



University of Nairobi

SCHOOL OF THE BUILT ENVIRONMENT
DEPARTMENT OF ARCHITECTURE AND BUILDING SCIENCE

INDOOR THERMAL COMFORT ANALYSIS OF INFILL BUILDINGS IN STONE TOWN ZANZIBAR

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B02/0913/2013

DEDICATION

To my late dad. This is for you.

DECLARATION

This thesis is my original work and to the best of my knowledge has not been presented for the award of a degree in this university of Nairobi or any other institution. This thesis is submitted in part fulfillment of the examination requirements for the award of the Bachelors of Architecture degree, Department of Architecture and building science, University of Nairobi.

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ACKNOWLEDGEMENT

To my Almighty God with whom all things are possible.

To my family, Mom, Salaton, Siano, Olonana and Soila for your love, prayers and support both in my academics and none academic ventures and most of all for your constant faith in me, that kept me going.

To my tutor Dr Linda Nkatha for your tireless efforts, sacrificial assistance and immense input throughout the process of writing this thesis.

To the chairman the department of Architecture and Building science Arch. Musau Kimeu, thank you for your insights, guidance and being an inspiration.

To the Year co-ordinator, Arch Nibert Musyoki for your invaluable instruct and feedback at every stage of shaping the dissertation.

To all lecturers ,Department of Architecture and Building Science: Professor Jerry Magutu, Professor Rukwaro Arch. Adnan Mwakulomba, Professor Tom Anyamba, Arch Bob Muhia, Arch. Kigara, Dr mahinda, Dr Kamenju, Kahare Miano and all whom i did not mention, Thank you for your assistance and for seeing me through to the final lap.

For my study, I appreciate the Stonetown Conservation and Development Authority office (STCDA) for its help in accessing the various case studies in stonetown Zanzibar. In particular Bw Rashid, Bi mafunda, Bi Madina, Muumin and Massoud I say thank you for all the assistance accorded.

To my classmates; You have positively influenced my life.

To my bay members, Benard, Alice, Sheila, Nasongo, Karuga and Kabubi It has been wonderful and pleasure knowing you all.

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ABSTRACT

Stonetown Zanzibar has been developing with new buildings coming up in the unbuilt plots, to replace old dilapidated buildings and also repairs to the old buildings. The new buildings have embraced the use of contemporary materials. A discussion on whether the traditional materials or the modern material are better for the climate of Zanzibar has been going on. This study was undertaken to establish which materials are best suited for Stonetown Zanzibar in terms of user thermal comfort and further give recommendations on the materials to be used for building in Stonetown Zanzibar.

Literature review confirms the changes in construction materials especially for the new constructions in Stonetown Zanzibar. Using case study strategy the author studies the urban morphology, street character and selected case study buildings in stonetown Zanzibar. For more clarity on the subject of thermal comfort, HOBO digital data loggers was used to record temperature and relative humidity of the case study buildings. From the comparative analysis the buildings that used traditional materials performed better, This evidence validates the use of traditional materials for building in stonetown Zanzibar in terms of user thermal comfort.

Concluding from that the author identified that the materials to be used in stonetown should be porous, bright to reflect heat and should also be poor conductors of heat.



INTRODUCTION

- 1.1 BACKGROUND STUDY
- 1.2 PROBLEM STATEMENT
- 1.3 AIMS AND OBJECTIVES
- 1.4 RESEARCH QUESTIONS
- 1.5 SCOPE AND LIMITATIONS
- 1.6 JUSTIFICATION OF STUDY
- 1.7 SIGNIFICANCE OF STUDY
- 1.8 RESEARCH METHODS
- 1.9 STRUCTURE OF THE RESEARCH PAPER

CHAPTER ONE



Fig 1.1 New developments in Stonetown Zanzibar.

Source :Author (2018)



Fig 1.2 Image of Gede ruins

Source :en.wikipedia.org

1.1 INTRODUCTION

Historic sites are places which give people a sense of wonder and makes them want to know more about a people and their culture (Feilden, 1997), the various historic centres of the globe have unfortunately faced undisputed changes in building construction methods and technology with varying implications. This is due to industrialisation and mechanisation of the building industry. Pressures to develop too have resulted in many new developments coming up in historic parts of urban centres as shown in Fig 1.1, the world over which are erasing past built environments from their respective local senses without any due care. Yet, these historic centres are not mere spaces just for passing through but are an expression of peoples way of life in terms of built form, technological, social cultural and economic achievements over time.

It is then the duty of the building industry professionals and especially architects and urban planners together with policy makers to find a means of conserving the historic sites with minimal destruction of the sense of wonder and learning of a culture. This can be done by developing policies and guidelines on how the traditional architecture could be married with the contemporary architectural approaches in design, to come up with architecture that does not jeopardise the character of historic sites, while embracing modern design technologies with sustainability taking the fore through proper environmental understanding of the respective areas. The traditional material should be improved to meet the contemporary needs and also to improve the strength and performance of this materials so as to ensure that the new buildings achieve comfortable indoor thermal comfort levels.

In Africa for instance, Moon-soon winds of the Indian ocean saw the growth of trade along the East African coast. This led to growth of cities stretching all the way from southern Somalia to northern Mozambique. These towns display unique character and cultural manifestations due to these trade (Siravo, 1996). However most of these cities have not survived to tell their story, Gede as shown in Fig 1.2 and Kilwa for instance which were once thriving communities in the East African coast, today only



Fig 1.3 Image showing a contemporary building in Vuga
Source: Author (2018)

excavated ruins to show their prior existence. The dilapidated old buildings and the new buildings that are being brought up in these cities have not considered to incorporate the old buildings construction methods and construction materials that were suitable to the climate of the site. The old buildings provided indoor thermal comfort to the users. This is however not the case for the new buildings in the East African coast cities.

Zanzibar grew as a key centre for slave trade and spices in 1800s under the control of Oman's. Zanzibar stone town stands as a testament of a mix of cultural influences by the Europeans, Arabs, Indians and indigenous Africans over time (Siravo,1996). Stone town, Zanzibar was declared a UNESCO World Heritage Site in 2000. According to UNESCO, stone town Zanzibar illustrates in its architecture and urban structure the intense seaborne trading activities between Asia and Africa over centuries. Stone town Zanzibar is developing and new buildings are coming up in the town. This thesis aims at studying the effects of these change in construction materials to the indoor thermal comfort of the infill buildings as expounded in the section below.



Fig 1.4 Image showing the old dispensary.
Source: Author (2018)

1.2 PROBLEM STATEMENT

Stonetown also known as *mji mkongwe* is located on the western coast of Unguja, the main island of Zanzibar archipelago (Siravo 1996). This Islands form part of the united republic of Tanzania. Stonetown is a unique cultural asset to Zanzibar island but the construction of contemporary buildings and ill-conceived repairs to the centuries old buildings using new construction techniques which are not in tune with the traditional construction methods and the use of modern materials is threatening its survival.

Both changes in construction methods as illustrated in Fig 1.3 , and the introduction of new materials and design unless guided will not only alter the character of stone town but also alter ther buildings thermal comfort. It is in the interest of these research to establish the effect of these alteration on



Fig 1.5 image of the Ariel view of stonetown Zanzibar.
Source: <http://8thingstodo.com>

the indoor thermal comfort. The new infill buildings have a poor thermal comfort and therefore tend to depend on the air conditioners as seen in Fig 1.3. However the traditional buildings as illustrated in Fig 1.4 do not depend on any mechanical ways of achieving thermal comfort. Since new buildings will be built in the Stone town, some to replace old structure and others to fill the pockets of empty and undeveloped plots. Then we must ask ourselves; can we synthesise traditional and contemporary materials ensure the product is environmentally friendly and fits in with peoples aspirations.

If changes on the buildings cannot be avoided then they need to be done with clear guidelines to retain the comfortable indoor thermal comfort performance of the building. It is the above reality that this research focuses on, namely a comparative analysis of the traditional and contemporary building materials in stone town through an investigation of human thermal comfort suitability of the buildings of stone town, which is in a warm-humid climate. Warm and humid climate requires careful building design considerations as it has large latent cooling loads as well as the need to mitigate the atmospheric stickiness caused by high humidity levels and the sweltering heat. (Szokolay, 2004).



Fig 1.6 image of contemporary building
Source: Author (2018)

The research aims to establish the appropriate building construction materials that will be used in contemporary architectural design without compromising the thermal comfort of the new buildings in stone town Zanzibar. The need to balance a rationalistic and coastal image with the contemporary one must also be portrayed in the material used in the construction as illustrated in Fig 1.6. It is in the interest of these thesis to establish whether building design harmony of traditional maritime building materials in stonetown like coral, lime, Mangrove and contemporary materials like concrete, glass and steel could be reached. With proper research, a harmony of traditional maritime building materials in stone town like coral, lime, mangrove and contemporary materials like concrete, glass and steel could be reached.



Fig 1.7 Image of the old fort
Source: Author (2018)

1.3 AIMS AND OBJECTIVES

1. To establish the traditional versus the new or modern materials currently in use in stone town Zanzibar.
2. To establish the thermal effect of building materials in the traditional stone houses.
3. To carry out an elaborate choice and selection of materials that may be used to ensure that new buildings adapt to the local climate of stone town, Zanzibar.

1.4 RESEARCH QUESTION

1. What are the traditional materials and new or contemporary materials currently in use in stone town Zanzibar?
2. What are the thermal effects of building materials in the traditional stone houses?
3. What materials should be used in stone town Zanzibar to ensure that new buildings adapt to the local climate?

1.5 JUSTIFICATION OF THE STUDY.

Previous studies investigating indoor thermal comfort of buildings in the warm humid climates have been undertaken for areas along the East African Coast. A thesis by Njeru Peter(2007) B. Arch Thesis UoN, examined into the subject in the coastal town of Mombasa where it focused on the traditional and contemporary houses and made a comparative analysis of their indoor thermal comfort. Building onto that body of knowledge this study seeks to investigate into a much similar situation but it will focus on the thermal comfort analysis of infill buildings in stone town of Zanzibar. According to Szokolay (2004), design in warm humid climate is sensitive and proper design should be undertaken to ensure the indoor thermal comfort needs of the users met.



Fig 1.8 Image of a building that uses new materials and therefore uses air conditioners to achieve thermal comfort.
Source: Author (2018)

Construction materials as shown in fig 1.8 have an impact on the thermal comfort of the houses in which they are used. It is therefore the intention of this study to contribute to the existing knowledge on design for warm humid climate and come up with ideal construction materials for Stone town Zanzibar. This study will also inform the people who intend on developing the stone town of Zanzibar

BACKGROUND STUDY

appropriately by ensuring that the materials used meet the indoor thermal comfort requirements as it is going to give a selection and choice of appropriate material to be used to develop new buildings in stone town.

1.6 SCOPE AND LIMITATIONS

This study examines construction materials and their thermal physical properties in traditional houses in Zanzibar. Whereas there are several building types found in stone town Zanzibar namely: Residential, markets, mosques, hospitals, bazaars, tombs and palaces. This study focuses only on the residential stone houses.

Due to time constraints and finances the study will involve two visits by the author to the town in the month of November 2018.

This scientific study inquires into the performance of the stone houses in Stone town Zanzibar, seeking to find out if it aggravates these environmental extremes or achieves human thermal comfort conditions and the Hygro-thermal comfort conditions. It aims at analysing quantifiable aspects such as temperature and humidity levels influencing sensorial/quality aspects of living spaces.

This study will also be limited to the investigation of the following parameters

1.6.1 LOCATION

Whereas Zanzibar has several regions as illustrated in figure 1.7, The study will only focus on stone town which is the oldest part of Zanzibar island. Stonetown is a conserved area due to its rich architectural history. As discussed in greater detail in chapter 4 Page 75.



Fig: 1.9 Map of Zanzibar island
Source: www.expertafrica.com



Fig: 1.10 Image of buildings with different colours.
Source: Author, (2018).



Fig: 1.11 Image showing the window to wall ratio of an old building in stoonetown Zanzibar.
Source: Author, (2018).

1.6.2 BUILDING TYPOLOGY

The study focused on the four major building typologies in stonetown namely; Caravan serai, The swahili house, The Indian shopfront and the Omani house.

1.6.3 BUILDING COMPONENTS

The study will investigate whether there is a change in materials used on the external and internal walls, Roof, ceiling, floor slab, doors and windows with the aim of determining the impact of the material used on the indoor thermal comfort of the buildings.

1.6.4 PARAMETERS OF THERMAL COMFORT

- **Colour-** The buildings along kiponda street as shown in Fig 1.8. The study will investigate on the impact of the colour of the material used on the various elements of the building and their impact on the indoor thermal comfort of the building.
- **Wall thickness-** The study will investigate on the thickness of the walls of the infill buildings which might be due to the change in material use and how that affects the thermal comfort of the new infill buildings.
- **Window to wall ratio-** The window to wall ratio for traditional building is approximately 1:3 as illustrated in Fig 1.9. The use of new materials on the other hand has allowed the builders to have reinforced columns and beams and therefore the external wall is no longer load bearing hence they are able to achieve wide openings on the wall. It is the intention of this study to find out the window to wall ratio of the new buildings and whether that has affected the indoor thermal comfort.
- **Porosity of the material-** Stonetown Zanzibar is in a warm and humid region hence it experiences high humidity levels due to its close proximity to the sea. It is therefore recommended that the materials used in the walls be porous in order to allow the humidity that is trapped inside the buildings to get out. This study will try and find out whether the new materials used in the infill buildings are porous.



Fig: 1.12 Image showing the external lime plaster affected by weather elements on mkunazini street.
Source: Author, (2018).

1.6.5 WEATHER ELEMENTS

The study will focus on the internal Air temperature and relative internal humidity measurements of the selected buildings for study. This will be monitored using air temperature and relative humidity data loggers for a period of 2 weeks.

1.7 RESEARCH METHODS.

This study will use quantitative methods of research. The scientific data loggers will be used to measure the relative humidity and the temperature levels of the various case study buildings selected for this study. The author will also conduct various interviews to the professionals at the stonetown conservation offices, the local artisans and the occupants of the various buildings. The data collected will build up a collective information for the study. As explained in chapter 3.

a) Literature Review on published materials

i) Battle, Stephen & Tony Steel. Conservation and design guidelines for stone town, Geneva: Aga Khan trust for culture 2001

The author of the book gives an elaborate guideline on how to design in stone town according to law and order to protect the cultural heritage of the buildings in stone town. The different materials and building technology appropriate for stone town is discussed in the book. Appropriate ways of carrying out repairs to old buildings in stone town is also explained.

ii) Bianca, Stefano and Francesco Siravo, Zanzibar: A plan for the historic stone town. Geneva Aga Khan Trust for culture.

The book contains an in-depth study in the architecture of Zanzibar, its development and an account of the building typologies in the island, their building technology and materials. It goes further to gives guidelines the future development in-order to conserve the historic heritage of Zanzibar.



Fig: 1.13 Image showing a mabati extension on an old building
Source: Author, (2018).

BACKGROUND STUDY



Fig 1.14 Image showing a building along Malawi road.
Source: Author (2018)



Fig 1.15 Image showing a bench along Mizingani road.
Source: Author (2018)

iii) UNESCO SWAHILI: Historic Urban landscapes, Report on the historic urban landscape workshops and field activities on Swahili Coast in East Africa 2011-2012, 2013

The author of the book highlights the causes of transformation in the Swahili towns. These are the challenges that UNESCO seeks to address by offering recommendations for development of the historic landscapes. The book focuses on the island of Mozambique, in Mozambique, Stone town of Zanzibar in the United Republic of Tanzania and Lamu old town in Kenya.

iv) Otto Koenigsberger (1975) Manual for Tropical housing and building, Orient Longman private limited, United Kingdom.

The book describes the various climatic zones and gives design considerations for building for the zones. For this study the part of interest is the warm humid climate and the design guidelines suitable in such a climate.

v) Salma Damar Salmuji (2008) The Architecture of Oman, Garnet Publishing limited, Reading, UK.

The book gives an account of the architecture of Oman, its architectural elements and building typology which shows the cultural and commercial influences through the history of Oman and her trade links with East Africa and India.

vi) Siravo F., Pulver A. 1986), Planning Lamu, conservation of East African seaport, National Museum of Kenya, Nairobi Kenya.

The book discusses the architecture of Lamu and the conservation of the old town. It gives the history of the town and a detailed study of the building typologies and elements of the town. The book is relevant as it gives account of changes and adaptations that have occurred over time.

vii) Steven Szokolay (2008) Introduction to architectural science, the basis for sustainable design, Architectural press.

The book looks into climatic characteristics of each climate. Of relevance to this study is the thermal comfort requirements for the warm and humid climate as it is comprehensively discussed in the book.



Fig 1.16 View of the Zanzibar port from Mizingani road.
Source: Author (2018)

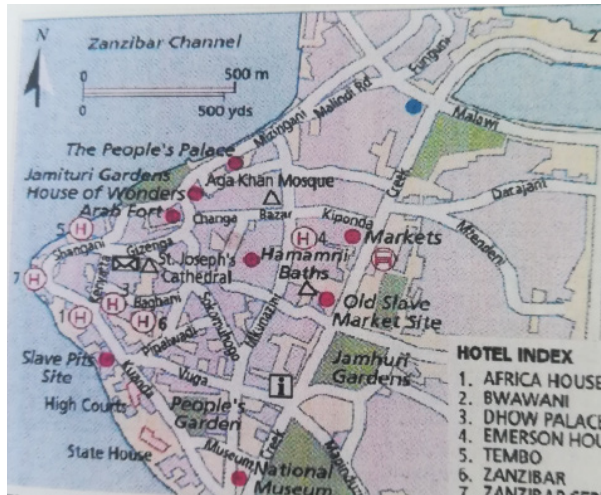


Fig 1.17 Map of stonetown Zanzibar showing main landmarks.
Source: www.dewawi.ca

viii) Linda Groat and David Wang Architectural Research Methods, 2002. John Wiley & Sons, New York.
The book gives an elaborate explanation of the guidelines to architectural research.

ix) Bjorn Berge. The ecology of building materials

The author discusses the various building materials and their ecological properties.

x) Fielden B.M: Conservation of historic Buildings. St. Edmundsbury Press Ltd, 1997.

The author explains the various ways of conserving the buildings in a historic site.

b) Unpublished material

i) Saad Yahya & Associates, (SYA), SIDA, UNESCO (2008), Zanzibar Stone Town, Heritage Management plan.

This article identifies the issues that are facing Zanzibar as a historic site and proposes actions to address the issues while at the same time protecting the cultural heritage of stone town.

ii) Malisius, U. (1987) The Stone Town of Zanzibar- A conservation of a difficult heritage

In article the author argues the following; Stone Zanzibar was mainly built and developed when it was having a boom of trade and spices, ivory and slaves. Stone town also represents a historical environment that has survived despite the many changes. The British however during their protectorate brought the good infrastructure and administration to Stone town. However the decline and the end of slave trade affected the economic development in the town, this is evident in the dilapidated state of few significant building.

iii) Manda Kakaire (2016) Thermal comfort analysis of buildings in stone town and Ngambo. Zanzibar.

This thesis looks gives an account of buildings in Zanzibar stone town which has older and more traditional buildings and Ngambo area which has more modern buildings and compares the thermal comfort levels in the buildings in the two regions.

BACKGROUND STUDY



Fig 1.18 Historic slave chamber in Mangapwani
North-western Zanzibar.
Source: www.dewawi.ca



Fig 1.19 Historic slave chamber in Mangapwani
North-western Zanzibar.
Source: www.dewawi.ca

iv) Mutonga P. (2014) Evolution of Swahili Architecture: A case study of Mombasa, Lamu and Zanzibar, University of Nairobi.

This thesis investigates the various factors that impacted on the transformation of Swahili Architecture and the contributions of various societies to the evolution of the architecture of the Swahili. This study is relevant as it gives the knowledge on the origin of the various historical elements of the different typologies of the traditional Stone town.

v) Muiruri E. (2013) Adaptations of Swahili stone house along the East African Coast; A case for southern Somali, Kenya, Tanzania and Northern Mozambique. University of Nairobi.

This thesis investigates the adaptations of Swahili stone houses along the East African coast and does a comparative analysis of the various buildings. This is relevant as it sets a foundation for the study of the entire Arab and other cultural influences along the East African Coast.

c) Internet sources

Various online website have been used to gather certain information especially that which is not published yet. Some of the images have also been gotten from the internet.

d) Fieldwork

i) Interviews.

Interviews were done with the relevant professionals in stone town Zanzibar conservation offices, the artisans and the craftsmen and the local residents who were randomly picked from the streets. For the case study buildings the author interviews Bi salma who was the owner of the new swahili house. She gave the general information of the building as she has been living in the house since the time it was constructed. For the Caravan serai the author interviewed Juma who has been living in the caravanserai since birth. In Forodhani park hotel the author interviewed the staff of the hotel who gave a brief history of the house. For



Fig 1.20 Image of dhows on the indian ocean.
Source: <http://www.zanzibarhistory.org>

ii) Measured drawings

Internal and external measurements of the various dwelling units that are selected for the study which are Malindi Caravan serai, the swahili house, Forodhani park hotel, The new darajani indian shopfront and the STCDA building were taken and used to generate measured drawings of the buildings which aided in the analysis of the case study buildings.

iii) Sketches and photography of the selected field areas of study

The study will involve doing analytic sketches of sokomuhogo street, Mkunazini street, Kenyatta street and the various dwelling units selected for the study, this will help in the comprehension of the elements of the swahili architecture of stone town Zanzibar. Some elements were however captured through analytic photographs of the selected areas of study.

iv) Scientific studies

The internal air temperature and relative humidity measurements were taken over a period of time and used to plot a graph that helps in the analysis of the thermal comfort levels of the selected case study buildings

v) Collection of climatic data from the meteorological stations

Data was collected from various meteorological stations which was used to document the climate conditions in stone town Zanzibar. This data is also used to inform the various variations in the climate and therefore one is able to identify the hottest and coldest months of the year and effectively design for these conditions.

vi) Collection of maps and drawings

Maps and drawings were collected from the STCDA offices in stonetown Zanzibar and these were used for the illustrations explained in the literature review of this thesis.



Fig 1.21 Image of dhows on the indian ocean.
Source: <http://www.zanzibarhistory.org>



Fig 1.22 Traditional house with a makuti roof in Zanzibar.
Source: www.alamy.com

vii) Observation

Some the issues discussed in this thesis were collected through observation. The author captured most of the activities on the streets and on the open spaces through observation.

1.8 CHAPTER BREAKDOWN.

1. Chapter One: INTRODUCTION

The chapter introduces the area of study , it highlights the research problem which is the emergence of contemporary buildings which are using contemporary building materials which are different from the historic building materials that were used in stone town. This change in material has contributed to the new buildings not being able to achieve internal thermal comfort. It also justifies the research and gives a breakdown of the chapters.

2. Chapter Two: THE SWAHILI COAST AND ITS ARCHITECTURE

This chapter discusses the Swahili coast and its architecture in an in depth way from the time it was established,when it thrived and also when its economy declined due to the end of the slave trade that made the economy to thrive. It also explains the architecture of the swahili coast as one that is influenced by the various cultures. It goes further to list the traditional and modern materials and their thermal physical properties.

3. Chapter Three: RESEARCH METHODS

The various modes of research to be used to gather the information required in this thesis are discussed in this chapter.

4. Chapter Four: ANALYSIS OF STONETOWN ZANZIBAR

This chapter analyses the whole of stonetown from its planning and development and it goes further to explain the architecture of the various main regions in stonetown.



Fig 1.23 Image of the daka
Source: Author (2018)



Fig 1.24 Image showing mangrove poles used on the ceiling.
Source: Author (2018)

5. Chapter Five: ANALYSIS OF THE CASESTUDIES

The climatic data collected from the various case studies are analysed in this chapter. The data collected is used to plot graphs which are used to create a basis for comparative analysis of the thermal comfort analysis of the traditional and contemporary buildings.

6. Chaptersix: CONCLUSIONS AND RECOMMENDATIONS

This chapter concludes the study and also gives recommendation for further study

1.9 DEFINITION OF TERMS

- a. **Baraza**- this is a Swahili term which refers to a public place where social meetings are held. In Lamu this is a raised stone bench on the front of stone houses where people sit and hold casual meetings. It also acts as a reception area. In shop fronts of stone houses in Zanzibar are called *otla*, in Mozambique it is referred to as *Patamar*.
- b. **Boriti**- Mangrove poles which are used to support the flat roofs and slabs for the buildings along the coast as shown in Fig 1.24. This term is used to refer to the rounded poles.
- c. **Banaa**-This is similar to boriti poles but are square in shape.
- d. **Buibui**- Black cloak worn over other clothing by Muslim women.
- e. **Biashara**- Swahili word which means business.
- f. **Chowk**- Hindu word for multi purpose courtyard
- g. **Daka**-A front veranda with concrete benches that are used to entertain visitors.
- h. **Dhows**- Traditional wooden sailing ship.
- i. **Harem**-private family quarters for a Muslim family house.
- j. **Kaskazi**- Swahili word for north-east moon soon winds which blow from October to February.
- k. **Kiswahili**- Historically Swahili people are the descendants of the Bantu,Kiswahili therefore is a Bantu language with many words from Arabic roots. It is a language used in the East African.
- l. **Kiwanda**- open courtyard
- m. **Kanzu**- Robe worn by Muslim men.
- n. **Mitaa**- ward group of buildings based on family and ethnic affinities.

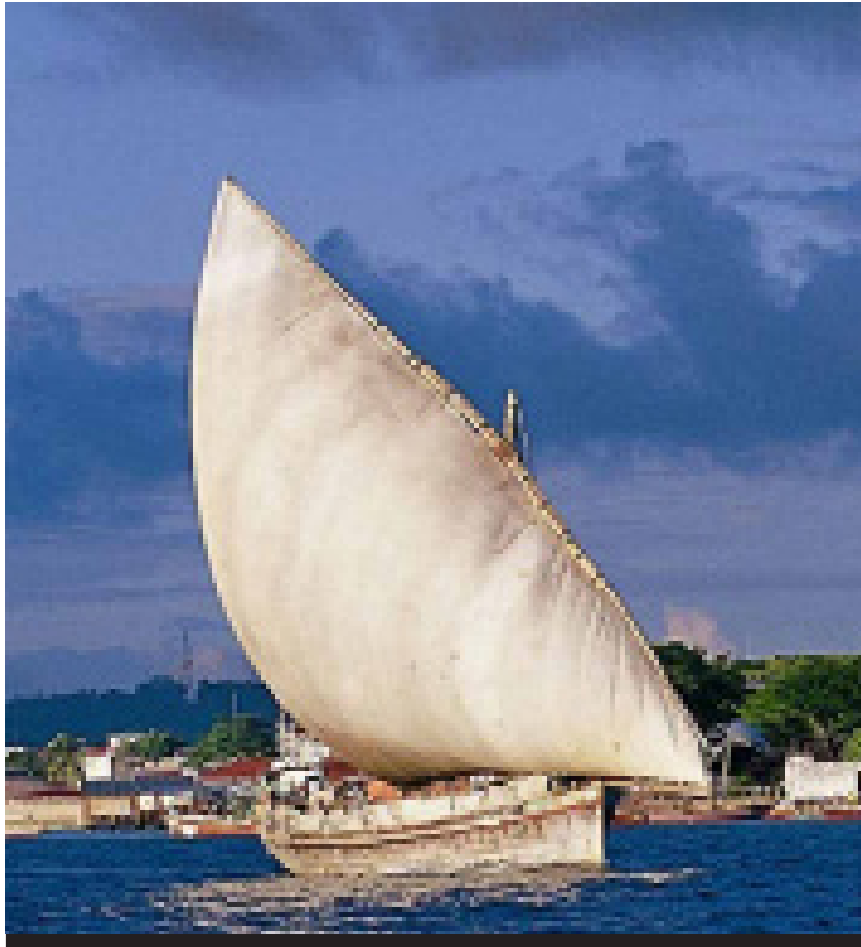


Fig 1.25 Image of the wikio
Source: Author (2018)



Fig 1.26 Image showing makuti used on the roof
Source: Author (2018)

- o. Mabati-** corrugated iron sheets
- p. Makuti-** Coconut palm thatch used for roofing of mud houses.
- q. Sebule-** indoor reception area usually next to the entrance.
- r. Stonetown-** The part of a traditional swahili town that was built primarily of permanent stone walling material and usually denotes the old part of a town, when referring to swahili city states.
- s. Wikio-** A bridge over connecting two houses that that are usually used by the women of the household to avoid getting into the street. See fig
- t. Zangh-** Arab word which means the coast of the black people.
- u. Zidaka-** niches on the walls
- v. Bioclimatic chart-** A chart generated using scientific. It presents the relative humidity data against the dry bulb reading in relation to the comfort zone.
- w. Psychometric chart-** A graph generated using scientific data, it presents physical and thermal properties of moist air.
- x. Human thermal comfort-** According to Szokolay (2004) It is the State of mind that expresses satisfaction with the surrounding thermal environment
- y. Hygro-thermal levels-** indoor and outdoor humidity and temperature levels that directly determine human comfort in the environment.
- z. Indoor climate-** humidity and thermal comfort levels in an enclosed space
- aa. Infill buildings-** New buildings that are coming up in stonetown and repair to the old buildings.



THE EAST AFRICAN COAST AND ITS ARCHITECTURE

2.0 INTRODUCTION

2.1 THE SWAHILI COAST

2.1.1 HISTORY

2.1.2 CIVILIZATION

2.1.3 MAJOR TOWNS IN THE EAST AFRICAN COAST

2.1.4 TOWN STRUCTURE AND PLANING IN THE SWAHILI COASTAL CITIES

2.1.5 MAJOR BUILDING TYPOLOGIES OF THE SWAHILI COAST

2.2 ZANZIBAR

2.2.2 CLIMATE OF STONE TOWN ZANZIBAR

2.2.3 STONETOWN ZANZIBAR

2.2.4 STONETOWN ZANZIBAR TOWN STRUCTURE

2.3 BUILDING TYPOLOGIES IN STONETOWN ZANZIBAR

2.3.1 TRADITIONAL STONE HOUSES TYPOLOGY IN STONETOWN ZANZIBAR

2.3.2 CONSTRUCTION TECHNIQUE

2.3.3 BUILDING COMPONENTS

2.3.4 SPECIAL ARCHITECTURAL FEATURES

2.4 THERMAL COMFORT ANALYSIS OF STONETOWN ZANZIBAR.

2.5 CONSTRUCTION MATERIALS IN STONETOWN ZANZIBAR

2.6 SUMMARY

CHAPTER TWO