years later they have completed university and he is alone in the palace with four bedrooms, three bathrooms, and he says, "and now what am I going to do this?"

He thought at the time that the family would be forever that size and that each had not ways of thinking, that each would stay there. In fact the children grow, as the birds fly from the nest and rightly so. They create their own lives.

Now with four bedrooms, a lounge, a gaming room, a garage for three cars. A huge mansion that he is now thinking of dividing to see if he can rent out part of the palace.

References of houses that have the sustainability criterion do not currently exist.

The fund Housing Support tried to create this sustainable version in Kongolote. An idea in Inkata, which is a condo for the area of Mlhampsene. But then they failed to reconcile the cost of housing and dreams for a home for the person who will live with such sustainability.

Some 30 years ago there was a process within the Ministry of Public Works. There was a department called Habitat, which started drawing this issue. This was named "the evolutionary house." It started as a room that was both a room and a living room. Then everything was designed so the person after some time had a three bedroom house, a lounge, bathroom and kitchen. Done gradually over time according to a certain design. It was very successful this evolutionary house in the population, but then the war destroyed all possible concepts. The plots that had been recommended for that disappeared, were donated and the process has become a mess.

But for me it was the embryo of an idea of sustainable home and I continue to believe that for our population it would be the best attitude. People have no money to built the house all at once, but if you have a plan for tehm to know "if I start with this room, when I have more money next year I can do that, and continue." So they can first manage their budget, they can also manage the building materials to buy.

There is a lack in integration for this process, what are the materials that are more durable in time, which are those that require less maintenance, and what are the rules introduced in building technology for the house to have a good foundation and construction upwards. What rules do you have to follow to be stable and does not require a lot of maintenance.

And it was lost over time in the department at the Ministry of Construction. Right now no one is in the country to guide this process. But in the course of sustainability in ISCTEM again we try to introduce these concepts so that students think not just of a complete house, but think rather on what can be done with a small budget, little by little, so that the person who will build can manage their economy.

Where do the people in the suburbs get knowledge to make their housing projects?

There is no monitoring, no formal training. What happens is that in the public there are many designers. In comparison to the city, the suburbs has lesser requirements in terms of rules and regulations to conform to.

Low income builders do not have the same requirements than that if someone builds within the city of Maputo. There is in each municipality a department that is tasked with walking the neighbourhoods and see what is happening in terms of construction, if they are building in protected areas or not.

Not long ago they had to demolish a lot of home, some 300 houses that were built in a water pressure basin.

The pressure basin was filled with houses and was creating major flooding in other neighbourhoods. And the city had to demolish houses that they had previously approved.

They approved the construction, but no one remembered seeing the plan where it was designated a water pressure basin and now they had to demolish them and there is no money to compensate anyone.

It is a somewhat complicated process but the municipalities do not have enough capacity to make this technical surveillance and take care of these processes.

How is it being built? It is the wisdom from Mason to Mason. The Mason passes his knowledge to his son wisdom, and if he made mistakes he also passes errors. The child can now commit even more errors. There is an error wisdom and wisdom of things well done following simultaneously which is transmitted and everything is built more or less. No steel rule or anything.

Our concrete rules requires that the pillars have four re-bars 12mm and having braces or straps 6mm and the spacing at 14.5mm. I've seen iron in 8mm vertical pillars, iron braces 4mm and the spacing at 30mm, and the house is standing.

There are houses on soil, with no foundation and zinc roofing. I have seen many porch roofs fall in the suburbs just because all the iron that there is not mounted according to the rules or with the correct diameter. So after a month, two months, it begins to bend and go down.

There is not an attempt to catch the masons and give a lesson of good rules. The Ministry of Public Works, after the independence, opened a school to form master builders, masons and carpenters for the country, but the school closed long ago.

All the masons and carpenters who are around have their wisdom originating from word of mouth.

They look at the neighbour's house and say "It did not fall, mine can be done the same."

> The different faculties can instil different principles when they look at the Vernacular or give more emphasis to the standardization of the International Style. Is there this duality in Maputo with ISCTEM and UEM?

We try to always show the student the widest possible range of what exists in the world.

Never push who is learning one way or another. You show the entire range, these tools are to build a multi-floor building with multi-functions, shows always images of what is done in the other side of the world, of other architects. Put the student confronted with how to design a building like this, and go from this large complex to the small cottage. He has to have the whole range of vision so as to learn that there is not a single construction methodology, one use for each of the materials, so there is no one method in architecture, there isn't a school that makes the buildings all square, they can also be curved.

We try to show the student that the sky is the limit but he has to have his feet always on the ground, for this they have to have full technological and financial understanding.

We do not restrict the student to one line of thought.

INTERVIEW: LUIS LAGE

Interview with Luis Lage, Director at the Faculty of Architecture and Physical Planning in Universidade de Eduardo Mondlane (UEM), partner architect at DOMUS,

Note: The interview was conducted primarily in Portuguese and transcribed into English afterwards.

What is your understanding and opinion regarding sustainability and sustainable design as it is practiced in Maputo, from a designers perspective?

LL: Well, first you may think of the concept of what is sustainable.

Sustainable concept is something that endures, and that somehow does not affect even the environment and endures over time also for future generations.

Sustainability means a process that is maintained over time.

Sustainability in the case of housing, we think of two ways, one thing is sustainable house that does not affect the environment, that endures over time and does not damage the environmental development of the Earth,. Another thing is sustainability of the house the concept that it is sustainable for the builder. the concept of transmission and durability over time.

These two concepts are two issues that must be seen one connected to the other. The three areas of sustainability: social, economic and environmental sustainability or just on the economic concept, what is the capacity that people have so they can build sustainably.

How do you see the current urban and suburban home developing, in regards to sustainable design?

Naturally, it is only the economic that practically develops.

The city has a duality. There is a town of consolidated cement with infrastructure and there is a second city that has grown very quickly and that in thirty years developed high density areas and has no infrastructure.

The cement city is not an inclusive city though, and has large infrastructure related problems when it comes to access, energy, sanitation, etc..

If you ask the buildings that are being made, the new ones that are being built, this new charge that the city has, is it sustainable? Well, I will say that it is sustainable for those who will use it, for a particular social stratum, with certain economic resources.

But if you ask me if they are sustainable buildings, observing environment-related issues, the relationships you have infrastructural needs, I will say no.

I will say that we continue to use cement, which is a material that by itself requires many energy sources, and is not really ideal as a construction material. But it is the ideal material that we have.

There are virtually closed buildings where the air conditioner is fundamental to the climate, and without it they don't work.

There is here a great contradiction. On the one hand it can be said that they are not sustainable for the impact that they cause, and on the other hand they are sustainable for the occupation of the person who will use them.

Unfortunately this is only applicable to a specific class, as I said, of a privileged few and this is for the cement city, the consolidated city.

The other side of the city, the suburban city,, because what people are doing is what they can afford and what is allowed by their economy.

They are building houses over several years, saving, for example a bag of cement a month, a metal sheet another month, so it is a sustainable way to be able to build their homes.

But if you ask me if these houses are environmentally the best, probably not, nor the materials nor the construction process, not the outcome that they offer. The houses are only covered in zinc sheeting and have deficient housing capabilities.

Before independence the first actions of the colonial government was to reorder somehow what was the informal occupation of the city.

The occupation was done in such a way so the people who lived on the outskirts of the city lived in houses in disrepair, and that was the rule they imposed.

The land ownership was defined, and the few spaces where there weren't Portuguese, those indigenous peoples who worked in the city of cement could group up and live.

It must also be said that in the 60s in the 70s there was great concern especially the city hall of Maputo,

It did great deeds in the urban outskirts of the city to reorder what was the occupation that existed, to facilitate access to it, as the country lived in a war situation.

The redevelopment of these areas also served to facilitate access, and population control as Mozambique was going through a moment of liberation. It was important to control the population within the city.

Since then, after independence, the city grew a disorderly bit. There was a flood of people in the early years after independence of the country to the city. They came to get in Maputo city about 120 000 people per year.

So it was because of this great flow and urban growth that 'operation production' came. It was a way of trying to lock access to the city of Maputo and as others, but especially Maputo.

After that, of course the suburbs grew and it grew from an organic and disorganized way.

It now is the way it is, with areas that are not urbanized, areas that are semi urbanized and areas that are highly urbanized. All in the periphery of the cement city.

> What are the design goals you seek to achieve in all your projects, regardless of specific client briefs?'

When we discuss housing we talk of living space and its comfort. When we talk about comfort we have to think what are the parameters we have for comfort, temperature, lighting, ventilation, etc., what is our physical space?

I think the ideal dwelling is one, similar to as Corbusier described, regarding the concept of the machine to live in..

I look for the middle ground between having the comfort eg temperature, lighting, ventilation, sound and space,

The materials that allow me to give this comfort without having to resort to other energy sources and other technological solutions,

I think I'm creating a space that is ideal. The ideal place is one that obeys the rules for a good sleeping space, the comfortable space for internal movement, the need to be eating, to have personal hygiene. These are the questions that are ideal premises.

> What are the resources and references you currently use to achieve your design goals? How do you see their work as relevant to these goals?

First look at what is done.

I think there is not so much written out there. But the first thing to do is observe.

First look at the city, especially any project that is being done anywhere. We first have to look through it, Be in the middle of it, feel it, understand the guidelines, see the land.

INTERVIEW: LUIS LAGE

I say this because the terrain talks so much with us. If you have a slope, if it is porous. The water falls and runs. So there are things to be respected. The water flows on the surface and our intervention will cover the soil with a building. We have to treat the water way.

Looking for guidance, for what is around, looking at vegetation, it all works. Protect the flora, giving it a convenient orientation, dependent on where you are.

After using the best possible materials. Those which are suitable in the sense that they exist, are on the market in Maputo. And they have a good performance, such as thermal, etc.

The sources of inspiration are always the magazines, although the magazines only have bad designs, which are not suitable to the environment and the area where we are. The weather conditions we have are very different.

We just need to build to protect ourselves. If I want to build on the North Pole, it is completely different from building in the desert. Our protection for my comfort are different from area to area. There are no rules, and the book does not seem to be the most appropriate. These magazines, pictures, which give us and can give us what is important is the aesthetic, excite us with something, with reading, for a picture. But I think we should not get stuck to these images.

What resources or knowledge do you believe would be most beneficial to designers in Maputo, that they may currently not have access to, to aid them towards better sustainable design goals?

We are in a phase of knowledge globalization. Knowledge can not be restricted. It has to be as open as possible. What is right today, tomorrow may not be. Science progresses.

We should all look at the world, in a critical way. We must be open to what is happening in South America, in Africa, in Asia. I am talking about a certain latitude. I'm building and design here, things that are in geographical areas of the planet with the same latitude and climate as mine and see what is taking place there and why.

We also discover all solutions to our problems.

The Internet, any communication apparatus is important to obtain knowledge, this exchange of information. The process of education and training is a process of dialogue, confrontation of ideas. If I do not rub my idea with another idea I'm not going to learn anything. This is important.

What reaction have you noted from the public and designers exposure to local and international sustainability-oriented projects?

First customers have stereotypes. We all have different cultures.

In our training we become accustomed to rationalizing certain spaces, and what happens is that the customer does not realize this.

Unfortunately, something that happens, culturally we are staying with stereotypes that are not ours, with values and signals that are not informed by design concept.

This is an exercise that the profession requires. The architects capacity must be carried out with the client - the dialogue, call them to reason and try to understand.

Sometimes the problem is not formal, but the economic costs that must be borne by surface elements, unnecessary, to obey these stereotypical images from the client. This is an exercise in dialogue,

There are situations where the customer arrives with magazines and an image. They want to make us their hand. Any of us know that when you have a pain we go to the pharmacy, and any of us also is convinced that to solve the problem of the house we all can do equally well.

Now, they often think that we are their instrument, e.g. the customer's hand to draw their project. But that's part of the profession.

How big a role do you think the clients and public have, in aiding the urban home landscape develop towards sustainable design?

The best customer is the one who knows very well what they want, the program they want. And besides that, they have great confidence in the architect for him to develop the project.

And that accompanies the sense to realize and understand. The exercise of creating a space is not an easy one, because we professionals have realized the quality of the space we are creating.

The architect has an image, the image transforms into the drawing. And the customer does not have this perception.

I had cases where we were designing schools with a particular area, comfortable, and respecting the space per student. And when we were in foundation stage, suddenly the client said that this here is very little, that not be any good.

Some people think that there is such a solution in the international style, which deals with standardization, and some people decide to look at what happens in context, the tradition, the vernacular. How is this discussion here in Maputo?

This school has focused on the practicality of detailing the construction project. This requires the students to understand the reality of the site and the characteristics of available materials.

On the one side this is good because the professionals leave the school knowing how to work in this context, understanding the constructive methods, knowing the materials, knowing the problems of designing in relation to the comfort in this environment.

International is also global. To look at what is happening outside, if this helps shape the building, provided that the form and function are in any way connected and functional, I have nothing against a form that comes from outside.

As long as I can understand how you use it and give the comfort and the necessary environment, and the functionality necessary for what needs to be designed.

Regarding the vernacular, we must also learn how to build. Because housing is a secular thing. People have always been building. There is a knowledge that exists there, in this process.

What are the construction materials that you used in the past, and how have they changed now?

When speaking about the new materials, new equipment: glass façades. Steel and glass. Steel is not a bad material, as long as people know how to work with it.

When speaking of aluminium in windows, the problem of the window is an interesting one. The window here in Mozambique is not just a hole. It is an indoor / outdoor relationship. It is a lighting comfort ratio. It is a ventilation ratio. It's all that and more.

It is also about security as it is through the window that thieves come in. And not only that, it is also safety control for an insect that kills many people in this country, which is the mosquito.

When you make a window, you use glass and a screen for protection There are a number of established principles.

Normally the window was made of wood. It is now clear that the timber is a material which unfortunately is not being produced to a marketable scale. It is more practical to do it in aluminium. Today aluminium is entering here in Mozambique.

But the aluminium window no longer meets safety requirements, when it comes to the screen. So this already on the one hand reduces the performance of the window. The wood can last if it is protected.

INTERVIEW: LUIS LAGE

When aluminium begin to have these security performances against insects, against the intrusion, vandalism and the bad guys, it will probably be easy to replace the wood with aluminium.

The incorporation of new materials has to happen so that people realize their satisfaction for the performance they offer and also for its use.

What materials do you know are available, which you have not employed? Why not?

The whole metal sheet you are using now, the IBR plate with integrated insulation is a wonderful sheet, although it has a very big price, which is not accessible. But just the fact that it already allows integrated insulation makes be believe it will be a successful thing.

I still think that the concrete block is still the solution. The reinforced concrete, remains another solution. I see no other materials that are easy to use.

INTERVIEW: JESSICA LAGE

Interview with Jessica Lage, PhD student at Porto University researching informal habitation in suburban Maputo.

Note: The interview was conducted primarily in Portuguese and transcribed into English afterwards

What is your understanding and opinion regarding sustainability and sustainable design as it is practiced in Maputo, from a designers perspective?

JL: There is a clear divergence between what is considered sustainable in the developed world, in the urban areas and in the suburban areas of Mozambique. In developed countries you may find self-sustaining buildings: solar panels, water capturing schemes and reuse, etc.

In contrast, in Mozambican urban areas there are few guidelines that focus on those elements of sustainability, and instead the great focus is on: the good use of space, well ventilated spaces, proper positioning of all wet-areas (such as bathrooms and kitchens), a separation between social and private areas, and so on.

There is a requirement for state buildings to have water recovery cisterns, but even this is not considered sustainable because It requires big investments, but such water is only available during a small period of the year; it is usually badly planned so during the rainy season the water is too plentiful to be captured and stored. The amount that is captured can be used to gardening and flushing toilets, but there is not a big practice of caring for the gardens and in order to reuse it in toilets it would require a whole reorganization of the plumbing system.

In the suburban areas, the concept of sustainability is greatly adapted to the evolution of the economy and current development level of the country. The principal areas become: the proper use of local materials and workforce, the use of recyclable materials, an improved latrine and sometimes rainwater collection, as well as an improvement in the distribution of space. It is essential to make the best use of the available space.

How do you see the current urban and suburban home landscape developing, in regards to sustainable design?

JL: The prediction for next year is over 100 new tall buildings in the city. EDM (Electricidade de Moçambique) has already stated they do not have the capacity to supply for buildings over 10 storeys, yet there are multiple 20 storey developments. The developers for the different projects only pay for the infrastructure upgrade inside their boundary line.

There is no system of tax for them to contribute towards infrastructural upgrades necessary to accommodate the resulting densification. The same applies for transportation and roadways, which have not yet been accounted for.

What are the design goals you seek to achieve in all your projects, regardless of specific client briefs?

JL: There are some common elements which are considered the base of good design, both in the urban and suburban contexts.

In both contexts, most of the desired qualities of a home may be quite similar to those in more developed countries: A thoughtful spatial distribution of rooms, proper cross ventilation, good room orientation but also overall solar building

orientation, disposition of windows and adequate illumination, security, and so on.

What are the resources and references you currently use to achieve your design goals? How do you see their work as relevant to these goals?

JL: There is a lot of material, studies and proposals available regarding urban planning in Maputo. There are fewer resources that focus on architectural aspects. One of the books that is widely used as a reference is Barefoot Architect by Johan Van Lengen, which details practical design and construction aspects that are essential knowledge, especially in the suburban context where knowledgeable builders, water and electricity may not be available.

What are the types of homes that clients are interested in developing? Has this changed?

JL: A side from the characteristics we have already listed regarding important design principles that are focus points in the urban context, there are several that are recurring and particular to the local context, that are not provided for by an international style of architecture: An ample veranda in front of the house, a rear entrance, outdoor cooking area, and so on.

In the suburban context there are additional considerations: exterior latrines instead of interior, the space allocation for crops that can be eaten or sold, and so on.

The project must allow for evolution and predict future extensions because as a result of personal economy, often times the house is built room by room, with the users already living in the house.

The houses tend to grow to accommodate future generations because living close to your family is an important concept. The families are generally big and the rooms can always be rented out.

What are the construction materials that you used in the past, and how have they changed now?

JL: The materials are always local. This is a matter of availability and cost of transport. To reduce construction costs there is also a lot of material up-cycling such as using beer bottles, car tyres, salvaged wood and paving. Not always are there glass panes in the fenestrations, sometimes just a net to keep the insects out.

In the suburbs often times the buildings are made of bamboo with straw walls and roofs, or more permanent intervention with cement blocks walls and corrugated sheet roofing. Window frames may be reused from elsewhere.

There are several creative alternatives seen in reference projects on the internet, but the people who have access and knowledge of such projects are the architects and more often than not these projects are designed by the users themselves.

Similarly, how have your construction methods changed, if at all?

JL: The builders and material providers always originate as close to the building site as possible. This is to reduce transportation costs.

All elements are standardised: doors, windows, room sizes. Sometimes these are only acquired after a time, so it is important that they are of standard sizes and shapes.

A lot of building work is done with manual labour because it is cheap. Mixing and casting concrete, digging the foundations, and so on.

There is a big necessity to teach these home owner designers basic principles, such as employing some type of ventilated suspended ceiling under metal roofing to avoid overheating.

INTERVIEW: JESSICA LAGE

What is the architectural discourse regarding the interplay between cultural and functional aspects in home designs, considering the Maputo context?

JL: There are two main schools of thought regarding "evolution" and progress in the design discipline.

One is led by architect Forjaz with a practical and functional approach, employing methods and techniques that may not be identified as typically and culturally Mozambican, but through testing and experience are indeed the most adequate and well suited solutions to the problems they tend to solve.

The other is led by architect Rosario who creates a relation between the project language and typical Mozambican decorative elements, in the design or construction. There is a greater desire for understanding the vernacular in its language.

Some final conclusions?

JL: I think it is clear that we are dealing with three distinct definitions for sustainability: what may be identified in developing countries, the so called "green architecture"; the kind that is employed in the urban context with the new money where the maximum commodity and luxury is desired; and finally the suburban context where they try to save as much as possible and make use of the scarce resources available to them.

Sustainability is not about minimising the carbon footprint. It is about providing a comfortable home in a situation where not everyone has access to adequate resources.

A good home must employ certain particular Mozambican features that you may not find in other countries: it needs an ample service area where clothes can be washed by hand and hung for drying; it requires bathrooms for maids if applicable; apartment buildings must have service balconies for drying clothes; and so on.

There are different house typologies such as the winding house, the evolutive house and the multi functional house.

NATURAL VENTILATION STRATEGIES

A whole-house fan or natural ventilation can store night time cool in high mass interior surfaces (night flushing), to reduce or eliminate air conditioning. This also serves to ventilate ceiling and attic spaces to maximize air temperature reduction.

It is possible to create air movement even when wind speeds are low, by maximizing vertical height between air inlets and outlets. This can be done through the use of open stairwells, two storey spaces and even roof monitors.

NATURAL VENTILATION STRATEGIES

To facilitate cross ventilation, the door and window placement should be located on opposite sides of the building. In addition, the larger openings should face upwind when possible. This maximises wind flow through the house.

Use open plan interiors to promote natural cross ventilation and reduce the number of interior rooms that have no direct access to an exterior wall.

Louvred openings, both windows and even doors can be an effective way of permiting free flows through the home.

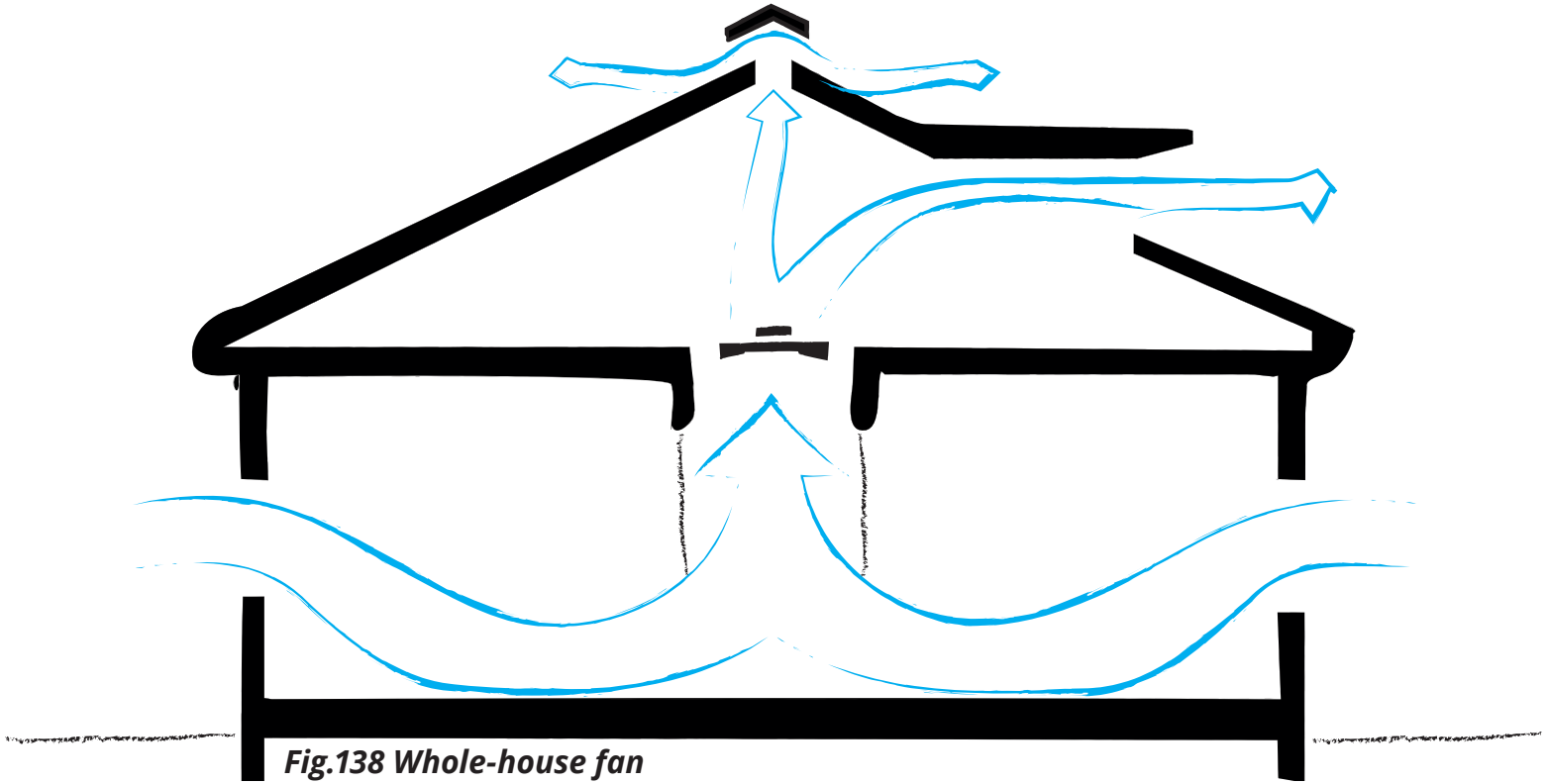

Fig.138 Whole-house fan

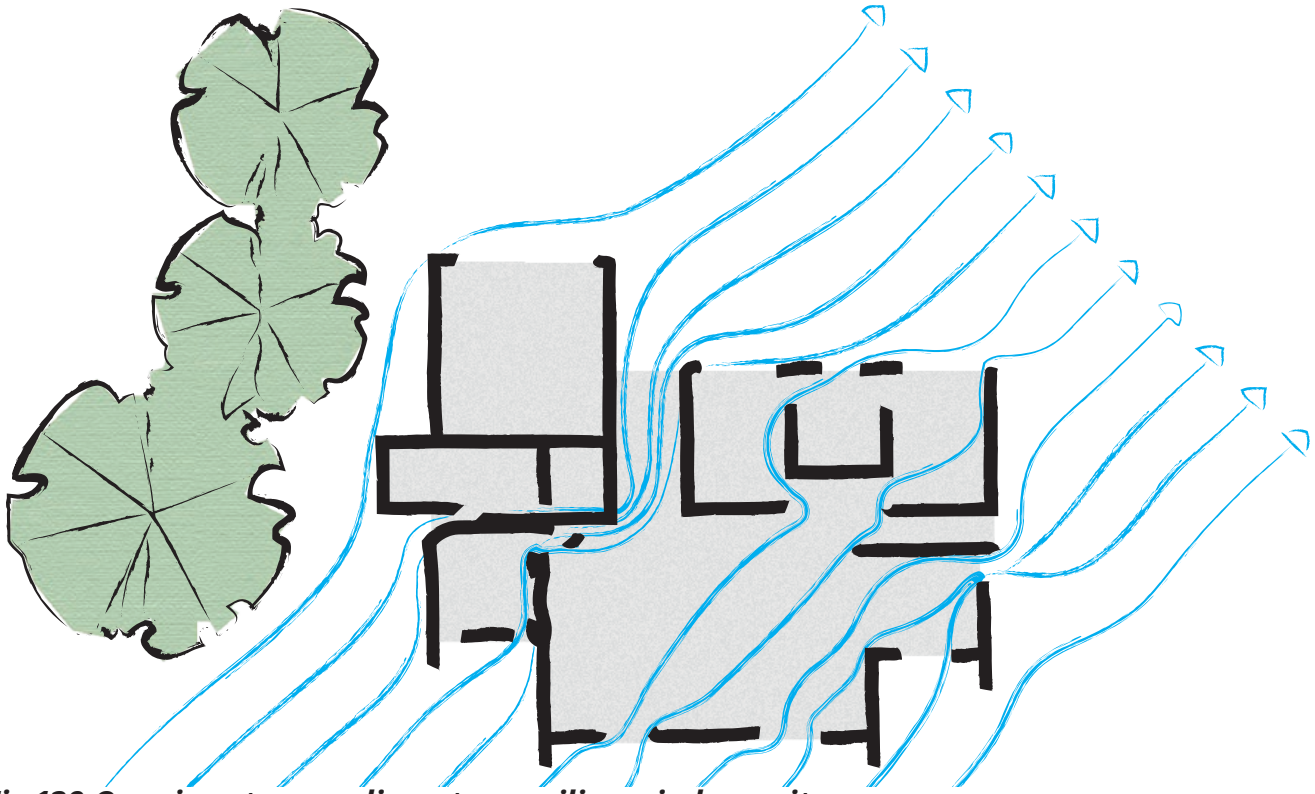

Fig.139 Openings to compliment prevailing winds on site

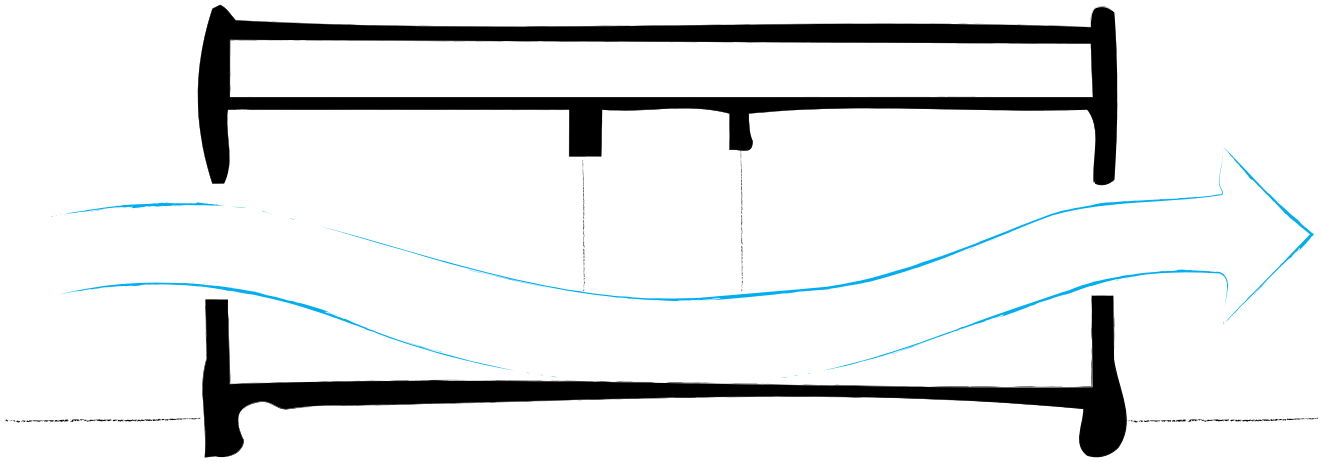

Fig.140 Cross ventilation through home

NATURAL VENTILATION STRATEGIES

The depth of the building also plays a role in the efficacy of natural ventilation. A rule of thumb establishes the passive area of a building, the area which may benefit from natural daylighting and ventilation, as limited to twice the ceiling height.

Using the figure as example, the circulation corridor does not count as a passive area because it has limited access to the exterior facade, and may have to be ventilated through mechanical means.

This can also be understood as the relationship between the volume of the building and the area of it's enveloping surfaces, such as roof and facade. In this situation, a building with a smaller volume to area ratio (also called building shape factor) benefits from easier natural ventilation.

Ideally, the building should be narrow in the direction of prevailing winds, with large overhangs towards the sunny side.

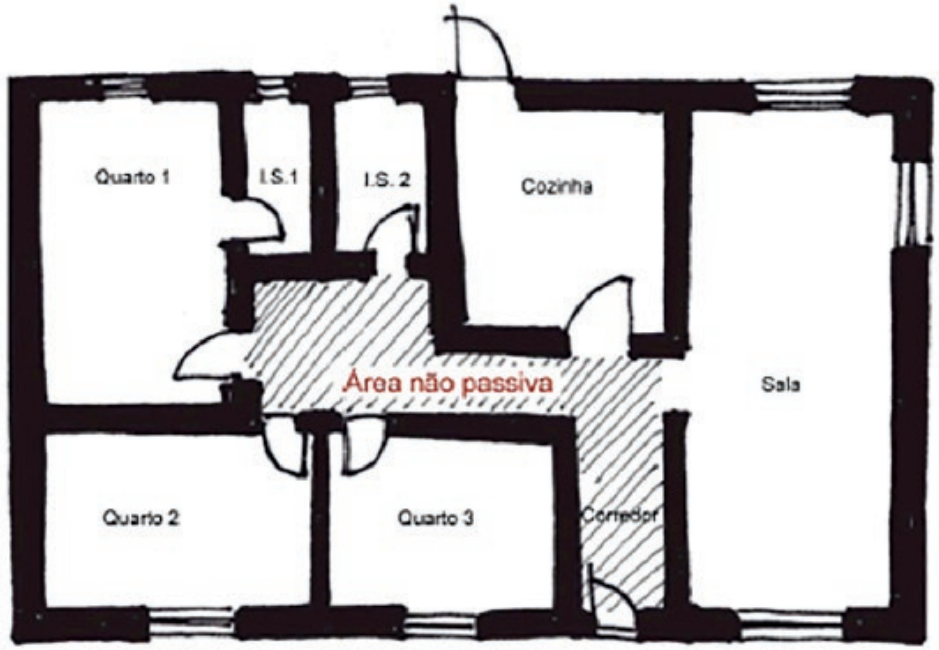

Fig.141 Passive and non passive areas
From climate consultant 6.0

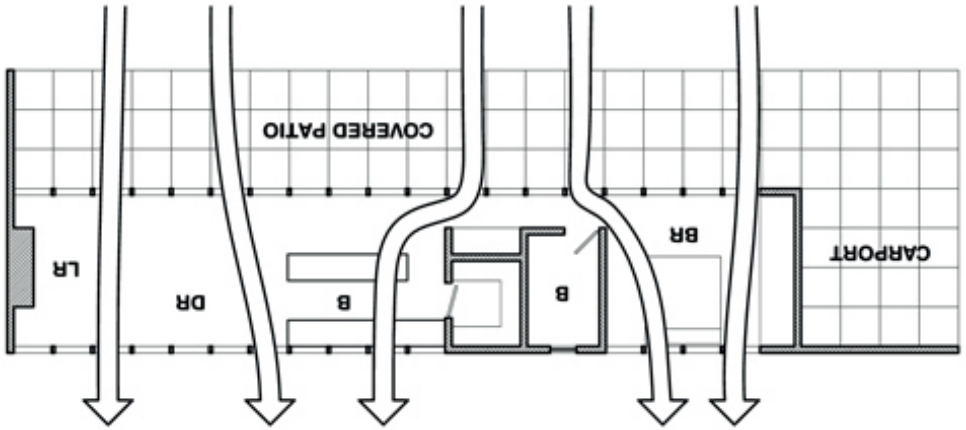

Fig.142 Narrow building in plan
From climate consultant 6.0

HIGH THERMAL MASS AND NIGHT VENTILATION STRATEGIES

A common practice with high mass walls is to use exterior insulation and exposing the mass on the interior, or adding plaster.

High mass interior surfaces such as tile, slate, stone, brick and adobe feel naturally cool on hot days and can be used to reduce day-to-night temperature swings.

It is also possible to make use of the ground as high mass, either with slab on grade to store night cool, or earth sheltering, as the earth stays near average annual temperature.

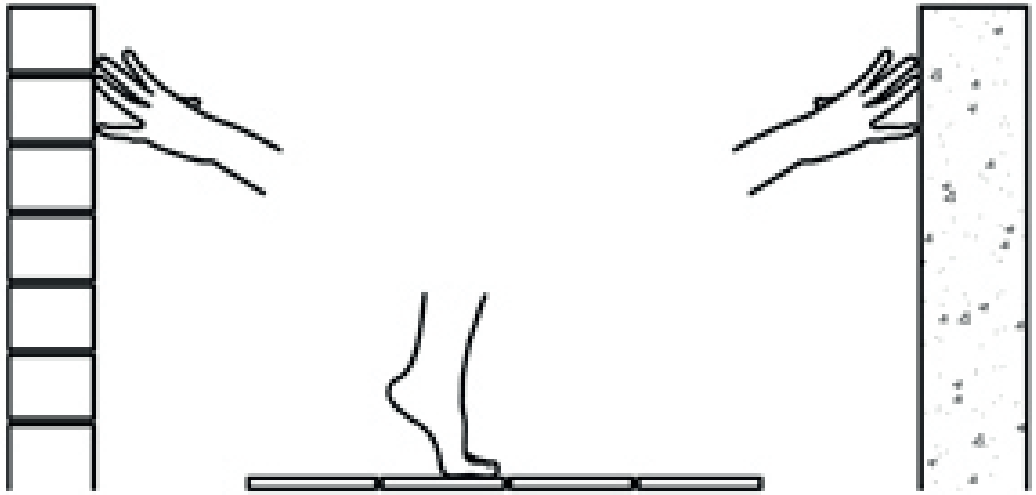

Fig.143 High thermal mass interior finishes
From climate consultant 6.0

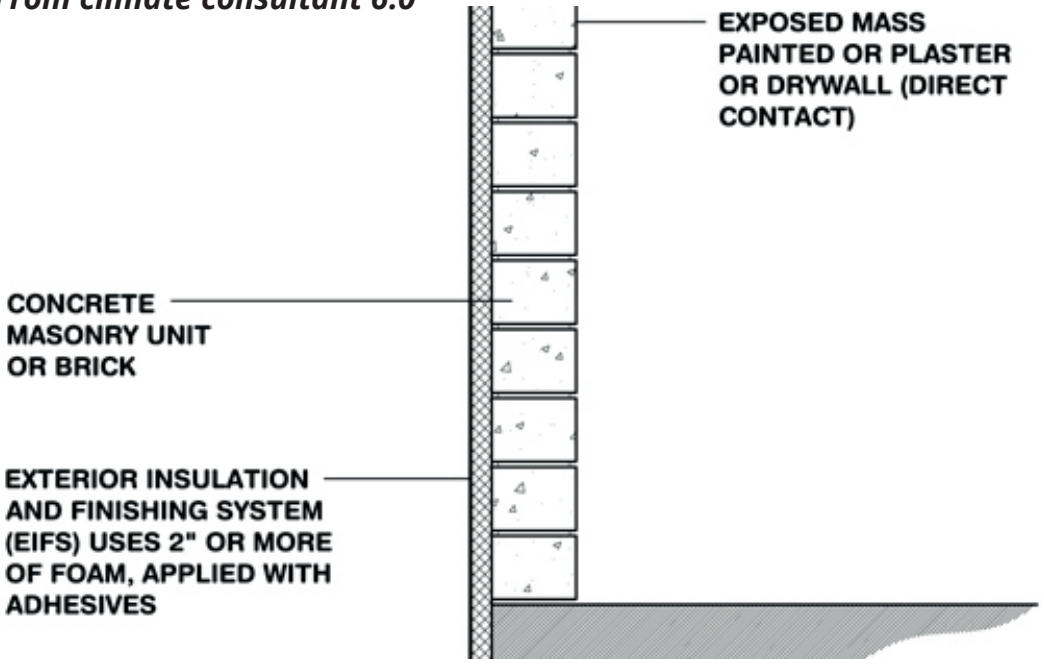

Fig.144 Placement of insulation and finishes on facade walls
From climate consultant 6.0

DESIGN GUIDELINES thermal comfort

SUN SHADING OF WINDOWS STRATEGIES

Low pitched roofs with wide overhangs are ideal, to maximise the shaded area of the facade.

Window overhangs designed for this latitude or operable sunshades that extend in summer can reduce the need for air conditioning.

Shaded outdoor buffer zones such as porches and patios should be oriented to the prevailing breezes. This can create comfortable shaded outdoor spaces that also minimize direct heat gain to the main building mass by protecting the facade from the sun.

Minimize or eliminate west facade glazing to reduce summer and fall afternoon heat gain.

Use plant material like bushes, trees and ivy-covered walls especially in the west facade to minimize heat gain.

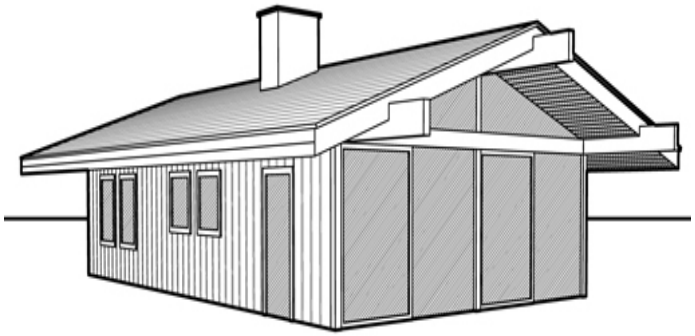

Fig.145 Wide overhangs
From climate consultant 6.0

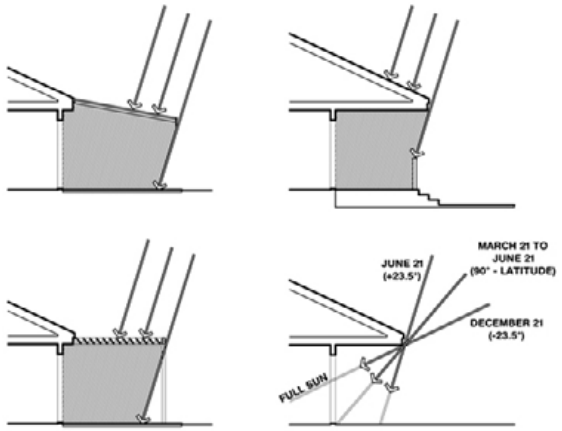

Fig.146 Window overhangs
From climate consultant 6.0

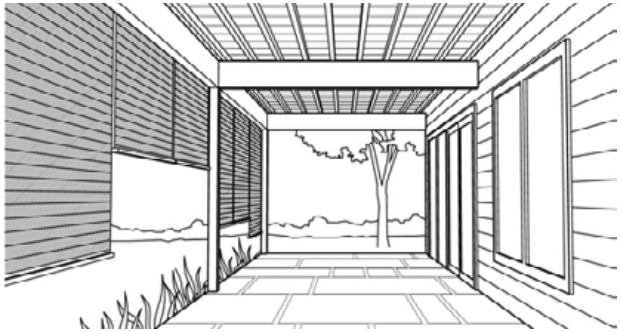

Fig.147 Shaded buffer zones
From climate consultant 6.0

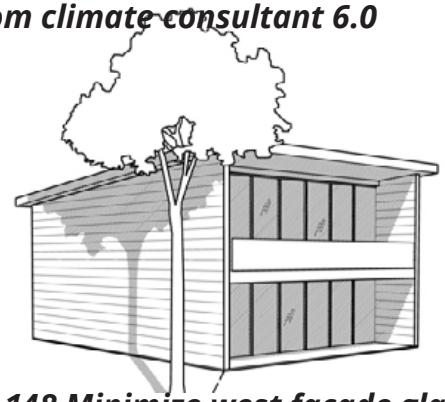

Fig.148 Minimize west facade glazing
From climate consultant 6.0

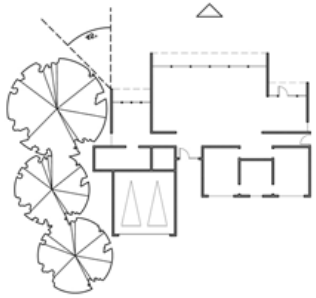

Fig.149 Plant material for shading
From climate consultant 6.0